

Full length Research Article

# Haematological values of cows during third trimester of pregnancy and early lactation in settled cattle herds in Zaria, Northern Nigeria

<sup>1</sup>Ate I.U., <sup>2</sup>Rekwot P.I., <sup>3</sup>Nok A. J. and <sup>1</sup>Tekdek L. B.

Departments of <sup>1</sup>Veterinary Surgery & Medicine, and <sup>3</sup>Biochemistry, Ahmadu Bello University, Zaria.

<sup>2</sup>Artificial Insemination Unit, National Animal Production Research Institute, Ahmadu Bello University, Zaria.

**ABSTRACT:** The haematological values of 176 cows during third trimester of pregnancy and early lactation in nine settled cattle herds in Zaria, Northern Nigeria, were studied. The total mean values of total protein (TP), packed cell volume (PCV), haemoglobin (Hb), red blood cell (RBC) and white blood cell (WBC) during pregnancy and early lactation did not differ significantly ( $P \geq 0.05$ ) while neutrophil, lymphocyte, monocyte and eosinophil values differed significantly ( $P < 0.05$ ). Neutrophil and lymphocyte values during early lactation were higher than those during third trimester of pregnancy, while monocyte and eosinophil values during third trimester of pregnancy were higher than those of early lactation. The herds mean haematological values closely resembled those of the total mean values. The herds mean values of TP, PCV, Hb, RBC and WBC during third trimester of pregnancy and early lactation did not differ significantly ( $P < 0.05$ ) except in one herd (VIII) where the early lactation value was significantly ( $p < 0.05$ ) higher. In some herds, the mean values of neutrophil, lymphocyte and monocyte during third trimester of pregnancy were significantly ( $p < 0.05$ ) higher than those of early lactation while in others, they were significantly ( $p < 0.05$ ) lower. The mean values of eosinophil during lactation were significantly higher than those of third trimester pregnancy in all the herds. This study has provided reference haematological values of cows that may be safely assumed to be adequate and consistent with normal health and metabolic state during third trimester of pregnancy and early lactation. The study has also confirmed the significant effect of herd factor on haematological parameters of cows.

**Key Words:** Haematological, parameters, pregnancy, lactation, cows, Zaria, Nigeria

## INTRODUCTION

The value of haematological parameters in the evaluation of the physical and health status of animals and birds (Hawky and Dennet, 1989; Zvorc *et al.*, 2006), the diagnosis, prognosis, treatment and prophylaxis of many livestock diseases (Hewett, 1974;

Saror and Coles, 1975; Hawky and Dennet, 1989; Klinkon and Zadnik, 1999) has been well stressed. Haematological parameters have also been used to assess nutritional status of animals (Rekwot *et al.*, 1997; Klinkon and Zadnik, 1999) as well as conjuring metabolic features of particular cases (Kronfield, 1972). In poultry, they have also been demonstrated to be important indices of production and adaptability to prevailing environmental conditions (Olufemi and Fatunmbi, 1980; Mitchell and MacLeod, 1983).

There are several haematological studies of pregnant and lactating animals including dairy cattle in the literature (Hewett, 1974; Lumsden *et al.*, 1980; Singh *et al.*, 1991; Mbassal and Poulsen, 1992; Harvey *et al.*, 1994; Klinkon and Zadnik, 1999; LaBorde *et al.*, 1999; Ozegbe, 2001; Zvorc *et al.*, 2006). The haematology of indigenous cattle and other livestock species and poultry has been well investigated (Saror and Coles,

Manuscript received: January 2009; Accepted: June 2009

\*Correspondence:

Tel.: 08054517528; 069875297

E-mail: utimphd@yahoo.com

1973; Saror and Coles, 1975; Oladele *et al.*, 2001a & b). Similarly, the haematology of some of these species has been investigated in important livestock diseases such as trypanosomosis (Esiebo and Saror, 1983; Bawa *et al.*, 2005). Investigation has also been made into the haematology of exotic cattle and their crosses with Zebu under the tropical conditions (Saror and Coles, 1975). However, literature is scarce on the haematology of pregnant and early lactating cows especially in relation to the existence of metabolic diseases in Nigeria. The study of the haematology of indigenous and crossbred cows during pregnancy and early lactation will be a useful approach in understanding the metabolic state of these animals. Increased livestock productivity, which may result from the cattle crossbreeding programmes in Nigeria, is associated with increased production diseases that reflect changes in blood profile (Hewett, 1974). Consequently, this study was conducted to evaluate the haematology of cows during third trimester of pregnancy and early lactation with a view of assessing the possibility of detecting impending occurrence of metabolic disorders in cows postpartum.

## **MATERIALS AND METHODS**

### ***Study location***

This work was carried out in Zaria, Kaduna State, Northern Nigeria, over a period of four years, from January 2001 to February 2005. Zaria is located at latitude 11° 08'N, at an altitude of 686 metres above sea level, and lies within the Guinea Savanna Zone. Three distinct seasons exist in the area where Zaria is located. These are the harmattan season (November to February), hot season (March to May) and rainy season (June to October) (Ayo *et al.*, 1998).

### ***Study herds – size, structure, and management practices***

Nine (9) out of about 20 settled herds in Zaria and its environments (within the radius of 50 kilometers) were selected with the owners' consent for the study. The selected herds were studied in details with respect to herd characteristics (size and structure as well as management practices - purpose, personnel in charge, housing, feeding, supplementation, watering, breeding, milking practice, weaning, nature of Veterinary care and disease prevention, record keeping and restraint), using the combination of a designed questionnaire and interview with the owners as well as visitation to the herds. The herd sizes ranged from 14 to 315 (average 79). The herds consisted of cows, heifers, mature bulls, young bulls and calves, all herded together except in

herds I and VII where the calves were separated from their dams and housed in calf pens. Herds III, V, VII, VIII and IX had Bunaji breed. The Bunaji and Bunaji x Friesian breeds were in herds I, IV and VI, and herd II had Bunaji and N'dama breeds. In herd I, the cows were subdivided into pregnant and open herds (non pregnant) and kept separately. In addition, sheep and goats were also kept in herds III and IV while goats were in herd VI, and sheep in herds VII and VIII.

The management practices in the study herds were summarized as follow: Herds I, II, VI and VII were Ahmadu Bello University herds while the rest were private herds. The cows in all the herds were grazed on pasture during the rainy season but in herds I and II, they were also provided *ad libitum* concentrate supplementation. There was a particularly limited grazing land available to the animals in herd IV. Herds I, III, IV and VII were dairy/beef herds while II, V, VI and IX were beef, and herd VIII, beef/feedlot. Hired herdsmen tend all the herds. Housing was essentially open sheds for all herds except for herds I and IV, where in addition, calf pens were available for calves. Only herd I had regular sanitation of housing and the rest were occasionally cleaned. Breeding was by natural mating except for herd I where Artificial insemination (AI) was used. Cows in herds I, III, IV and VII were hand - milked while those in the rest of the herds were not milked. Herds I and II had adequate restraint facilities and record keeping while the others either had fairly adequate (III, V) or none at all (IV, VI, VII, VIII and IX). Calves were weaned in herds I and IV but there was no weaning in the rest of the herds. Veterinary care was regular in herds I, II, V and VI but occasional in the rest of the herds, and watering was by varying sources such as borehole (I, II), borehole and dam (III), tap and river (IX), dam (V, VII) and well (IV, VIII).

### ***Study animals***

One hundred and seventy six (176) cows in their third trimester of pregnancy determined by breeding records and/or rectal palpation, and during the first week of lactation were used for the study. Each animal was adequately identified by ear tag or as identified by the owner. The study animals were provided individual record sheets provided in hard – covered log books containing the following information: age (identified by dentition and/or record), breed, parity (record in history and according to first, second, third parity etc), weight (measured by chest girth tape) and body condition score (according to Pullan, 1978). Animals that were found to be in earlier trimesters of pregnancy joined the study as they entered the third trimester of pregnancy.

**Experimental procedure**

Animals were identified and clinically examined in detail at the first instance and 1 clinical findings recorded on their individual record sheets. They were closely monitored on a weekly basis before parturition and two weeks after parturition. Five (5) ml of blood sample was collected from each study animal via jugular vein using 18G needle mounted on a 5 ml syringe, and kept in an EDTA – bottle (1 mg of EDTA/1 ml of blood). The samples were kept in cold packs and transported to the laboratory for haematological analyses.

**Haematological analyses**

The collected blood samples were processed in the clinical pathology laboratory of the Faculty of Veterinary Medicine, Ahmadu Bello University. Standard techniques in haematology (Schalm *et al.*, 1975) were used for the analyses. Smears for differential counts were made as soon as the samples got to the laboratory. Three milliliters (3 ml) of EDTA – containing blood was used for the determination of complete blood count (CBC). Total protein (TP) was determined using the hand refractometer (Pat. Pend., USA). Packed cell volume was determined by the microhaematocrit technique. Haemoglobin was obtained by dividing the packed cell volume by three. Red blood cell and total leukocyte count (TLC) were determined by the Nebauer haemocytometre method. Thin blood films stained with Giemsa stain were used for the determination of differential leukocyte count, by counting 100 white cells from each slide and the relative abundance in per cent of each white cell type was determined.

**Data Analysis**

The simple mean haematological parameters were obtained using appropriate statistical methods. Paired t – test was used to compare the total (overall) and herd mean haematological parameters of cows during the third trimester of pregnancy and early lactation. All data were analyzed using statistical analysis systems package (SAS, 1997).

**RESULTS**

**Total mean haematological values of cows during third trimester of pregnancy and early lactation**

The total mean haematological values of third trimester and early lactating cows are shown in Table 1. The mean values of total protein (TP), packed cell volume (PCV), haemoglobin (Hb), red blood cell (RBC) and

white blood cell (WBC) during third trimester of pregnancy and early lactation were not significantly different ( $P>0.05$ ) while those of neutrophil, lymphocyte, monocyte and eosinophil differed significantly ( $p<0.05$ ) without a consistent trend. The total mean values of neutrophil and lymphocyte during early lactation were significantly higher ( $P<0.05$ ) than the values during third trimester of pregnancy while the mean values of monocytes and eosinophil during third trimester of pregnancy were significantly higher ( $P<0.05$ ) than values during early lactation.

**Table 1:**

Mean total hematological values of cows during the third trimester of pregnancy and early lactation in settled cattle herds in Zaria

Parameter	Unit/ Normal range	Status	Total (n = 176)
Total Proteins (TP)	g/dl (6.2 – 8.2)	p1	7.99±0.77 <sup>a</sup>
		p2	7.99±0.75 <sup>a</sup>
Hematocrit (PCV)	% (24 - 46)	p1	34.07±12.74 <sup>a</sup>
		p2	34.21±13.58 <sup>a</sup>
Haemoglobin (Hb)	% ( 8 – 15)	p1	11.24±3.78 <sup>a</sup>
		p2	11.87±8.25 <sup>a</sup>
Erythrocyte (RBC)	10 <sup>6</sup> /µl (5 – 10)	p1	5.66±0.67 <sup>a</sup>
		p2	5.70±0.66 <sup>a</sup>
Leucocyte (WBC)	10 <sup>3</sup> /µl (3.8 – 11.0)	p1	10.41±2.61 <sup>a</sup>
		p2	10.68±2.81 <sup>a</sup>
Neutrophil	% (15 -61)	p1	23.16±7.07 <sup>a</sup>
		p2	25.05±8.43 <sup>b</sup>
Lymphocyte	% (26 - 68)	p1	69.95±21.92 <sup>a</sup>
		p2	72.52±26.58 <sup>b</sup>
Monocyte	% ( 0 - 12)	p1	1.14±0.77 <sup>a</sup>
		p2	0.88±0.72 <sup>b</sup>
Eosinophil	% ( 0 - 28)	p1	2.36±1.33 <sup>a</sup>
		p2	1.56±1.29 <sup>b</sup>

P1- prepartum values, p2 – postpartum values. a,b superscripts: where similar between p1 and p2 (a, a) indicates lack of significant difference ( $p>0.05$ ) and where different between them (a, b) indicates significant difference. ( $p<0.05$ ) (T – test) . . n – total number of cows

**Tale 2:**

Mean herd haematological values of cows during third trimester of pregnancy and early lactation in settled cattle herds in Zaria

Herd	Blood parameter								
	TP (g/dl) (6.28.2)*	PCV (%) (24-36)*	Hb (%) (5.5-7.7)*	RBC ( $10^6/\mu\text{l}$ ) (8.5 -13.2)*	WBC ( $10^3/\mu\text{l}$ ) (3.8-11.0)*	NEUT (%) (15-68)*	LYM (%) (26-28)*	MON (%) (0-12)*	EOS (%) (0-28)*
	p1 p2	p1 p2	p1 p2	p1 p2	p1 p2	p1 p2	p1 p2	p1 p2	p1 p2
1	7.8±0.8 7.9±0.6	35.6±4.0 35.5±4.0	11.9±8.0 13.1±6.5	5.9±0.4 5.9±0.6	11.2±2.0 11.2±1.1	23.4±2.0 24.6±3.1	72.4±4.7 73.0±3.2	1.5±0.7 0.9±0.7	2.5±1.3 1.4±1.2
2	8.3±0.7 8.2±0.8	32.2±11.4 31.1±1.3	10.5±1.2 10.0±1.3	5.4±0.7 5.3±0.7	9.9±1.8 10.0±1.3	23.0±4.3 23.8±4.2	73.5±4.2 71.1±4.7	1.1±0.7 1.1±0.7	2.4±1.8 2.0±1.5
3	8.5±0.8 8.0±0.8	35.5±6.3 35.9±5.5	11.0±2.7 12.1±2.4	5.6±1.3 6.0±1.1	8.7±2.5 8.9±1.1	25.8±4.5 26.1±4.2	71.4±4.5 71.6±4.2	0.6±0.9 0.4±0.5	1.9±1.4 1.9±1.5
4	8.6±0.6 8.5±0.8	36.8±4.7 35.5±5.0	12.1±1.4 11.8±1.8	6.1±1.4 5.9±0.8	9.5±0.1 10.0±0.2	26.6±3.5 27.3±3.8	70.0±4.0 72.0±4.0	0.9±1.1 0.6±0.5	1.8±2.1 1.5±1.2
5	9.2±1.2 9.0±1.1	33.0±2.6 34.0±1.6	10.9±0.9 11.3±0.6	5.5±0.4 5.6±0.3	9.9±4.4 9.6±0.6	22.5±5.8 25.8±4.0	75.0±4.6 72.2±4.3	0.9±1.1 0.6±0.5	1.8±1.5 1.6±1.4
6	8.6±0.6 8.5±0.8	36.8±4.7 35.5±5.0	12.1±1.4 11.8±1.8	6.1±1.4 5.9±0.8	9.5±0.1 9.8±0.2	26.6±3.5 27.3±3.8	70.0±3.7 71.5±4.0	0.9±1.1 0.6±0.5	1.8±2.1 1.5±1.2
7	8.8±0.6 7.6±0.8	33.0±2.6 34.0±1.5	10.9±0.9 11.3±0.6	5.5±0.3 5.7±0.3	9.5±2.5 12.8±3.2	22.0±5.9 25.6±6.8	74.5±4.5 72.8±5.9	1.00±0.0 0.6±0.6	2.3±1.3 1.0±0.1
8	7.6±0.4 7.9±0.4	32.8±4.9 32.9±4.0	11.0±1.4 11.0±1.4	5.5±0.9 5.5±0.9	5.6±0.6 <sup>a</sup> 12.9±2.8 <sup>b</sup>	26.6±3.8 26.6±0.4	70.0±9.1 70.0±4.0	0.5±0.5 0.5±0.5	3.0±1.1 1.6±1.2
9	8.1±0.4 8.1±0.6	33.3±8.0 33.5±7.0	11.1±0.6 5.6±0.9	5.5±0.6 5.5±0.6	12.1±2.4 10.7±0.6	27.7±4.2 26.5±5.2	70.0±4.2 71.8±8.3	0.7±5.4 0.3±5.4	3.3±2.3 1.2±1.2

*P1 – prepartum value, P2 – postpartum value. T – test comparing prepartum and postpartum means of haematological parameters did not show statistical significant difference ( $p>0.05$ ) within herds except in herd V III where postpartum WBC values were higher (a, b superscripts). Analysis of variance (ANOVA) on herd means showed statistical difference among herds ( $p<0.05$ ). \* - Normal range;  $x \pm$  standard deviation*

### ***Herds mean haematological values of cows during pregnancy and early lactation***

The herds mean haematological values of cows during third trimester of pregnancy and early lactation are as shown in Table 2. The mean values of TP, PCV, Hb, RBC, and WBC during third trimester of pregnancy and early lactation did not differ significantly ( $p \geq 0.05$ ) except for herd VIII where the WBC of early lactation was significantly ( $P < 0.05$ ) higher than the value during third trimester of pregnancy. Mean neutrophil, lymphocyte, monocyte and eosinophil values of the herds during third trimester of pregnancy and early lactation differed significantly ( $p < 0.05$ ). The neutrophil values during third trimester of pregnancy were lower than values during early lactation in all herds except in herd VIII and IX where the reverse was the case. Whereas in herds II, V, and VII, the lymphocyte values during third trimester of pregnancy were higher than those of early lactation, in herds I, IV, VI, and IX, they were lower. In herds I, III, IV, V, VI, VII, and IX, the values of monocytes during third trimester of pregnancy were higher than those during early lactation. The eosinophil values during early lactation were higher than the values during third trimester of pregnancy in all herds. There was significant difference ( $P < 0.05$ ) in the values of haematological parameters among the herds.

### **DISCUSSION**

The total mean values of hematological parameters of cows obtained in this study are generally comparable with those given by Wosu (2002) for indigenous cattle in Nigeria and other workers (Schalm, 1961; Saror and Coles, 1975; Lumsden *et al.*, 1980). However, the mean values of lymphocytes obtained in this study were slightly higher than the figures for female Holstein cattle reported by Lumsden *et al.* (1980). In this study, the total mean values of some of the haematological parameters (neutrophil and lymphocyte, monocytes and eosinophils) during third trimester of pregnancy and early lactation differed significantly while no significant differences existed for others (TP, PCV, Hb, RBC, and WBC).

The lack of significant difference in TP, PCV, Hb, RBC, and WBC values during third trimester and early lactation is in tandem with the reports of other workers (LaBorde *et al.*, 1999) that the near term values of RBC, Hb, PCV and TP decrease but return to normal soon after delivery. Singh *et al.* (1991) also reported a decreased Hb during pregnancy due to its mobilization into foetal circulation and dilution of blood as a consequence of plasma volume increase. According to

Zvorc *et al.* (2006), Hb concentration decreases significantly during lactation while WBC remains unchanged in sows. Some studies have reported on the haematological values at parturition specifically and following calving and found haematological parameters to be higher during the former than the latter period except eosinophils (Klinkon and Zadnik, 1999). In this study, samples were not collected specifically at parturition but prior to parturition and following parturition. The higher values of neutrophils and lymphocytes during early lactation than third trimester of pregnancy agrees with the results of The higher values of monocytes and eosinophils during third trimester of pregnancy than during early lactation disagrees with the reports of Klinkon and Zadnik (1999) who reported that basophils and monocytes were not affected by the periparturient period. Late pregnancy and lactation have been reported to be associated with decreased PCV and RBC in rats (Ozegbe, 2001).

The higher value of neutrophil during early lactation compared with the value during third trimester of pregnancy agrees with similar findings in mares (Harvey *et al.*, 2004). The mean values of haemoglobin and packed cell volume obtained in this study for cows during third trimester of pregnancy are higher than the values reported for adult non – pregnant animals by other workers (Oduye and Okunaiya, 1971; Saror and Coles, 1973; Saror and Coles (1975), and cattle under traditional husbandry practices (Saror and Coles, 1975). The better management system in these settled herds may have accounted for their higher haematological values. Institutional and research herds have been reported to have better management and nutritional factors (Saror and Coles, 1975) that could account for the higher haematological values. Since the mean values of most of the haematological parameters obtained in this study are within the range reported in literature (Lumsden *et al.*, 1980; Wosu, 2002), and that none of the animals showed obvious clinical disease, it can be safely assumed that this study has provided haematological baseline or reference values that are consistent with normal health and devoid of metabolic disorders.

The statistically significant differences in the mean haematological parameters among herds obtained in this study support the reports of other workers that herd as a factor affects haematological values (Hewett, 1974). Haematological values are known to be influenced by other factors such as age, breed, sex, seasonal variations, lactation and pregnancy ((Payne and Leech, 1964; Hewett, 1974; Poulsen, 1974; Schalm *et al.*, 1975; Sastry, 1989). Management factors such as levels of feeding, quality of feeds, hygiene, soil conditions, and fertilizer type and intensity in herds

have been considered as prime factors in determining the levels of different blood components (Hewett, 1974). The lack of consistent trend in the difference in values of white blood cell series in the different herds during pregnancy and early lactation further confirms the herd factor. The higher values of eosinophil during early lactation than during pregnancy obtained in all the herds in this study agrees with the result of Klinkon and Zadnik (1999) that eosinophil values were higher during lactation than during the precalving and at calving periods.

In conclusion, this study has established reference values of haematological parameters of cows during third trimester of pregnancy and early lactation in settled cattle herds that are consistent with normal health. It has also confirmed the herd effect on haematological parameters which has to be considered in interpreting haematological parameters of animals. It is recommended that the study be extended to cover other stages of pregnancy as well as at parturition.

#### **Acknowledgements**

*The authors are thankful to the owners for allowing access to their herds for this study; Ahmadu Bello University for funding this research and the technical staff for the laboratory analyses of the samples.*

#### **REFERENCES**

- Ayo, J.O., Oladele, S.B., Ngam, S., Fayomi, A. and Afolayan, S.B. (1998). Diurnal fluctuations in rectal temperature of the red Sokoto goat during the harmattan season. *Res. Vet. Sci.*, 66, 7 – 9.
- Bawa, E.K., Sekoni, V.O., Olorunju, S.A.S., Esievo, K.A.N., Uza, D.V., Ogwu, D. and Oyedipe, E.O. (2005). Comparative clinical observations on *Trypanosoma vivax* infected pregnant Yankassa and West African Dwarf ewes. *J. Anim. Vet. Adv.*, 4(7), 630 – 637.
- Esievo, K.A.N. and Saror, D. (1983). Leucocytes responses in *T. vivax* infection in cattle. *J. Comp. Path.*, 93, 165 – 169.
- Harvey, J. W., Asquith, R. L., Patel, M. G., Kivipelto, J., Chen, C. L. and Ott, E. A. (1994). Haematological findings in pregnant, postparturient and nursing mares. *Comparative Haematology International*, 4 (1), 25 – 29.
- Hawky, C.N. and Dennet, A. (1989). *A Colour Atlas of Comparative Veterinary Haematology*. pp. 192. Wolfe Medical Publication, England.
- Hewett, C. (1974). On the causes and effects of variations in the blood profile of Swedish dairy cattle. *Acta Veterinaria Scandinavia Supplement* 50, AVSPAC 50. 1 – 152.
- Klinkon, M. and Zadnik, T. (1999). Dynamics of red and white blood picture in dairy cows during the periparturient period. *Comp. Haem. Intl*, 9(3), 156 – 161.
- Kronfield, D. S. (1972). Diagnosis of metabolic diseases of cattle. *J. Amer. Vet. Med. Assoc.*, 16, 1259 – 1264
- LaBorde, J. B., Wall, K. S., Bohn, B., Kumpa, T. S., Patton, R., Zheng, Q., Kodell, R. and Young, J. F. (1999). **Haematology and serum chemistry parameters of pregnant rats.** *Laboratory Animals*, 33 (3), 275 – 287.
- Lumsden, J. H., Mullen, K. and Rowe, R. (1980). Haematology and serum biochemistry reference values for female Holstein cattle. *Can. J. Comp. Med.* 44, 24 -31.
- Mbassal, G. K. and Poulsen, S. J. D. (1992). The comparative haematology of cross – bred and indigenous East African goats of Tanzania and breeds reared in Denmark. *Journal of Veterinary Research Communications*, 16 (3), 227 – 228.
- Mitchell, M. A. and Macleod, M. G. (1983). Some biochemical effects associated with changes in heat production and food intake in domestic fowl during adaptation to high environmental temperature (320C). *IRCS Medical Science*, 20, 96 – 103.
- Oduye, O. O. and Okunaiya, O. A. (1971). Haematological studies on the white Fulani and N'dama breeds of cattle. *Bull. Epiz. des Dis. Afri*, 19, 213 - 218
- Oladele, S. B., Ogundipe, S., Ayo, J. O. and Esievo, K. A. N. (2001a). Seasonal and sex variations in packed cell volume, haemoglobin and total proteins of indigenous ducks in Zaria. *Bull. Anim. Hlth Prod. Afri*, 47, 163 – 165.
- Oladele, S. B., Ogundipe, S., Ayo, J. O. and Esievo, K. A. N. (2001b). Effects of season and packed cell volume, haemoglobin and total proteins of indigenous pigeons in Zaria, Northern Nigeria. *Veterinarski Arhiv*, 71(5), 277 – 286.
- Olufemi, B. E. and Fatunmbi, O. O. (1980). Haematological study on clinically normal Nigerian ducks (*Anas spp*). *IRCS Medical Science*, 8, 87.
- Ozegbe, P. C. (2001). Influence of pregnancy on some erythrocyte biochemical profiles in the rabbits. *Afr. J. Biomed. Res.*, 4, 135 – 137.
- Payne, J. M. and Leech, F. B. (1964). Factors affecting calcium and inorganic phosphorus concentrations in the cow with particular reference to pregnancy, lactation and age. *Brit. Vet. J.*, 120, 385 – 388.
- Payne, J. M., Dew, S. M., Manston, R. and Faulks, M. (1970). The use of metabolic profile in dairy herds. *Vet. Rec.*, 87, 150 – 157.
- Poulsen, J. S. D. (1974). Variations in the metabolic acid – base balance and some other clinical chemical parameters in dairy herds during the year. *Nord. Vet. Med.*, 26, 281 – 288.
- Pullan, N.B. (1978). Condition scoring of white Fulani cattle. *Trop. Anim. Hlth. Prod.*, 10, 118 – 120.
- Rekwot, P. I., Kumi – Diaka, J.O., Akerejola, O. O. and Oyedipe, E. O. (1997). **Haematological values of Bunaji and Friesian x Bunaji bulls.** *Nig. Vet. J.*, 18, 63 – 72.

- Saror, D. I. and Coles, E. H. (1973).** The blood picture of white Fulani (Zebu) and white Fulani/Friesian cattle. *Bull. des Epiz. Dis. des Afri.*, 21, 495 – 499.
- Saror, D. I. and Coles, E. H. (1975).** Haematological parameters of zebu cattle under native husbandry practices. *J. Nig. Vet. Med. Assoc.*, 4 (2), 89 - 92
- SAS (1997).** SAS/STAT soft ware: changes and enhancement through release 6.12. Cary, SAS Institute. pp. 571 – 702.
- Sastry, G. A. (1989).** *Veterinary Clinical Pathology*. Third Edition. 1 – 41 CBS Publishers and Distributors, PVT Ltd.
- Schalm, O. (1961). *Veterinary Haematology*. **Lea and Fabiger. Philadelphia.**
- Schalm, O. W., Jain, N. C. and Carol, E. J. (1975). *Veterinary Haematology*. **Second Edition. pp. 32. Lea and Fabiger. Philadelphia.**
- Singh, R., Singha, S. P. S., Singh, R., and Seita, M. S. (1991).** Distribution of trace elements in blood, plasma and erythrocytes during different stages of gestation in buffalo (*Bubalus bubalus*). *Buffalo Journal*, 1, 77 – 85.
- Wosu, L.O. (2002):** *The Veterinarian's Handbook*. First Edition. p.16. Mike Social Press.
- Zvorc, Z., Mrljak, V., Susic, V., and Gotal, J. P. (2006). **Haematological and biochemical parameters during pregnancy and lactation in sows.** *Veterinarski Arhiv*, 26 (3), 245 – 253.