



# Hematological Changes Associated with Pregnancy in Domestic Sows (*Suis domesticus*)

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## ABSTRACT

**Background:** Pregnancy involves complex biological interaction and communication between the developing conceptus and maternal uterus, which may alter the blood cellular elements. The present investigation evaluated the hematological changes associated with pregnancy in domestic sows.

**Methods:** Blood samples were collected by auricular venipuncture from twenty sexually mature domestic sows from four pig farms. Hematological analyses were carried out on the blood samples following standard procedures.

**Result:** The mean packed cell volume (PCV), the red blood cell (RBC) count, hemoglobin (Hb) concentration, mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and absolute lymphocyte count were higher during pregnancy and lower following parturition, whereas, the mean corpuscular volume (MCV) was lower during pregnancy and declined further following parturition. The mean total white blood cell (TWBC) count and the absolute neutrophil count were higher during pregnancy and further elevated postpartum while the absolute monocyte count was lower during pregnancy and elevated postpartum. The absolute eosinophil count was significantly ( $p < 0.05$ ) lower in the pregnant sows ( $0.35 \pm 0.13$ ) and postpartum sows ( $0.21 \pm 0.15$ ) than in the non-pregnant sows ( $1.06 \pm 0.27$ ). These hematological alterations could assist in monitoring the physiological and health status of the dam, fetuses and pregnancy diagnosis.

**Key words:** Domestic sows, Hematological parameters, Parturition, Postpartum, Pregnancy.

## INTRODUCTION

The pig (*Suis domesticus*) is one of the most prolific food (meat) animals. On the average, it can have 2.3 farrows per year, producing about 9-25 piglets or more and has a short gestation period of average of 114 days (101-128 days) (Tur, 2013). Pork production is increasing rapidly and when compared to other forms of meat, it is consumed worldwide more than any other meat (McGlone, 2013). Though, in a recent report by the Food and Agricultural Organization however, pork ranked second to poultry as the most consumed meat in the world, but that was as a result of the ravaging effect of African swine fever in China which is the world's leading producer of pig and pork (FAO, 2019). The potentials and value of pig and pork production have not yet been realized in Nigeria because of a variety of factors, part of which is lack of knowledge, hence the need for more research and improvement in pig production to combat the current protein deficit in Nigeria. Deficiency in securing institutional loans (61%), cost of feeding and feed raw materials (46.3%), outbreak of diseases (17.1%) and pilfering (14.1%) are also among the major constraints to improved pig production in the country (Uddin and Ososagie, 2016).

Pregnancy is said to have occurred when there is / are developing conceptus or fetus(es) within the female's body (Felix, 2018). It involves complex biological interaction and communication between the developing conceptus and maternal uterus (Bazer, 2013). Many changes (anatomical and physiological) occur in the body of female individual affecting the gastrointestinal, renal, respiratory,

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cardiovascular, central and peripheral nervous, endocrine, musculoskeletal, dermatological, mammary tissue and ocular systems during pregnancy (Datta *et al.* 2010). These alterations help the dam to meet the increase in metabolic needs and allow for normal development of the conceptus and normal delivery (Bhatia and Chhabra, 2018). Some of these changes may involve alterations in the blood cellular elements. Pregnancy is a very important physiological change and the hematological and biochemical changes at different stages are important in monitoring the physiological as well as health status of the developing conceptus and the dam (Ajala *et al.* 2016). Hematology is the numerical and morphological study of the blood cells, the application of the knowledge in disease diagnosis as well as prognosis and evaluation of hematological parameters which offer good indices of the physiological status of an animal (Etim *et al.* 2014). The alterations in

hematological parameters during gestation have been reported in different species by different researchers. The fall in the hemoglobin concentration that occurs in pregnancy as a result of plasma volume expansion towards the end of gestation is often referred to as physiological anemia, though with increase in red cell mass showing a kind of normocytic normochromic anemia (Das *et al.* 2013). Variations in blood parameters in pigs based on age, sex, experimental procedures and geographical location have been reported (Aladi *et al.* 2008). Hematological parameters are also affected by breed of the animal, nutrition, housing, starvation, estrus, pregnancy, crossbreeding, stress as well as transportation (Balikci *et al.* 2007). The hematological parameters of various species of animals have been well studied and had been in use for disease diagnosis and prognosis (Tongun *et al.* 2007). There is, however, paucity of information in available literatures, on the hematological alterations associated with pregnancy, especially on weekly or biweekly basis during gestation, in the domestic pig breeds in Nigeria.

The aim of this study, therefore, was to evaluate the alterations in hematological parameters during gestation in the domestic sows (*Suis domesticus*).

## MATERIALS AND METHODS

### Ethical statement

Adequate measures were taken to minimize pain or discomfort on the animals studied. The investigation was carried out in accordance with the Guidelines laid down by the Institutional ethics committee and in accordance with local laws and regulations on animal welfare and production.

### Experimental animals

Twenty sexually mature domestic sows in three categories (the non-pregnant, the pregnant and post-parturition or postpartum sows) from four different farms at Ovoko,

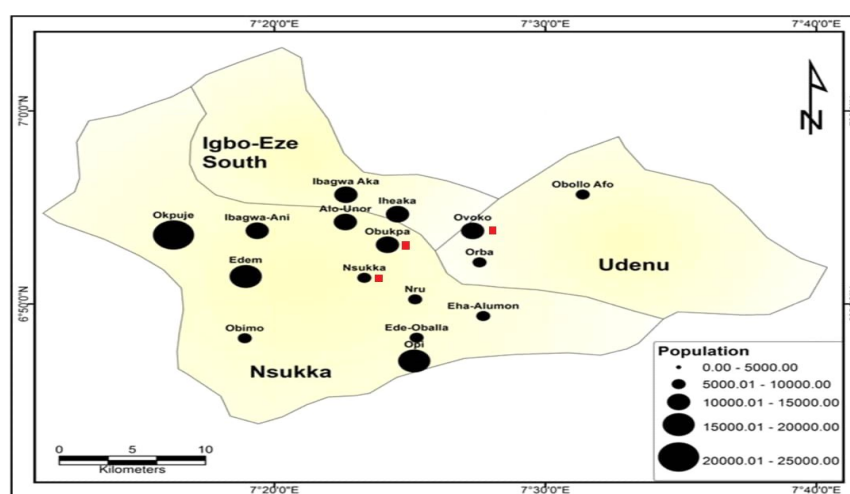
Obukpa and Nsukka in Nsukka geopolitical area of Enugu state, Nigeria (Fig 1), were used in this study. The choice of farm setting was to capture what happens in real production environment in the locality and four farms were chosen to ensure a fair spread within the area. This study was carried out between May and September, 2019, in the Department of Veterinary Pathology and Microbiology, Faculty of Veterinary Medicine, University of Nigeria, Nsukka, Nigeria.

### Mating of the sows and sample collection

Twelve sexually mature sows, three from each farm, were chosen for mating (through natural breeding) within a week, under the supervision of the owners of the farms sampled. Twelve sexually mature sows, three from each farm which were not mated, were chosen to serve as control. Feeding of the sows was done by the animal attendants of the farms sampled, according to the laid down procedures for pig production and water was given adequately throughout the gestation period. Two (2) ml of blood samples were collected through auricular venipuncture into sample bottles containing EDTA, from the two groups, after the animals were properly restrained. Blood samples were collected from the sows between 9:00-9:45 am, on day 1 after mating, week 4 and subsequently, bi-weekly till parturition. Eight out of the twelve sows that were served conceived and farrowed. Blood sample collection continued daily from the 8 farrowed sows, which formed the third category (the postpartum sows) from day 1 to day 7 post-parturition.

### Laboratory analysis

Blood samples collected from 12 sows (the non-pregnant or the control group), 8 pregnant sows and same 8 sows after parturition were analyzed. The PCV was determined by the microhaematocrit method, hemoglobin concentration (Hb conc.) by the cyanomethaemoglobin method, RBC count and TWBC count by hemocytometer method and differential WBC counts using Leishman technique (Thrall and Weiser, 2002;



Key ■ = Sampled area.

**Fig 1:** Map of Igbo-Eze South, Udenu and Nsukka Local Government Areas, Nsukka Agricultural zone, Enugu State, Nigeria. (Source: Department of Geography, University of Nigeria, Nsukka, Nigeria).

Higgins *et al.* 2008). The mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were calculated using the standard formulae.

### Statistical analyses

The data obtained from the experiment were subjected to one way analysis of variance and variant means were separated using the least significant difference (LSD) method. The level of significance was considered at  $p < 0.05$ . All statistical analyses were carried out on SPSS statistical software (version 20).

## RESULTS AND DISCUSSION

### The erythrocytic alterations in pregnant domestic sows

The erythrocytic parameters exhibited lots of variations through the different stages of the gestation. The PCV, Hb concentration and RBC count showed slight elevation up to the 6<sup>th</sup> week of gestation, dropped slightly at the 8<sup>th</sup> week and remained constant up to the 12<sup>th</sup> week. However, at the 14<sup>th</sup> week, the three parameters, especially the PCV dropped below that of the non-pregnant sows that served as control, came up again at the 16<sup>th</sup> week (parturition period) and remained fairly constant postpartum (Fig 2). The MCV, MCH

and MCHC remained fairly constant throughout the gestation period (Fig 3). There was no statistically significant difference ( $p > 0.05$ ) in the mean values of the PCV, Hb conc., RBC counts, MCV, MCH and MCHC between the pregnant and the non-pregnant sows and that of the postpartum sows (Table 1).

### Total and differential white blood cell counts of pregnant domestic sows

The TWBC and the absolute lymphocyte counts rose sharply while the neutrophil count was slightly elevated at the 4<sup>th</sup> week of gestation and dropped at the 6<sup>th</sup> week. While the absolute lymphocyte count remained fairly constant till parturition, the TWBC and the absolute neutrophil counts came up at the 10<sup>th</sup> week, dropped at the 14<sup>th</sup> week then rose again at the 16<sup>th</sup> week of gestation (Fig 4). The absolute eosinophil and the monocyte counts dropped sharply at the 6<sup>th</sup> week of gestation, came up at the 8<sup>th</sup> week, dropped at the 12<sup>th</sup> and 14<sup>th</sup> week, rose again at the 16<sup>th</sup> week and dropped postpartum (Fig 5). The mean values of the TWBC and absolute neutrophil counts were higher during pregnancy and further elevated postpartum, however none of these changes was statistically significant ( $p > 0.05$ ). The mean absolute lymphocyte count was higher during

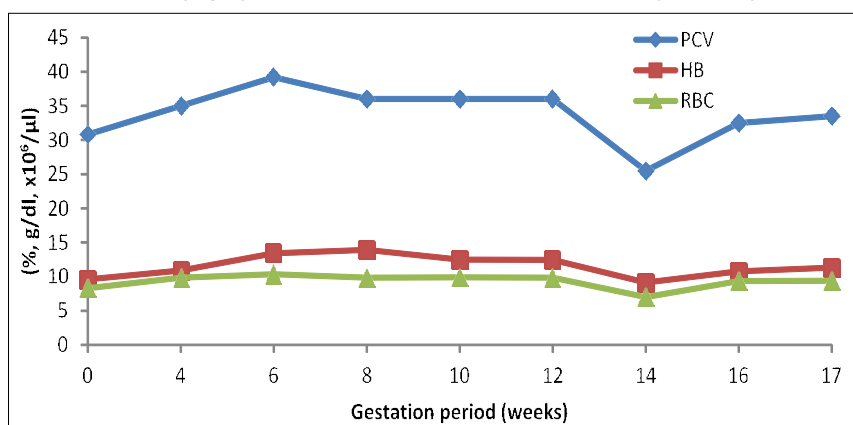


Fig 2: The trend of change in the packed cell volume (PCV), hemoglobin concentration (Hb conc.) and red blood cell (RBC) counts in pregnant sows.

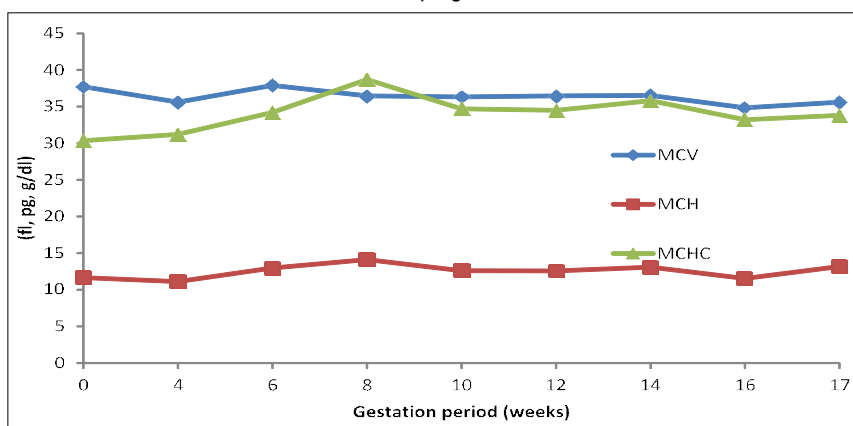
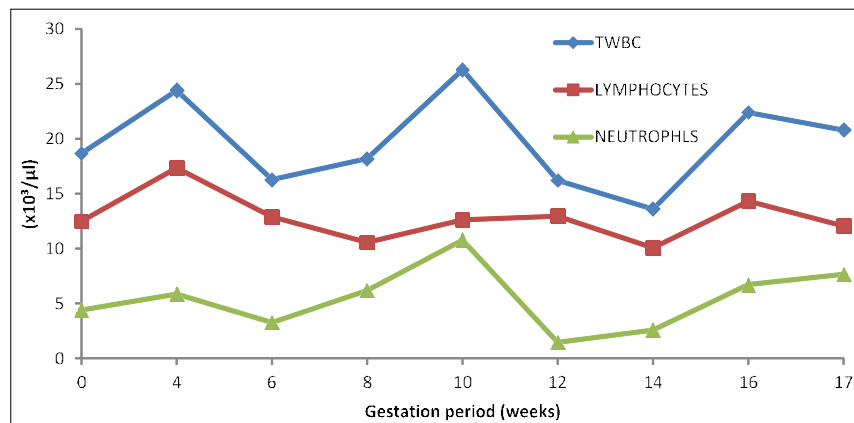
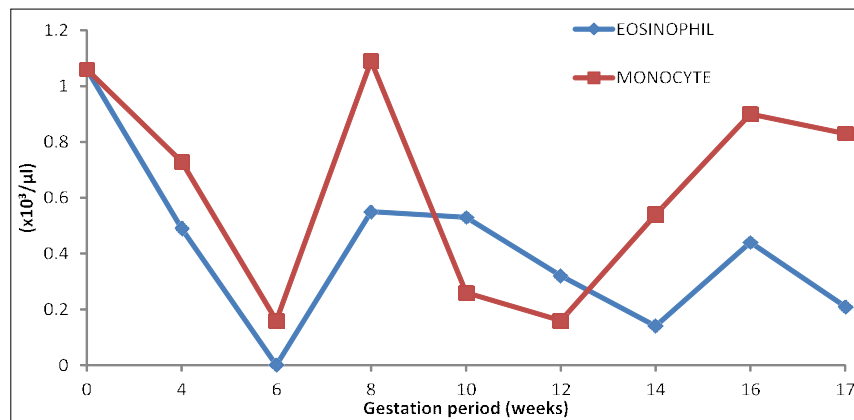


Fig 3: The trend of change in the mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) in pregnant sows.

**Table 1:** The erythrocytic profile ( $\pm$  SEM) of the non-pregnant, pregnant and postpartum sows.

Parameters	Non-pregnant sows (n=12)	Pregnant sows (n=8)	Postpartum sows (n=8)
PCV (%)	30.82 $\pm$ 2.36	34.31 $\pm$ 1.25	33.50 $\pm$ 3.29
Hb conc. (g/dl)	9.60 $\pm$ 1.09	11.87 $\pm$ 0.62	11.32 $\pm$ 1.91
RBC ( $10^6/\mu$ l)	8.28 $\pm$ 0.81	9.44 $\pm$ 0.51	9.41 $\pm$ 1.12
MCV (fl)	37.22 $\pm$ 1.78	36.35 $\pm$ 2.26	35.60 $\pm$ 1.84
MCH (pg)	11.59 $\pm$ 0.83	12.57 $\pm$ 0.81	12.03 $\pm$ 1.17
MCHC (g/dl)	31.15 $\pm$ 2.26	34.60 $\pm$ 1.83	33.80 $\pm$ 3.43

n = Number of animals sampled.

**Fig 4:** The trend of change in the total white blood cell (TWBC), lymphocyte and neutrophil counts in pregnant sows.**Fig 5:** The trend of change in the Eosinophil and Monocyte counts in pregnant sows.

pregnancy and dropped following parturition while the mean absolute monocyte count was lower during pregnancy and elevated postpartum, though, not statistically significant ( $p > 0.05$ ). The mean absolute eosinophil count was significantly ( $p = 0.04$ ) lower in the pregnant ( $0.35 \pm 0.13$ ) and postpartum ( $0.21 \pm 0.15$ ) than in the non-pregnant sows ( $1.06 \pm 0.27$ ) (Table 2).

The determination of the alterations in the hematological parameters during pregnancy is important in swine production as it assists in monitoring the physiological as well as the health status of the dam, which translates to that of the developing fetus. This study was designed to picture the hematological changes that occur during gestation period in the domestic sows on biweekly basis so as to build

data that will assist veterinarians and other animal health workers in proper monitoring of pregnancy in this pig breed. There was an initial elevation of the red parameters (the PCV, Hb concentration and RBC counts), within the first four weeks of gestation, in this study. These findings are in agreement with those of Prakash and Yadav (2015) who reported that during pregnancy, there is an increase in the red cell mass as well as an elevated plasma volume to accommodate the needs of the growing fetus(es). The increase in red cell mass is as a result of increased erythropoiesis which is suspected to be caused by enhanced effect of erythropoietin by placental lactogen; whereas the increase in plasma volume is mediated by activation of the rennin- angiotensin- aldosterone system and increased

**Table 2:** Total and differential white blood cell counts ( $\pm$  SEM) of the non-pregnant, pregnant and postpartum sows.

Parameters	Non-pregnant sows (n=12)	Pregnant sows (n=8)	Postpartum sows (n=8)
TWBC ( $10^3/\mu\text{l}$ )	19.03 $\pm$ 2.18	19.13 $\pm$ 2.20	20.77 $\pm$ 2.17
Lymphocytes ( $10^3/\mu\text{l}$ )	12.5 $\pm$ 1.80	12.97 $\pm$ 1.36	12.06 $\pm$ 1.72
Neutrophils ( $10^3/\mu\text{l}$ )	4.41 $\pm$ 0.67	5.26 $\pm$ 0.85	7.67 $\pm$ 1.21
Monocytes ( $10^3/\mu\text{l}$ )	1.06 $\pm$ 0.32	0.55 $\pm$ 0.45	0.83 $\pm$ 0.45
Eosinophils ( $10^3/\mu\text{l}$ )	1.06 <sup>a</sup> $\pm$ 0.27	0.35 <sup>b</sup> $\pm$ 0.13	0.21 <sup>ab</sup> $\pm$ 0.15
Basophils ( $10^3/\mu\text{l}$ )	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00

Means in the same row with different superscript letters (<sup>a</sup>, <sup>b</sup>) are significantly different at  $p < 0.05$ . n = Number of animals sampled.

secretion of vasopressin during pregnancy (Songhavi and Rutherford, 2014). Hence, the resultant hematological status of a pregnant animal at any point in gestation is dependent on the combined effect of these two mechanisms. There was a sharp drop in the red cell parameters between the 12<sup>th</sup> and 14<sup>th</sup> week of pregnancy to levels below the values for non-pregnant sows and sows postpartum. This could be attributed to the mobilization of maternal hemoglobin into fetal circulation and the dilution of blood as a result of plasma volume expansion becoming more than the effect of erythropoiesis (Zvorc *et al.* 2006). This fall in the red cell parameters that occurs in pregnancy as a result of plasma volume expansion towards the end of gestation (third trimester) has been described as physiological anemia (Ozegbe, 2001; Kim, 2002; Das *et al.* 2013). Although there was no statistically significant difference in the PCV, Hb concentration and RBC counts among the three categories (the pregnant, non-pregnant and postpartum sows), the mean values were higher in the pregnant than in the non-pregnant and postpartum sows. This could be attributed to compensatory response to increased oxygen demand for fetal development during pregnancy (Zanjani *et al.* 1974). These results concur with the ones reported by Ajala *et al.* (2016) but contrary to our findings, Zvorc *et al.* (2006) observed a decrease in PCV, Hb and RBC counts throughout the gestation period in sows.

The MCV showed no significant difference across the three groups, except for slight elevation at the 6<sup>th</sup> week of gestation. This suggests presence of macrocytic erythrocytes which is an indication of active erythropoiesis (Keer, 2002). The MCH and MCHC were slightly higher in the pregnant sows, though the mean values decreased after parturition. The increase in MCV, MCH and MCHC in pregnant sows could all be attributed to compensatory response to increased oxygen demand for fetal development during pregnancy. Similar findings were also reported by Ajala *et al.* (2016) where the MCV, MCH and MCHC were higher in pregnant than in non-pregnant sows. Contrary to our findings, Zvorc *et al.* (2006) observed lower MCV, MCHC and MCH in the pregnant sows than in the non-pregnant sows.

The initial elevation of the absolute lymphocyte count which translated to high TWBC count at the first 4 weeks of pregnancy could be attributed to the immune (cell-mediated) response of the dam to the pregnancy, which recognized

the conceptus as a foreign body (Blumenreich, 1990). The 10<sup>th</sup> week of gestation witnessed neutrophilic leukocytosis. Pregnancy is one of the conditions that may cause neutrophilia and this was observed in the 10<sup>th</sup> week of pregnancy in this study. A sharp drop in the monocyte and eosinophil counts was observed in the 6<sup>th</sup> week of gestation and also in the 12<sup>th</sup> and 14<sup>th</sup> weeks respectively. Stress leukogram has been used to describe the increase in absolute neutrophil count and decrease in absolute eosinophil count during pregnancy (Seddon, 2011). Monocytopenia is also seen at the initial stage of stress. There was no significant difference in the mean values of the TWBC, lymphocyte, neutrophil, monocyte and basophil counts. This is similar to the observations made by Zvorc *et al.* (2006).

## CONCLUSION

This study found that pregnancy in sows caused alterations in hematological parameters, the most striking being the significantly lower eosinophil count, a known marker of stress. Veterinarians and breeders are therefore advised to pay more attention to the pregnant sows, especially at the 6<sup>th</sup> and 14<sup>th</sup> weeks of gestation as such stress, if not well managed, could lead to abortion and loss in production.

One major challenge of this study is lack of funding as the research would have looked at the weekly or biweekly changes in some biochemical parameters as well as oxidative stress parameters which would have given credence to the significantly lower eosinophil count, a known marker of stress recorded in the present study. The authors of this work intend to do this shortly with availability of funds envisaged.

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