Antibody Response and Haematological Changes of Nigerian Locally Adapted Turkeys to Sheep Red Blood Cells (SRBC)

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Abstract

Haemagglutination assay and haematological analysis of 143 poults generated as F₁ individuals by artificial insemination from randomly selected turkeys of White, Black and Lavender genotypes which are classified by antibody titre was carried out so as to confirm their antibody titre levels in response to sheep red blood cells (SRBC). Results showed that mean values obtained for high and low antibody titres were 7.31 and 2.67 respectively, resulting in the classification of the turkeys into Black high and low, Lavender high and black, and White high and low antibody titres. The genotype's titre had significant ($P < 0.05$) effect on the packed cell volume (PCV), haemoglobin (Hb), red blood cells (RBC), white blood cells (WBC) and basophil (BAS) of the basal haematological parameters. Genotype's titre had no significant ($P > 0.05$) effect on the primary response haematological parameters. Meanwhile, the primary response haematological parameters to SRBC antigen varied along the genotypes with the WBC increasing drastically in all the genotypes, signifying the presence of an antigen. The study concluded that the F₁ turkey poult population studied diverged along the high and low antibody titre in response to SRBC. Thus, the F₁ generation of the high antibody titre genotypes (Black high, White high and Lavender high) can be used as foundation stock for selection of local turkeys for high antibody titre.

Keywords: antibody titre, haematology, SRBC.

Introduction

An economically important trait in animals and poultry, including turkeys (*Meleagris gallopavo*), for which gene identification remains a challenge, is immune response, which can be either cellular or humoral (Tuoyu *et al.*, 2015). Because antibody-mediated immune response or antibody response may neutralize, destroy and remove invading pathogens from the animal body, an analysis of the molecular basis of antibody response may provide a basis for improving the natural resistance of

animals to disease. The level of antibody production or antibody titre is a feature of antibody response. Consequently, antibody response selection may increase immunity to vertebrate disease (Gross *et al.*, 1980; Tuoyu *et al.*, 2015). Haematological parameters are being used in avian medicine as physiological indicators and disease diagnostic tools (Quintavalla *et al.*, 2001). According to Adeyemo *et al.* (2018), the information gained from investigation of haematological values, disease diagnosis and managerial factors are

the main tools for developing new genotypes of birds which are genetically able to resist different diseases.

Divergent selection for a single trait (antibody response) using a multi-determinant and non-pathogenic antigen such as sheep red blood cells (SRBC) is a direct and efficient way to create divergent populations (Lamont *et al.*, 2003). Compared to a specific antigen, SRBC, a T-cell – dependent, non-specific antigen, is preferentially used in studies to dissect molecular basis of antibody response.

According to Ogah (2011), turkeys are seldom raised by poultry farmers in Nigeria compared to chickens, however, several farms are beginning to breed the bird at commercial level owing to increasing interest as a provider of meat, complementing the chicken. Even though natural selection has led to the selection of some locally adapted breeds of turkeys which have come to adapt to the environment, the issue of disease outbreak is still of major concern to the farmers who are developing interest in turkey production because of the huge losses incurred when such a catastrophic disaster occurs (Okaroafor, 2014).

As consumers continue to voice concerns about the health and safety of foods derived from animals, it is important to find effective methods for reducing chronic antibiotic use and enhancing the effectiveness of vaccine protection by improving birds ' innate ability to respond to antigenic challenges through genetic selection (Lamont *et al.*, 2003). Therefore, this research aimed at describing the resources that could identify foundation for improving the natural immune capacity of Nigerian locally adapted turkeys by identifying genotypes that have high immune response (i.e. high antibody titre value) to SRBC.

Materials and Methods

Experimental site

The experiment was conducted at the poultry unit, Directorate of University Farms (DUFARMS) Federal University of Agriculture (FUNAAB) Abeokuta, Ogun State. The laboratory analysis was carried out at the Department of Animal Breeding and Genetics biotechnology laboratory, FUNAAB.

Experimental animals and management

A total of 143 poults used for this research were selected at random from the F₁ generation

of three genotypes of Nigerian locally adapted turkeys (Black, White and Lavender) that had shown divergent response (high or low antibody titre) to sheep red blood cells (SRBC) antigen. Antibiotic-free starter's mash (Energy: 3010Kcal/Kg; Crude Protein: 23.00%) and water was made available *ad libitum*.

Sheep red blood cells (SRBC) preparation and inoculation of poults

Approximately 5ml blood was withdrawn under aseptic condition from a healthy male sheep into an EDTA tube. The sheep blood was centrifuged at 3500 rpm for 5 minutes and the supernatant was discarded. The sediment erythrocytes were given three washings with Phosphate buffered solution (PBS) at 3500rpm for 5 minutes. The packed erythrocytes were reconstituted in PBS to make 1% suspension of SRBC. The poults were immunised with 1ml of the 1% suspension of SRBC at 6th week through the brachial vein.

Blood and sera collection

Approximately 1ml of blood samples were collected through the brachial vein at the 5th week for basal haematology evaluation before injection of SRBC. At 6th week blood samples was also collected 5 days after SRBC injection for the post-primary (PPI) haematological examination and haemagglutination assay. Sera were harvested and stored at -4°C until all samples were analysed simultaneously for total antibodies to determine the antibody titres for the primary response and to evaluate the antibody titre levels among the F₁ progeny from their parent's titre level.

Haemagglutination assay

Sera harvested from each poult were used to determine the antibody titres by haemagglutination assay as described by Wegmann and Smithies (1966). The anti-serum underwent 2-fold dilution multiple times in a V-bottomed 96-well plate containing 1% suspension of SRBC, and then this mixture was incubated at 37°C for 45 minutes for antibody titre reading. Titres were expressed as log₂ of the reciprocal of the highest dilution in which there was complete haemagglutination. Titres with complete haemagglutination < 4 were classified as low titres, while ≥ 5 were classified as high titre.

Haematology evaluation

Blood collected before the injection and five-days post-injection of SRBC at 6th week from the poults was taken to the Haematology Labora-

tory, College of Veterinary Medicine, FUNAAB to evaluate the following parameters: packed cell volume (PCV), haemoglobin (Hb), red blood cells (RBC), white blood cells (WBC), heterophil (HET), lymphocytes (LYM), eosinophil (EOS), basophil (BAS), mean corpuscular volume (MCV), mean concentration haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) for the basal and primary responses to SRBC using standard procedures.

Statistical analysis

The differences between the observed and expected numbers of antibody titre levels was compared using a goodness-of-fit Chi-Square (χ^2) test.

$$\chi^2 = \sum \frac{(obs - exp)^2}{exp}$$

Homogeneity test of haematological parameters was carried out while the antibody titre values of the F_1 progeny were transformed to reciprocal $\log_2$ units of greatest dilution showing 100% agglutination prior to analysis. Analysis of variance of both untransformed and transformed data was performed using the General Linear Models (GLM) procedure of the SAS[®] University Edition (Copyright © 2018, SAS Institute Inc.) to evaluate genotype differences in anti-SRBC titres within and among the Lavender High (LH), Lavender Low (LL), Black High (BH), Black Low (BL), White High (WH) and White Low (WL) genotypes. The basal values of the haematological parameters were used as covariate in the analysis.

$$Y_{ij} = \mu + X\beta + G_i + e_{ij}$$

where:

Y_{ij} - Observed performance of the j^{th} individual of the i^{th} genotype by titre level

μ - Overall mean for the parameters of interest

$X\beta$ - Basal values of haematological parameters used as covariate

G_i - Fixed effect of the i^{th} genotype (i^{th} = LH, LL, BH, BL, WH and WL)

e_{ijk} - Residual error

Means were separated using the Tukey-Kramer Honest Significant Difference.

Results

Antibody response of Nigerian locally adapted F_1 turkey poults to sheep blood cells (SRBC)

The mean values obtained for high and low antibody titres were 7.31 and 2.67 respectively (Table 1: Anti- $\log_2$ transformed). A significant difference ($P < 0.05$) was observed among the genotypes, with the high antibody titre genotypes (LH, WH and BH) having higher titre values than their low antibody titre (LL, BL and WL) counterparts (Table 2). Table 3 shows the Chi-square analysis of the 1st filial generation of Nigerian locally adapted turkey primary response to SRBC. From a total population of 143, the observed high antibody titre population (54) is greater than the expected (43) while the observed low antibody titre population (89) is less than the expected (100). Thus, the chi-square statistic was significant ($P < 0.05$) at with P-value of 0.0449.

Changes in haematological parameters of Nigerian locally adapted F_1 turkey poults in response to sheep blood cells (SRBC)

The mean values of the following haematological parameters: packed cell volume (PCV), haemoglobin (Hb), red blood cells (RBC), white blood cells (WBC), heterophil (HET), lymphocytes (LYM), eosinophil (EOS), basophil (BAS), mean corpuscular volume (MCV), mean concentration haemoglobin (MCH) and mean corpuscular

Table 1. Overall means $\pm$ standard error of antibody titre of Nigerian locally adapted F_1 turkey poults primary response to SRBC

Antibody titre	N	Means $\pm$ S.E.	Min	Max
High	54	7.31 $\pm$ 0.27	5	11
Low	89	2.67 $\pm$ 0.12	1	4

N = Number of Samples; Min = minimum; Max = maximum

Table 2. Means $\pm$ standard error of antibody titre of Nigerian locally adapted F₁ turkey poult primary response to SRBC

Genotypes	Sample No.	Means $\pm$ S.E.
Black High	16	7.12 $\pm$ 0.48 ^a
Black Low	26	2.61 $\pm$ 0.21 ^b
Lavender High	22	7.50 $\pm$ 0.41 ^a
Lavender Low	23	2.91 $\pm$ 0.19 ^b
White High	16	7.25 $\pm$ 0.52 ^a
White Low	40	2.57 $\pm$ 0.18 ^b

^{a,b} Means within the same column with different superscripts differ significantly (P < 0.05)

Table 3. Chi-Square (χ^2) for antibody primary response of Nigerian locally adapted F₁ turkey poult to SRBC

Antibody titre	Observed	Expected	P-value	χ^2
High	54	43	0.0449	4.0239*
Low	89	100		
Total	143			

*P < 0.05

haemoglobin concentration (MCHC) for Nigerian locally adapted F₁ turkey poult genotypes are presented in Tables 4 and 5. Table 4 shows the basal haematological parameters of Nigerian locally adapted F₁ turkey poult before inoculation with sheep red blood cells (SRBC). Significant differences (P < 0.05) were observed only in the PCV, Hb, RBC, WBC and BAS. For the primary response haematological parameters after inoculation of SRBC, no significant differences (P > 0.05) was observed among the turkey genotypes (Table 5). Only the WBC haematological parameter for the primary response was greater than the basal WBC for all genotypes, while the basal parameters either increase or decrease relative to the primary response for other parameters.

Discussion

There are very practical (i.e. raising animals with natural resistance to infections) and economic (i.e. reduction in cost of production) reasons for pursuing enhancement of immunity via direct selection for immune response. A significant statistic obtained from the chi-square analysis in this study, testify to the fact from literatures (Siegel

& Gross, 1980; van Der Zijpp & Leenstra, 1980; Martin *et al.*, 1990; Pinard *et al.*, 1992; Kuehn *et al.*, 2006) that the pattern of inheritance of antibody response of avian to inoculation of SRBC responds to divergent selection i.e. the genes responsible for antibody response undergoes segregation which is expected because the populations from this study are the first generation of turkeys to be selected for high and low antibody response to SRBC. The significant differences observed between the high and low genotypes in this study is consistent with the findings of Pinard *et al.* (1992) who reported that after three generations, there were significant differences in antibody response between genotypes of ISA Warren chickens selected for high and low antibody titre at 5 days after immunization at 35 days of age with SRBC.

Packed Cell Volume (PCV) or haematocrit is the proportion of blood volume that is occupied by erythrocytes i.e. the ratio of red blood cells to the whole blood volume. The PCV values of the basal and primary responses across all the genotypes of turkeys observed in this study were within the normal range of 35.90 - 41.00% for avian stated by Mitruka and Rawnsley (1997), which means

Table 4. Means $\pm$ Standard Error of basal haematological parameters of Nigerian locally adapted F₁ turkey poults

Haematological Parameter	Black High	Black Low	Lavender High	Lavender Low	White High	White Low
PCV (%)	27.40 $\pm$ 1.28 ^b	32.92 $\pm$ 1.07 ^{ab}	32.91 $\pm$ 1.79 ^{ab}	37.35 $\pm$ 1.07 ^a	33.83 $\pm$ 0.95 ^{ab}	36.71 $\pm$ 1.62 ^a
Hb (g/dl)	9.24 $\pm$ 0.40 ^b	11.08 $\pm$ 0.36 ^{ab}	11.14 $\pm$ 0.58 ^{ab}	12.55 $\pm$ 0.35 ^a	11.31 $\pm$ 0.31 ^{ab}	12.24 $\pm$ 0.52 ^a
RBC ($\times 10^{12}$ /L)	2.28 $\pm$ 0.10 ^b	2.77 $\pm$ 0.09 ^{ab}	2.74 $\pm$ 0.15 ^{ab}	3.12 $\pm$ 0.09 ^a	2.85 $\pm$ 0.07 ^{ab}	3.00 $\pm$ 0.13 ^a
WBC ($\times 10^9$ /L)	8.72 $\pm$ 0.37 ^b	11.09 $\pm$ 0.36 ^{ab}	10.83 $\pm$ 0.40 ^{ab}	10.53 $\pm$ 0.48 ^{ab}	11.46 $\pm$ 0.25 ^a	11.75 $\pm$ 0.41 ^a
HET (%)	30.80 $\pm$ 2.83	30.88 $\pm$ 1.17	33.33 $\pm$ 2.09	30.40 $\pm$ 1.46	31.75 $\pm$ 1.78	33.85 $\pm$ 1.37
LYM (%)	65.60 $\pm$ 2.15	66.65 $\pm$ 1.28	65.50 $\pm$ 2.04	68.10 $\pm$ 1.51	65.58 $\pm$ 1.85	63.50 $\pm$ 1.35
EOS (%)	1.00 $\pm$ 0.44	0.69 $\pm$ 0.14	0.16 $\pm$ 0.11	0.60 $\pm$ 0.16	0.50 $\pm$ 0.23	0.64 $\pm$ 0.22
BAS (%)	1.80 $\pm$ 0.58 ^a	0.65 $\pm$ 0.15 ^{ab}	0.33 $\pm$ 0.14 ^b	0.30 $\pm$ 0.10 ^b	0.91 $\pm$ 0.25 ^{ab}	0.85 $\pm$ 0.25 ^{ab}
MONO (%)	0.80 $\pm$ 0.37	1.15 $\pm$ 0.18	0.66 $\pm$ 0.22	0.65 $\pm$ 0.23	1.25 $\pm$ 0.35	1.35 $\pm$ 0.24
MCV (fl)	120.14 $\pm$ 0.50	118.54 $\pm$ 0.66	119.95 $\pm$ 0.42	119.75 $\pm$ 0.29	118.38 $\pm$ 0.84	120.76 $\pm$ 0.70
MCH (pg)	40.54 $\pm$ 0.33	39.90 $\pm$ 0.25	40.65 $\pm$ 0.25	40.26 $\pm$ 0.13	39.58 $\pm$ 0.29	40.31 $\pm$ 0.37
MCHC (g/dl)	33.74 $\pm$ 0.19	33.66 $\pm$ 0.08	33.83 $\pm$ 0.21	33.61 $\pm$ 0.09	33.41 $\pm$ 0.13	33.33 $\pm$ 0.17

PCV= pack cells volume; Hb = haemoglobin; RBC = red blood cells; WBC= white blood cells; HET= heterophil; LYM= lymphocytes;

EOS= eosinophil; BAS= basophil; MCV= mean corpuscular volume; MCH = mean concentration haemoglobin;

MCHC = mean corpuscular haemoglobin concentration;

^{ab} Means within the same row with different superscripts differ significantly (P <0.05).

Table 5. Means $\pm$ Standard Error of primary response haematological parameters of Nigerian locally adapted F₁ turkey poults to sheep red blood (SRBC)

Haematological Parameter	Black High	Black Low	Lavender High	Lavender Low	White High	White Low
PCV (%)	36.33 $\pm$ 2.33	41.33 $\pm$ 2.59	33.50 $\pm$ 6.50	32.66 $\pm$ 1.96	33.16 $\pm$ 2.91	38.16 $\pm$ 3.93
Hb (g/dl)	12.13 $\pm$ 0.97	13.95 $\pm$ 0.89	11.25 $\pm$ 2.15	11.01 $\pm$ 0.65	11.28 $\pm$ 0.96	12.76 $\pm$ 1.29
RBC ($\times 10^{12}$ /L)	3.16 $\pm$ 0.31	3.51 $\pm$ 0.23	2.85 $\pm$ 0.55	2.78 $\pm$ 0.18	2.78 $\pm$ 0.23	3.18 $\pm$ 0.31
WBC ($\times 10^9$ /L)	14.30 $\pm$ 2.31	13.50 $\pm$ 0.85	14.95 $\pm$ 2.45	12.98 $\pm$ 1.05	13.13 $\pm$ 1.21	12.90 $\pm$ 0.98
HET (%)	33.00 $\pm$ 4.50	29.50 $\pm$ 3.61	37.00 $\pm$ 0.00	32.50 $\pm$ 2.02	31.16 $\pm$ 3.40	35.00 $\pm$ 2.28
LYM (%)	69.33 $\pm$ 3.84	68.66 $\pm$ 3.67	63.50 $\pm$ 0.50	64.00 $\pm$ 1.69	67.16 $\pm$ 3.05	62.50 $\pm$ 2.44
EOS (%)	0.33 $\pm$ 0.33	0.16 $\pm$ 0.16	0.00 $\pm$ 0.00	1.16 $\pm$ 0.47	0.83 $\pm$ 0.30	0.33 $\pm$ 0.33
BAS (%)	0.00 $\pm$ 0.00	0.50 $\pm$ 0.34	1.00 $\pm$ 1.00	0.66 $\pm$ 0.42	0.50 $\pm$ 0.34	1.00 $\pm$ 0.25
MONO (%)	0.67 $\pm$ 0.67	1.16 $\pm$ 0.54	1.50 $\pm$ 1.50	1.66 $\pm$ 0.49	0.66 $\pm$ 0.33	1.16 $\pm$ 0.47
MCV (fl)	118.63 $\pm$ 0.52	118.36 $\pm$ 1.31	117.50 $\pm$ 0.10	117.58 $\pm$ 1.38	119.11 $\pm$ 1.37	119.68 $\pm$ 0.57
MCH (pg)	39.70 $\pm$ 0.21	39.93 $\pm$ 0.28	39.50 $\pm$ 0.10	39.63 $\pm$ 0.59	40.56 $\pm$ 0.45	40.06 $\pm$ 0.40
MCHC (g/dl)	33.43 $\pm$ 0.14	33.71 $\pm$ 0.18	33.60 $\pm$ 0.10	33.71 $\pm$ 0.30	34.03 $\pm$ 0.20	33.46 $\pm$ 0.24

PCV= pack cells volume; Hb = haemoglobin; RBC = red blood cells; WBC= white blood cells; HET= heterophil; LYM= lymphocytes; EOS= eosinophil; BAS= basophil; MCV= mean corpuscular volume; MCH = mean concentration haemoglobin; MCHC = mean corpuscular haemoglobin concentration.

that the inoculation of SRBC does not influence the PCV status of the birds. The mean values of PCV obtained in this study is consistent with the report of haematological parameters, local, crossbreed and exotic turkeys reared in southern Nigeria by Isidahomen *et al.* (2013) and with the report of haematological parameters of Norfolk and Mammoth turkeys at 8th and 16th weeks of age by Ibrahim (2014), so also with report of haematological parameters of Bronze turkey from Brazil by Schmidt *et al.* (2009). The haemoglobin (Hb) is the protein in the blood that holds the oxygen. The Hb mean values obtained for the basal as well as the primary response to SRBC are within the normal range of 7.00 - 13.00g/dl for avian stated by Mitruka and Rawnsley (1997). The results obtained are lower than the values reported of Schmidt *et al.* (2009) and Isidahomen (2013) but in agree with the report of Ibrahim (2014). Even with the slight increase/decrease after the inoculation observed across all the genotypes of turkey observed in this study, the SRBC has no influence on the Hb status of the turkey genotypes. The red blood cell count (RBC) is the number of red blood cells which helps to deliver oxygen and carbon dioxide through the body (Isaac *et al.*, 2013). The normal range for RBC in avian which is $4.21-4.84 \times 10^{12}/L$ (Mitruka & Rawnsley, 1997), was higher than the mean values of RBC for the basal and primary responses obtained in this study. This is an indication of anaemia among the turkey genotypes observed in this study. Schmidt *et al.* (2009) stressed that red cell mass of birds is influenced by environmental factors, age, hormonal and disease. This result is similar to the report of Peters *et al.* (2011) but contradicts the investigation of Ibrahim (2014) which reported high values of RBC counts above the reference range. The mean corpuscular volume (MCV) shows the average size of the RBC, the mean corpuscular haemoglobin (MCH) tells how much haemoglobin (a protein) is in the typical RBC which carries oxygen to the organs and tissues while the mean corpuscular haemoglobin concentration measures the concentration of haemoglobin in a certain amount of blood (WEBMD, 2019). The MCV and MCH mean values obtained from this study are very high and above the normal range (MCV: 81.60-89.10fl, MCH: 27.20-28.90pg) while the MCHC mean values obtained are slightly above normal range (MCHC: 32.41-33.37g/dl)

for avian stated by Mitruka and Rawnsley (1997). This result is consistent with the reports of Isidahomen *et al.* (2013) and Peters *et al.* (2011) for Nigerian native chickens but contradict the findings of Adeyemo (2018) which reported MCV and MCH values below the reference range in Nigerian indigenous chicken genotypes. The White blood cells (WBC) or leukocytes alongside the differentials (heterophils - HET, lymphocytes - LYM, eosinophils - EOS, basophils - BAS and monocytes - MONO) are immune system cells that protect the body against diseases and foreign invaders (Chiaet, 2016). This study revealed that the lymphocytes are the most abundant leukocyte in the peripheral blood of the turkey genotypes which confirm to the similar reports of Bounous *et al.* (2000) from haematological studies of wild turkeys and Bounous and Stedman (2000) for chickens and turkeys. The basal WBC count and lymphocytes percentage obtained in this study are above the reference ranges (WBC count: $4.07-4.32 \times 10^9/L$, Lymphocytes: 20.00-50.00%) stated for avian by Mitruka and Rawnsley (1997). Which indicates that the turkey genotypes observed are healthy with the capability of generating antibodies in the process of phagocytosis and subsequently have high degree of immune response and resistance to diseases (Soetan *et al.*, 2013; Etim *et al.*, 2014), but the heterophil and monocytes percentages are below the stated ranges (Heterophil: 40.00-75.00%, Monocytes: 5.00-10.00) by Mitruka and Rawnsley (1997), which signifies that they are susceptible to bacteria and fungus infections (Chiaet, 2016) which can be attributed to the management of the birds (Etim *et al.*, 2014). The results obtained in this study is in accordance with the findings of Ibrahim (2014), Isidahomen *et al.* (2013) and Schmidt *et al.* (2009) who all reported WBC counts in turkeys which is above the reference value as well as Peters *et al.* (2011) who also reported WBC counts above the reference value in Nigerian native chickens. Interestingly, the inoculation of the birds with SRBC caused an increase in the WBC counts across the turkey genotypes, which signifies the identification of foreign invaders i.e. SRBC by the immune system of the birds (Chiaet, 2016) with the Lavender High (LH) genotype having the highest WBC primary response mean value and the White Low (WL) genotype having the least. For the other differential counts, the changes in

the primary response and secondary response mean values varies across the turkey genotypes: the LH has the highest HET mean value for the primary response while the BL has the least; the BH has the highest LYM mean value for the primary while the WL has the least; the LL has the highest EOS mean value for the primary response while the LH has the least; the WL has the highest BAS mean value; the LL has the highest MONO mean value while the WH and BH has the least for the primary response. The variations in the basal and primary response haematological parameters among the turkey genotypes might be due to season, species, immune system, management and nutrition especially protein deficiency (Fudge, 2000; Oladele *et al.*, 2001; Campbell, 2004; Etim *et al.*, 2014; Adeyemo, 2018).

Conclusions

The F_1 turkey poult population studied diverge along the high and low antibody titre in response to the SRBC antigen. The genotype's titre had significant effect on the PCV, Hb, RBC, WBC and BAS of the basal haematological parameters but no significant difference was observed among the primary response haematological parameters. The basal haematological parameters of the Nigerian locally adapted F_1 turkey poult observed in this study were within the reference ranges of the avian haematological values except the RBC. While the primary response of haematological parameters to SRBC antigen varies along the genotypes with the WBC increasing drastically in all the genotypes signifying the presence of a foreign invader. Thus, the F_1 generation of the high antibody titre genotypes (Black high, White high and Lavender high) can be used as foundation stock for selection of local turkeys for high antibody titre.

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