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Correlations, sex and genotype effect on Immune response traits of three genotypes of Nigerian Indigenous chickens at different ages

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Abstract

The study evaluated correlations and sex by genotype interaction effect on immune response traits in three genotypes of Nigerian Indigenous chickens (Normal feathered (NF), Frizzle feathered (Fz) and naked neck (Nk)). Blood samples from 60 birds (20 per genotype) were collected for haematology from a population of 200 birds. Haematological parameters were: Pack cell volume (PCV), White blood cell (WBC), Red Blood Cell (RBC), Eosinophils (Eos), Monocytes (Mono), Haemoglobin (Hb), Lymphocytes (Lym), Heterophils (Heter), Basophils (Bas). The research lasted for 12 weeks and the association between the chicken's immune response traits were assessed at weeks 4, 8 and 12 of age. Sex showed significant effect on the immune response traits of Nigerian Indigenous Chicken. Females of Nigerian Indigenous Chicken had higher means in PVC, Wbc, Heter, Lym, Eos and Mono than the males counterpart for the same traits, respectively, measured while the other immune response traits were similar as measured at different ages. Genotype significantly jnfluenced some immune response traits of Nigerian Indigenous chicken. The result showed that RBC was significantly ($p<0.05$) higher in Frizzled feather, followed by Naked neck and Normal feathered, respectively. WBC which is responsible for immunity was significantly ($p<0.05$) higher in Fz but lower in NF while Eosinophils, basophils and lymphocytes which are components for immunity were significantly ($p<0.05$) higher in Frizzled feathers chicken. The highest and positive association among immune response traits were found between PCV and Hb, PCV and RBC, Hb and Rbc, Bas and Eos, Eos and Mono, respectively.

Keywords: Ages; Antiviral Activity; Correlations; Genotypes; Immune Response Traits; Sex

1 Introduction

Nigerian indigenous chickens, often referred to as "local" or "village" chickens, play a crucial role in the rural economy and culture. These chickens are typically raised in free-range systems, where they forage for food and are often left to roam freely around homesteads. They are hardy birds, well adapted to the local environment and are known for their resilience to diseases and harsh climatic conditions compared to exotic breeds. Nigerian indigenous chicken are believed to have been domesticated from wild fowl species in Africa and have since evolved but not absolute as disease outbreak can still occur. They are also excellent at brooding and can successfully hatch and rear chicks under natural conditions. Despite their resilience, these chickens often face health challenges. With the awareness through clinical test some of the disease could be taken care of. Therefore, understanding the role of these haematological indices and their functions are quite essential for optimizing breeding and management of the health status of these chickens.

Haematological indices are crucial for health assessment and physiological status of poultry. These indices include packed cell volume, haemoglobin concentration, red blood cell count and white blood cell count which are influenced by genotype and sex. PCV of 33.8% which aids in better oxygen transport was recorded by [1] studies, haemoglobin concentration of 12.4g/dl which also aids in oxygen circulation [2] , white blood cell count of 17.8× 10^3/µl which indicates stronger immune response to fight infection [3]. However, Nigerian local chicken is still found to be self-reliant

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and hardy birds with the capacity to withstand harsh weather condition and adapt favorably [4]. Genetic resistance to disease is a powerful tool to control and prevent diseases and thereby improving production and dividend in livestock and poultry [5]. Research in this field has gained increasing importance due to the growing recognition of the need to preserve indigenous chicken breeds and optimize their productivity. There is an increasing emphasis on the conversation and optimal use of indigenous chicken breeds [6]. This study aims to explore the effects of genotype by sex on haematological parameters and correlation in Nigerian indigenous chickens, providing insights into the mechanisms and potential strategies for intervention.

2 Materials and methods

2.1 Experimental site

The study was carried out at the Poultry unit, Teaching and Research Farm of the Department of Animal Science, University of Uyo. Akwa Ibom State. Uyo is found between latitude $4^{0}3'$N and 45^{0} 3′S and longitude $7^{0}3'$ and 45^{0} 35′W. The altitude of the area is 38m above the sea level and a mean rainfall of 200mm. The relative humidity is 79% with average Temperature of 28℃ [7]. Genomic analysis was carried out at the Biotechnology Laboratory, Department of Animal Breeding and Genetics, Federal University of Agriculture, Abeokuta, while haematological analysis was carried out at the Biochemistry Laboratory University of Uyo, Uyo.

2.2 Experimental birds and management of the birds

A total of two hundred and fifty-day-old chicks of Nigerian indigenous origin which comprises of Normal feathered, frizzle feathered and naked-neck were purchased from Federal University of Agriculture, Abeokuta Poultry's Farm.

Birds were reared under intensive system of management. Chicks from each genetic group were allotted to the prepared brooders and brood for 4 weeks before transferred to rearing pen and terminated aw 12 weeks of age. Birds were individually identified by wing tagging according to genotype by sex prior to transfer. The chicks were vaccinated against new castle disease on arrival and other medications were given routinely preventing disease outbreak. Lighting sources: stove and electricity bulb were provided for heat. Feed and water were given *ad libitum.* The beddings were changed weekly if wet. Starter mash (CP- 23% and ME 3462kcal/kg) was provided *ad libitum* throughout the brooding stage. The standard management practice was strictly adhered to till termination at 12 weeks of the study. At rearing stage of 5 to 6 weeks grower ration (20% CP and 300 kcal/kg ME) from 6 to 12 weeks finisher ration (18% CP and 2850 kcal/kg ME) was fed to the chickens.

2.3 Data collection

2.3.1 Haematology

Data were collected for haematological analysis. Hematological parameters were: Packed cell volume (PCV), White blood cell (WBC), Red blood cell (RBC), Haemoglobin (Hb). Blood samples were collected from the wing vein of 120 randomly selected chickens according to their genotype and sex. 40 per genotype of 20 per sex for each genotype and stored in the EDTA bottle for the haematological analysis. Haematological parameters were collected at different ages (4, 8 and 12 weeks) of the birds in the course of the experiment.

2.4 Statistical analyses

Model 1

The main effect model is given below:

$Y_{ijk} = \mu + S_i + C_j + SC_{ij} + \epsilon_{ijk}$
Where, Y_{ijk} = Observed trait of interest in Nigerian local chickens population
μ = population mean
S_i = fixed effect of i^{th} sex (male, female)
C_j = fixed effect of j^{th} Chicken genotype (Frizzled feather, Naked neck, Normal feathered)
SC_{ij} = interaction effect of i^{th} sex of $_j{}^{th}$ genotype
ϵ_{ijkl} = random residual error.

3 Results and Discussion

3.1 Effects of Chicken genotypes on the Immune Response Traits in the Three Nigerian Indigenous Chicken's Genotypes at Week 4 of age.

The results showed that Frizzle feather chicken recorded significantly ($P < 0.05$) high value of (1.414±0.24cell/McL) in Eosinophil than Normal feathered chicken with (0.968±0.21cell/McL) and Naked neck (0.660±0.24cell/McL) at week 4 of age measured. However, Normal feathered chicken (0.96±0.21cell/McL) and Naked neck chicken (0.660±0.24cell/McL) were statistically ($P > 0.05$) similar in their mean values. For Basophil, Frizzle feathered chicken had higher ($P < 0.05$) significant means of (1.261±0.27um) than Normal feather chickens with (0.782 ±0.24um) and Naked neck (0.314±0.27um) at week 4 of age, while Normal feather chicken (0.782±0.24um) was significantly ($p<0.05$) higher than (0.314±0.27um) of naked neck chickens for the same trait at week 4. However, there was no significant ($P > 0.05$) difference existing in Pcv, Hb, Rbc, Heter, Lym and Mono at week 4 in this study (Table 1).

Table 1 Effects of Chicken genotypes on the immune response traits in the three Nigerian indigenous chicken's genotypes at week 4 of age

Trait	Frizzle Feathered	GENOTYPE Naked Neck	Normal feathered
PCV(mL)	29.378±1.49	31.400 ±1.50	28.787±1.31
Hb(mL)	9.889±0.50	10.330±0.50	9.688±0.44
RBC(m/mm^3)	2.534±0.13	2.522±0.13	2.536±0.11
WBC(g/dl)	13.496±0.73	12.647±0.73	13.101±0.64
Heter(um)	32.725±2.10	29.943±2.11	32.882± 1.84
Lym(k/uL)	63.847±2.07	67.723±2.08	64.622±1.81
Eos(cell/McL)	1.414± 0.24^a	0.660±0.24^{bc}	0.968±0.21^b
Bas(um)	1.261±0.27^a	0.314±0.27^c	0.782±0.24^b
Mono(ml)	0.917±0.34	1.244±0.34	0.910±0.29

PCV= Packed Cell Volume Mono= Monocytes Heter = Heterophils WBC= White Blood Cell Hb= Haemoglobin, Bas= Basophils Eos= Eosinophils Lym= Lymphocytes RBC= Red Blood Cell

3.2 Effects of Chicken genotypes on the immune response traits in the three Nigerian indigenous chicken's genotypes at week 8 of age.

There was no significantly ($p>0.05$) difference in all the haematological parameters used to assess the immune response on Nigerian indigenous chickens (Frizzle feathered, Naked neck and Normal feathered) genotypes measured in this study at week 8 of age (Table 2)

Table 2 Effects of Chicken genotypes on the immune response traits in the three Nigerian indigenous chicken's genotypes at week 8 of age.

Trait	Frizzle Feathered	Genotype Naked neck	Normal Feathered
PCV(mL)	31.443± 1.209	29.019± 1.209	30.342± 1.209
Hb(mL)	10.402±0.412	9.697± 0.413	10.047 ± 0.360
RBC(m/mm^3)	2.599± 0.114	2.465± 0.115	2.461± 0.100
WBC(g/dl)	12.444 ± 1.142	11.910 ±1.14	12.965± 0.99
Heter(um)	28.039 ± 2.091	28.162±2.09	28.891±1.82
Lym(k/uL)	70.236± 1.970	69.841±1.97	69.216±1.72

Eos(cell/McL)	0.520± 0.150	0.535±0.15	0.534±0.13
Bas(um)	0.375±0.230^{b}	0.405±0.23^{a}	0.294±0.20^{c}
Mono(ml)	0.827±0.280^{c}	1.05±0.28^{b}	1.063±0.25^{a}

PCV= Packed Cell Volume Mono= Monocytes Heter = Heterophils WBC= White Blood Cell Hb= Haemoglobin, Bas= Basophils Eos= Eosinophils Lym= Lymphocytes RBC= Red Blood Cell

3.2.1 Effects of Chicken genotypes on the immune response traits in the three Nigerian indigenous chicken's genotypes at week 12 of age.

The results showed that Frizzle feather chicken recorded significantly (P< 0.05) high value of (15.96±1.25mL) in White blood cell than naked neck chicken with (15.629±1.25mL) and Normal feather (13.832±1.09mL) at week 12 of age measured. Naked neck was significantly (p<0.05) higher (31.494±1.78) in Heterophil than frizzle feathered (26.917±1.78um) and Normal feather (26.786±1.55um) while frizzle feathered and normal feathered were statistically similar in their mean values. In lymphocyte, Frizzle (70.218±1.60k/uL) and Normal feather (69.483±1.40k/uL) were statistically(p>0.05) similar in their mean values and significantly (p<0.05) higher than naked neck (65.409±1.61k/uL). However, Normal feather was significantly (P<0.05) higher (1.150±0.25 k/uL) than naked neck (0.71±0.29 k/uL) and Frizzle feather (0.635±0.29k/uL) respectively. Although naked neck and Frizzle feathered were statistically (p>0.05) similar in mean at week 12 of age studied (Table 3).

Table 3 Effects of Chicken genotypes on the immune response traits in the three Nigerian indigenous chicken's genotypes at week 12 of age.

Trait	**Frizzle Feathered**	**GENOTYPE Naked Neck**	**Normal Feathered**
PCV(mL)	34.663±1.52	35.036±1.52	34.052±1.33
Hb(mL)	11.488±0.51	11.750±0.51	11.332±0.45
RBC(m/mm^{3})	2.883±0.15	2.968±0.15	2.860±0.13
WBC(g/dl)	15.961±1.25^{a}	15.629±1.25^{ab}	13.832±1.09^{c}
Heter(um)	26.917±1.78^{b}	31.494±1.78^{a}	26.786±1.55^{bc}
Lym(k/uL)	70.218±1.60^{a}	65.409±1.61^{c}	69.483±1.40^{ab}
Eos(cell/McL)	1.471±0.28	1.417±0.28	1.504±0.25
Bas(um)	0.635±0.29^{bc}	0.71±0.29^{b}	1.150±0.25^{a}
Mono(ml)	0.754±0.34	0.962±0.35	1.117±0.30

PCV= Packed Cell Volume Mono= Monocytes Heter = Heterophils WBC= White Blood Cell Hb= Haemoglobin, Bas= Basophils Eos= Eosinophils Lym= Lymphocytes RBC= Red Blood Cell

3.3 Effect of Sex on the immune response (haematological) traits in Nigerian indigenous chicken's genotype at week 4 of age.

There were significant (p<0.05) difference in sex effect on some immune response traits of Nigerian Indigenous chickens measured at different ages in this study.

The result in Table 4 indicated that females recorded significantly (p<0.05) higher mean values in Wbc (13.565±0.56g/dl), Heter (33.211±1.26 um), Lym (66.477±1.60k/uL), Eos(1.135±0.18 cell/McL) and Mono (1.178±0.26ml) than the males counterpart with 12.598±0.72 g/dl, 30.489±1.62 um, 64.318±2.04 k/uL, 0.893±0.23 cell/McL and 0.869±0.33ml for the same traits, respectively measured at week 4 of age while the other immune response traits were not significant.

Table 4 Effects of Sex on the immune response (haematological) traits in Nigerian indigenous chicken's genotype at week 4 of age.

Trait	SEX Female	Male
PCV(mL)	29.837±1.15	29.874±1.47
Hb(mL)	9.937±0.38	10.002±0.49
RBC(m/mm^3)	2.479±0.10	2.582±0.12
WBC(g/dl)	13.565±0.56^a	12.598±0.72^b
Heter(um)	33.211±1.26^a	30.2489±1.62^b
Lym(k/uL)	66.477±1.60^a	64.318±2.04^b
Eos(cell/McL)	1.135±0.18^a	0.893±0.23^b
Bas(um)	0.718±0.21	0.853±0.27
Mono(ml)	1.178±0.26^a	0.869±0.33^b

PCV= Packed Cell Volume Mono= Monocytes Heter = Heterophils WBC= White Blood Cell Hb= Haemoglobin, Bas= Basophils Eos= Eosinophils Lym= Lymphocytes RBC= Red Blood Cell

3.4 Effects of Sex on the immune response (haematological) traits in Nigerian indigenous Chicken's genotype at week 8 of age.

There were significant ($p<0.05$) difference in sex effect on some immune response traits of Nigerian Indigenous chicken measured at different ages in this study.

The result in Table 5 indicated that females recorded significantly ($p<0.05$) higher mean values in Wbc (14.674±0.88g/dl), Heter (29.295±1.61um), Lym (70.604±1.94 k/uL) than the males counterpart with 12.205±1.12 g/dl, 27.434±2.05 um, 68.924±1.61k/uL for the same traits, respectively measured at 8 week of age while other immune response traits showed no significant ($p>0.05$) difference. In their means

Table 5 Effects of Sex on the immune response (haematological) traits in Nigerian indigenous chicken's genotype at week 8 of age.

Trait	SEX Female	Male
PCV(mL)	29.804±0.93	30.732±1.19
Hb(mL)	9.881±0.31	10.216±0.40
RBC(m/mm^3)	2.472±0.08	2.544±0.11
WBC(g/dl)	14.674±0.88^a	12.205±1.12^b
Heter(um)	29.295±1.61^a	27.434±2.05^b
Lym(k/uL)	68.924±1.52^b	70.604±1.94 ^{a}
Eos(cell/McL)	0.511±0.11	0.548±0.15
Bas(um)	0.333±0.17	0.383±0.22
Mono(ml)	0.934±0.22	1.029±0.28

PCV= Packed Cell Volume Mono= Monocytes Heter = Heterophils WBC= White Blood Cell Hb= Haemoglobin, Bas= Basophils Eos= Eosinophils Lym= Lymphocytes RBC= Red Blood Cell

3.5 Effects of Sex on the immune response (haematological) traits in Nigerian indigenous chicken's genotype at week 12 of age

The result in Table 6 indicated that females recorded significantly ($p<0.05$) higher mean values in PVC(35.220±1.17ml), Wbc (17.097±0.96 g/dl), Heter (29.922±1.37 um), Lym (69.828±1.58 k/uL), Eos(2.422±0.22 cell/McL) and Mono (1.059±0.26 ml) than the males counterpart with 33.946±1.50 ml, 15.185±1.23 g/dl, 27.876±1.75 um, 67.912±1.24k/uL, 1.506±0.28 cell/McL and 0.830±0.34 ml for the same traits, respectively, measured at week 12 of age while the other immune response traits were not significantly ($p>0.05$) difference measured in this study at week 12 of age.

Table 6 Effects of Sex on the immune response (haematological) traits in Nigerian indigenous chicken's genotype at week 12 of age.

Traits	SEX Female	Male
PCV(mL)	35.220±1.17[a]	33.946±1.50[b]
Hb(mL)	11.764± 0.39	11.282±0.50
RBC(m/mm^3)	2.987±0.11	2.821±0.14
WBC(g/dl)	17.097±0.96[a]	15.185±1.23[b]
Heter(um)	29.922±1.37[a]	27.876±1.75[b]
Lym(k/uL)	69.828±1.58[a]	67.912±1.24[b]
Eos(cell/McL)	2.422±0.22[a]	1.506±0.28[b]
Bas(um)	0.705±0.22	0.961±0.28
Mono(ml)	1.059±0.26 [a]	0.830±0.34[b]

PCV= Packed Cell Volume Mono= Monocytes Heter = Heterophils WBC= White Blood Cell Hb= Haemoglobin, Bas= Basophils Eos= Eosinophils , Lym= Lymphocytes RBC= Red Blood Cell

4 Discussion

The effect of sex on immune response traits of Nigerian indigenous chicken's genotypes at different ages were presented in Tables 1 to 3. Sex significantly ($p<0.05$)influenced some of the immune response traits measured in this study at week 4, 8 and 12 weeks of ages in this study in Tables 1, 2 and 3, respectively. This is in tandem with Younis and Ghoneim [8] who observed sex differences in their study on the relationship between Sex hormones, Immune Response and Productive Performance of Broiler chicken. Significant effect observed in Eosinophils and Monocyte to show a significant ($p<0.05$) effect at different ages in this study Tables 4 to 6 is an indication that there is absence of stress reaction, steroid and some allergic reactions. This observation is in line with the report of Onyishi *et al.* [9] who reported a low value of the same parameters with increased in age.

According to Falcones *et al.* [10], lymphocytes which is a fraction of the white blood cells are natural killer cells and are able to kill cells of the body that do not display MHC class 1 molecules, or display stress markers such as MHC class 1 polypeptide-related sequence A (M/C-A). However, the higher the lymphocytes, the better and stronger the immune system of the animal. These cells play both an immediate and delayed role in response to infection or inflammation. Increased numbers of lymphocytes are associated with most viral infections and some bacterial infections whereas decreased numbers of lymphocytes are characterized by steroid exposure, immunodeficiency and renal failures.

The significant value of heterophils recorded for Naked neck chicken in this study may be an indication that heterophils is part of WBC and have the phagocytic ability regardless of the presence or absence of antibodies. The observation in this study is not in tandem with the report of Opoola *et al.* [11] who reported of no significant difference in the quantity of heterophils produced in Nigerian indigenous chicken.

The test for WBC levels is very important to detect and measure the ability of the body to destroy diseases. A high level of WBC may be due to immunological challenge which may be largely informed by the associated inherent resistance to tropical diseases [12]. It is also noteworthy that, the subsisting ecological condition support several vectors and

parasites of economic significance. Nosike *et al.* [12] also observed the effect of genotype on WBC to be highly significant ($p<0.05$) in a gene of chickens.

The red blood cell of this study decreases as age of the chicken increases though not significant. This might results from the amount of feed consumed as there's effect of dietary feed on chickens, since young chicks consume less amount of feed compared to grown chickens [13]. Normal red blood cell production requires diet containing protein, iron, coppers, vitamin B2, B6, B12 and folic acid [13].

The Packed cell volume (PCV) obtained in this study were showing a rapid increase in values with age, and the highest PCV values significant, were observed at week 12 of age. This is not in line with the research findings of Addass *et al*. [14] and Nosike *et al. [12]* on indigenous chickens. This could be due to age group effect as observed on PCV. Increased PCV shows a better transportation and thus results in an increased primary and secondary polythelia. According to Adedibu *et al.* [15], Pcv value may be useful markers for predicting spermatozoa maturation in testes, sexual maturity and the onset of semen production. PCV is the volume of the red blood cells in the blood. Higher PCV values are usually due to a higher weight gain as well as reduction in heat load. Selection of Nigeria local chicken high PCV would therefore lead to a boost in the growth and productive life. PCV can serve as a trait for selection of Nigeria local chicken for improved growth and productive life of bird through improved weight gain and heat-tolerance [12].Pearson correlation among immune response traits in Nigerian indigenous chickens at 4 weeks of age

The Correlation coefficients among immune response traits of Nigerian Indigenous chickens ranged between -0.015 and 0.992 at week 4.Nevertheless, there were positive relationship in most of the correlated traits, while some showed negative relationships among this traits studied.

The results showed very highly ($p<0.001$) significant correlation coefficient between Pcv (Hb and RBC), Rbc and Hb; and Eos (Bas and Mono), respectively at 4 weeks of age, and were positively correlated. However, Heter recorded a negative significant correlation ($P<0.05$) between heterophils and monocytes. The correlation coefficients ranged between -0.006 to 0.992 with the highest correlation coefficient was recorded for Pcv and Hb with 0.992. The least relationship was between Mono and Lym (-0.006). The positive relationships were recorded between Pcv and Rbc (0.910), Hb and Pcv (0.992), Wbc and Pcv (0.005), Heter and Pcv(0.002), Eos and Pcv (0.095), and Mono and Pcv(0.028); Hb and Rbc (0.926), Hb and Wbc (0.020), Hb and Heter (0.013), Hb and Eos (0.096), and Hb and Mono (0.009); Rbc and Wbc (0.064), Rbc and Eos (0.061), Rbc and Bas (0.066), and Rbc and Mono (0.006); Heter and Lym (0.154); Eos and Bas (0.289), and Eos and Mono (0.452), Bas and Mono (0.17). However, other immune response traits relationships were negatively correlated at week 4 in Table 6.

Table 7 Pearson correlation among immune response traits in Nigerian indigenous chickens at 4 weeks of age.

TRAITS	PCV(mL)	Hb(mL)	RBC(m/mm^3)	WBC(g/dl)	Heter(um)	Lym(k/uL)	Eos(cell/McL)	Bas(um)
Hb(mL)	0.992***							
RBC(m/mm^3)	0.910***	0.926***						
WBC(g/dl)	0.005	0.020	0.064					
Heter(um)	0.002	0.013	-0.043	-0.122				
Lym(k/uL)	-0.015	-0.023	-0.043	0.154	0.154			
Eos(cell/McL)	0.095	0.096	0.061	-0.080	-0.080	-0.165		
Bas(um)	-0.042	-0.036	0.066	-0.005	-0.005	-0.058	0.289**	
Mono(ml)	0.028	0.009	0.006	-0.114	-0.227*	-0.006	0.452***	0.17

PCV= Packed Cell Volume Mono= Monocytes Heter = Heterophils WBC= White Blood Cell Hb= Haemoglobin, Bas= Basophils Eos= Eosinophils Lym= Lymphocytes RBC= Red Blood Cell; *= Significant ($p<0.05$) correlation; **= highly ($p<0.01$) significant correlation; ***= very highly ($p<0.001$) significant correlationPearson correlation among immune response traits in Nigerian indigenous chickens at 8 weeks of age.

The results of the correlation among the immune response traits measured showed very high significant ($p<0.001$) correlation coefficients between Pcv (Hb, Rbc) Hb and Rbc, Heter and Lym, Eos and mono, respectively. However, Heter and mono were highly ($P<0.01$) significant but negatively correlation, while Heter and Eos showed were but negatively correlated at week 8 of age. The relationship were positive in most of the correlated traits while some showed negative relationships. The correlation coefficient ranged from -0.006 to 0.972 with the highest correlation coefficient recorded

for Pcv and Hb(0.972) while the least relationship was between Pcv and Lym(-0.006). The positive relationships were recorded between Pcv and Hb(0.972), Pcv and Rbc(0.877), Pcv and Wbc(0.062), Pcv and Heter(0.076), Pcv and Mono(0.037); Hb and Rbc(0.903), Hb and Wbc(0.015), Hb and Heter(0.099), Hb and Mono(0.067); Rbc and Wbc(0.032), Rbc and Heter(0.069), Rbc and Mono(0.075); Wbc and Heter(0.131); Wbc and Eos (0.032), Lym and Eos (0.119), Lym and Bas(0.073), Lym and Mono(0.097); Eos and Mono (0.512); Bas and Mono (0.078). However, other immune response traits relationships were negatively correlated at week 8 of the study, Table 8

Table 8 Pearson correlation among immune response traits in Nigerian indigenous chickens at 8 weeks of age.

TRAITS	PCV(mL)	Hb(mL)	RBC(m/m^3)	WBC(g/l)	Heter(um)	Lym(k/L)	Eos(cell/M)	Bas(um)
Hb(mL)	0.972***							
RBC(m/mm^3)	0.877***	0.903***						
WBC(g/dl)	0.062	0.015	0.032					
Heter(um)	0.076	0.099	0.069	0.131				
Lym(k/uL)	-0.006	-0.096	-0.067	-0.113	-0.976***			
Eos(cell/McL	-0.079	-0.047	-0.011	0.032	-0.246*	0.119		
Bas(um)	-0.123	-0.130	-0.137	-0.027	-0.180	0.073	-0.124	
Mono(ml)	0.037	0.067	0.075	-0.167	-0.277**	0.097	0.512***	0.078

PCV= Packed Cell Volume Mono= Monocytes Heter = Heterophils WBC= White Blood Cell Hb= Haemoglobin, Bas= Basophils Eos= Eosinophils Lym= Lymphocytes RBC= Red Blood Cell; *= Significant (p<0.05) correlation; **= highly (p<0.01) significant correlation; ***= very highly (p<0.001) significant correlation

4.1 Pearson correlation among immune response traits in Nigerian indigenous chickens at 12 weeks of age.

The results of correlation coefficient among the immune response traits measured showed very high (p<0.001) significant correlation between PCV (Hb, RBC) Hb and RBC, heter and Eos; Eos and mono, respectively at weeks 12 of age.

Lym and Eos; heter and mono were negatively correlated but significant. Also, there was positively significant (p<0.05) correlation between Pcv and Wbc, Hb and Wbc, and Eos and Bas, respectively while heter and Bas showed negative significant (p<0.05) correlation at week 12 of age in Table 9

There was positive relationship in most of the relationships while some showed negative relationships. The correlation coefficient ranged between -0.015 to 0.989 with the highest correlation coefficient recorded for Pcv and Hb (0.989) while the lowest was between Lym and Mono (0.015).

Table 9 Pearson correlation among immune response traits in Nigerian indigenous chickens at 12 weeks of age.

TRAITS	PCV(mL)	Hb(mL)	RBC(m/mm^3)	WBC(g/dl)	Heter(um)	Lym(k/uL)	Eos(cell/McL)	Bas(um)
HB(mL)	0.989***							
RBC(m/mm^3)	0.873***	0.898***						
WBC(g/dl)	0.249*	0.260*	0.188					
Heter(um)	0.145	0.154	0.123	0.146				
Lym(k/uL)	-0.081	-0.100	-0.058	-0.094	-0.921			
Eos(cell/McL)	-0.174	-0.151	-0.162	-0.160	-0.921***	-0.325**		
Bas(um)	-0.115	-0.105	-0.069	-0.101	-0.219*	-0.024	0.243*	
Mono(ml)	-0.134	-0.119	-0.178	-0.101	-0.321**	0.015	0.536***	0.190

PCV= Packed Cell Volume Mono= Monocytes Heter = Heterophils WBC= White Blood Cell Hb= Haemoglobin, Bas= Basophils Eos= Eosinophils Lym= Lymphocytes RBC= Red Blood Cell; *= Significant (p<0.05) correlation; **= highly (p<0.01) significant correlation; ***= very highly (p<0.001) significant correlation

Positive relationships were recorded between Pcv and Hb (0.989), Pcv and Rbc(0.873), Pcv and Wbc (0.249), Pcv and Heter (0.145); Hb and Rbc(0.898), Hb and Wbc (0.260), Hb and Heter (0.154); Rbc and Wbc(0.188), Rbc and Heter(0.123); Wbc and Heter(0.146); Lym and Mono (0.015); Eos and Bas (0.243); Eos and Mono (0.536); Bas and Mono (0.190). However, other immune response traits relationships were negatively correlated at week 12 of the study

5 Conclusion

To determine immune response traits in Nigerian local chickens, it was observed that frizzle feathered genotype recorded the highest significant effect on immune response traits (Red blood cells, Eosinophils, Basophil, white blood cells and lymphocyte), which makes it highly recommended and preferable. Naked neck and normal feather genotypes had their effect on only heterophil, monocyte and Basophil respectively at different stages of growth. Frizzle feather male and naked neck female had the highest effects on four different immune response traits (Basophil, white blood cell, lymphocyte and red blood cells for frizzle feather male) and (Haemoglobin, Red blood cell, monocyte and packed cell volume for naked neck female), respectively. It could be observed that the haematological parameters of local chicken could be affected by genotype. Females recorded significantly ($p<0.05$) higher mean values in PVC, Wbc, Heter, Lym, Eos and Mono than the males counterpart for the same traits, respectively, measured at week 12 of age while the other immune response traits were not significantly ($p>0.05$) difference as measured in this study at different ages.

WBC could serve as a marker indicating immunity and inherent resistance to tropical poultry diseases and parasites. Among the immune response trait studied in Nigerian indigenous chicken, PCV/Hb showed the highest association or correlation. It is recommended that males of improved Nigerian indigenous chickens should be raised for meat production purpose since it had higher means for live weight and carcass quality traits measured in this study.

Compliance with ethical standards

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Disclosure of conflict of interest

Author declares that there is no conflict of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in this manuscript.

Statement of ethical approval

This research was conducted in accordance with ethical guidelines governing the use of animals and genetic materials in scientific research as stipulated by the Ethical Committee of Department of Animal Science, Faculty of Agriculture, University of Uyo, which is in line with Animal health care constitution.

Author declaration

Author have declared that this article is original article submitted for publication which has not been published anywhere in the world.

Author's Consent

Author has given an approval and consent for the article to be submitted for publication.

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