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Effect of genotype and sex on physiological response and haematological indices of four different strains of broiler chicken

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Abstract

The experiment was conducted to investigate the effect of genotype and sex on physiological response and haematological parameters of Arbor Acre (AA), Arbor Acre Plus (AAP), Cobb and Ross. A total of two-hundred-day-old chicks of mixed sexes were allocated into five cells. Physiological parameters considered were Respiratory Rate (RR), Pulse Rate (PR), Rectal Temperature (RT), Skin Temperature (ST) and Heat Stress Index (HSI) which were measured at week 4, 8 and 12. Blood samples were collected via brachial vein and analysis of Mean corpuscular volume, Mean corpuscular haemoglobin, Mean corpuscular haemoglobin concentration, Haematocrit (HCT), Platelet, Red blood cell (RBC), Haemoglobin, Packed cell volume (PCV), White blood cell (WBC) and its differentials were determined. There were significant ($P < 0.05$) effects of genotype and sex on RR and PR across ages. Arbor Acre Plus exhibited lowest RR, PR and favourable haematology under heat stress with higher level of PCV and WBC. Males showed higher RR and PR, which suggested that male broilers experienced higher cardiovascular stress under heat stress. There was a significant ($P < 0.05$) effect of genotype and sex on all haematological parameters except RBC and HCT. Based on the chicken superior heat tolerance and strong immune profiles therefore, AAP chickens are recommended for production in high ambient temperature environments.

Key words: Genotype, sex, physiological response, haematological parameter, heat stress, broiler

Introduction

Broiler production is one of the most rapidly expanding sectors in livestock farming, providing an important source of cheap protein worldwide (Moreki *et al.*, 2025). Its value is particularly pronounced in tropical regions, where the demand for poultry meat continues to rise due to rapid urban development and population growth (Mottet and Tempio, 2017). Broilers high conversion of feed into meat, making them a stable option for tackling protein deficiencies and boosting food security. However, the tropical environment poses threat to broiler production, with thermal balance

being a central concern (Oke *et al.*, 2024).

Heat stress is one of the most formidable challenges in poultry farming, particularly for broilers, which are highly prone to high environmental temperatures (Lara and Rostagno, 2013). Heat stress can reduce growth performance, feed intake, egg production, and overall health, leading to financial losses in the poultry industry (Nawab *et al.*, 2018). The impact of heat stress on broilers is influenced by a complex interaction between genetic and non-genetic factors. Genetic factors refer to the heritable traits (heat-tolerant traits) that affect a broiler's

capacity to tolerate heat, while non-genetic factors (such as age and sex) contribute to heat tolerance, which is critical for elevating broiler productivity in hot climates. Under high temperatures, broilers struggle to maintain their internal body temperature due to reduced evaporative cooling efficiency. The temperature for performance is between 18 to 22°C for broilers but when the chicken body temperature is above 41.7 °C and the atmospheric temperature exceeds 25°C (Tellez *et al.*, 2017), chickens may suffer from heat stress which depends on chicken strain, feathering, nutrition, production, and management (Sesay, 2022). Birds lack sweat glands but have developed several adaptive behaviours to cope with heat, including increased respiratory rate, panting, and elevated wing position (Krishnan *et al.*, 2023). In commercial poultry, high production has made broilers more vulnerable to environmental stressors. The insulation provided by feathers in birds is one of the major hindrances in birds' thermoregulation (Barve *et al.*, 2021).

Physiological responses play a vital role in alerting the presence of heat stress in the body and these can be assessed by rectal temperature (RT), pulse rate (PR), respiratory rate (RR) and body or skin temperature (ST) (Adedeji *et al.*, 2015). Altan *et al.* (2003) found that high ambient temperature and humidity increase heat stress, which raises the rectal or body temperature of birds.

Haematological parameters are often used as indicators of a broiler's response to heat stress (Afolabi *et al.*, 2010). Heat stress induces physiological changes that are reflected in blood parameters, including red blood cell (RBC) count, haemoglobin levels, haematocrit and white blood cell (WBC) count. Changes in these haematological indices are often associated with the body's adaptive mechanisms to tolerate heat, such as increased blood circulation to the skin and changes in metabolic rate (Mylostyvyi, 2025). In heat-stressed broilers, a common response is an increase in RBC count and haemoglobin concentration (Ayo and Ogbuagu, 2021),

which helps improve oxygen delivery to tissues that may be compromised due to increased body temperature. Additionally, an elevated WBC count may indicate an immune response to stress or inflammation (Wlaźlak *et al.*, 2023). Monitoring these haematological changes is vital for assessing the severity of heat stress and evaluating the effectiveness of breeding or management interventions aimed at improving heat tolerance.

Materials and Methods

Experimental Site

The experiment was conducted at the Poultry Unit of the Teaching and Research Farm of the Department of Animal Science, Al-Hikmah University, Igbaja Campus, Kwara State located approximately 56kms north-east of Ilorin and north-north-east of Ajase-Ipo, on Latitude 8°23'60"N and Longitude 4°53'60"E at an altitude of 394.97 meters and 1295.83 feet above sea level (Google map). The blood profile analysis was carried out at Central Research Laboratory, Ilorin, Kwara State located on latitude 8°30'0"N and longitude 4°32'60"E (Google, 2023).

Experimental Animals

Data was generated from two-hundred-day-old chicks of mixed sex comprising of fifty chicks per strain of broiler namely Arbor Acre from Amo Farms in Oyo, Cobb 500 from Zartech Farms, Oluyole, Ibadan; Ross 308 from Agrited Nigeria Limited, Alomaja Ibadan and Arbor Acre Plus from CHI Farms Ibadan all in Oyo State. Birds were raised in a deep litter system which was divided into five cells containing forty birds per cell thereafter; the birds were weighed, leg banded individually and later wing tagged at 4 weeks for easy identification.

Brooding and Rearing Management

Prior to the arrival of the day-old chicks, the brooder pen was washed with Lysol® and fumigated with formaldehyde, lime and potassium permanganate. The dimension of each brooder pen was 10m × 10m. Wood-shaving was spread on the floor of

each cell and heat source was placed at the centre of each cell to provide warmth for the chicks. At the arrival of the chicks, they were given multi vitamin drugs which served as an anti-stress. The chicks were brooded for two weeks. Adequate heat, ventilation, medication and feeding were provided. The chicks were duly vaccinated and antibiotics was administered as required. The litter was changed at five days intervals to prevent accumulation of ammonia gas. All chicks remained on deep-litter throughout the period of the experiment.

Experimental Feeds and Feeding

The birds were given *ad libitum* access to commercial feed and water throughout the experiment. All birds were placed on convectional broiler starter crumble containing 21.0% Crude Protein and 2900kcal/kg Metabolizable Energy for four weeks and finisher pellet containing 17.0% Crude Protein and 3000kcal/kg Metabolizable Energy till the end of the experiment.

Experimental Design

Randomized Complete Block Design (RCBD) in a 4 x 2 factorial arrangement was used for this research because day-old chicks of four genotypes comprising of ten birds per strain were randomly assigned to each cell, sex of the birds were noted and they were raised under the same environmental condition and routine management practices.

Physiological Response to Heat Sampling

The experiment was carried out in the dry season between December to March. At four weeks of age, 80 birds were randomly selected, comprising of 16 birds per cell (2 males and 2 females), afternoon reading was taken between the hour of 1300hrs and 1500hrs two times every four weeks.

Respiratory Rate (breath/min): This was measured by counting the movement of the flank per minute using a stopwatch and recorded as breath per minute.

Pulse Rate (beat/min): This was determined with the use of stethoscope per minute using a

stopwatch and recorded as beat per minute.

Rectal Temperature (T^oc): Data was determined with the use of digital rectal thermometer inserted in the cloaca of the birds about 5cm deep for one minute and recorded.

Skin or Body Temperature (°c): This was taken with the use of digital thermometer placed on the skin for one minute and recorded.

Heat Stress Index: This was derived from the relationship between observed pulse and respiratory rate together with their normal values.

The formula is as follow: $H = AR/AP \times NP/NR$ (Yakubu *et al.*, 2018)

Where; H=Heat stress index

AR= Observed respiratory rate

AP= Observed pulse rate

NP= Normal pulse rate (beat per minute)

NR= Normal respiratory rate (breath per minute)

Haematological Parameters

At 12 weeks of age, 1ml of blood samples were collected from twenty-four six birds comprising of 3 males and 3 females from each genotype. Blood was collected with syringe via brachial vein as described by Ayorinde *et al.* (2001) and Sewalem *et al.* (2002) using a sterile 5ml syringe and needles into ethylene diamine tetra acetic acid (EDTA) bottles. The following parameters were determined; Mean Corpuscular Volume (fL), Mean Corpuscular Haemoglobin (pg), Mean Corpuscular Haemoglobin Concentration (g/dL), Haematocrit (%), Platelet ($\times 10^3/\mu\text{L}$), Red blood cell ($\times 10^6/\mu\text{L}$), White blood cell ($\times 10^3/\mu\text{L}$), Neutrophils ($\times 10^3/\mu\text{L}$), Eosinophils ($\times 10^3/\mu\text{L}$), Lymphocytes ($\times 10^3/\mu\text{L}$), Basophils ($\times 10^3/\mu\text{L}$), Monocytes ($\times 10^3/\mu\text{L}$).

Haemoglobin (g/dL) and Packed Cell Volume (%) was measured using an automated cell counter within 24 hours after collection of blood (Subhadarsini, *et al.*, 2020). Haemoglobin (Hb) concentration was estimated using haemoglobinometer and Packed Cell Volume (PCV) was determined using the micro haematocrit method. Differential leukocyte count and RBC, WBC

counting was carried out using compound microscope. The Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC) was determined (Subhadarsini, *et al.*, 2020).

The following formulars were used in estimation of:

MCV in femtolitre (fL) = $10 \times \text{PCV (\%)/RBC counts (millions/\mu)}$

MCH in pg/cell = $\text{haemoglobin (g/100 ml)/RBC counts (millions/\mu)}$

MCHC in g/dl = $\text{haemoglobin (g/100 ml)} \times 100/\text{PCV (\%)}$

Statistical Analysis

The data of both physiological response and haematology were subjected to the procedure of General Linear Model of SAS 9.4 (2023) and significant means was separated by Duncan Multiple Range Test.

Model for Physiological Response and Haematology

$$Y_{ijk} = \mu + G_i + S_j + e_{ijk}$$

Where,

Y_{ijk} = Response variable (RR, RT, PR, ST)

μ = Overall mean

G_i = Fixed effect of i^{th} genotype ($i = 1, 2, 3, 4$)

S_j = Fixed effect of j^{th} sex ($j = 1, 2$)

Table 1: Mean values of physiological response parameters as affected by sex of broiler genotypes at week 4

GEN	OBS	RR (breath/min)	PR (beat/min)	RT (T°C)	ST (°C)	HSI
AA	20	74.80±2.38 ^b	79.55±2.80 ^a	41.69±0.09 ^a	8.73±0.12	41.59±0.08
AAP	20	75.65±1.50 ^a	79.30±1.94 ^a	41.76±0.09 ^a	8.74±0.09	41.58±0.14
COBB	20	73.35±2.41 ^c	75.90±2.54 ^c	40.23±1.55 ^b	8.83±0.07	41.69±0.07
ROSS	20	74.00±2.07 ^b	77.65±2.56 ^b	41.59±0.10 ^a	8.74±0.08	41.43±0.12
SEX						
MALE	40	73.93±1.55 ^b	78.95±1.04 ^b	41.73±0.06 ^a	41.61±0.06	8.72±0.07
FEMALE	40	74.98±1.43 ^a	79.75±1.16 ^a	40.91±0.77 ^b	41.54±0.09	8.80±0.06

^{abc} = Means occupying the same column having different superscripts are significantly different ($P < 0.05$).

OBS = Number of observations, **GEN** = Genotype, **AA** = Arbor Acre, **AAP** = Arbor Acre Plus, **COBB** = Cobb 500, **ROSS** = Ross 308, **RR** = Respiratory rate, **PR** = Pulse rate, **RT** = Rectal temperature, **ST** = Skin temperature and **HSI** = Heat Stress Index.

e_{ijk} = Experimental error which is evenly distributed

Results and Discussion

The mean values of Respiratory Rate (RR), Pulse Rate (PR), Rectal Temperature (RT), Skin Temperature (ST) and Heat Stress Index (HSI) as affected by genotype of Arbor Acre (AA), Arbor Acre Plus (AAP), Cobb 500 and Ross 308 broiler chickens at week 4, 8 and 12 are shown in Table 1 to 3. The result showed that genotype had a significant ($P < 0.05$) effect of genotype on RR, PR and RT at week 4, RR, PR, ST at week 8 and RR, PR, RT and ST at week 12. The rectal temperature was quite unstable throughout the experiment which ranges from 40°C to 42°C at week 12. The skin temperature remained within the limit of 41°C throughout the experiment. AAP exhibited the highest value of RR at week 4, AA had highest mean values of RR and PR at week 8 while Ross was observed with the highest RR and PR at week 12.

Table 1 to 3 also showed significant ($P < 0.05$) effect of sex on RR, PR and RT at week 4, RR, PR and ST at week 8 and RR, PR, ST at week 12. Male chicken had higher RR, PR and RT at week 4, higher RR, PR, ST at week 8 and higher RR, PR, ST at week 12.

Table 2: Mean values of physiological response parameters as affected by sex of broiler genotypes at week 8

GEN	OBS	RR (breath/min)	PR (beat/min)	RT (T°C)	ST (°c)	HSI
AA	20	78.65±3.16 ^a	84.70±3.14 ^a	41.78±0.16	8.51±0.19	40.47±0.20 ^b
AAP	20	74.55±3.29 ^c	79.05±2.30 ^c	41.88±0.21	8.59±0.24	40.94±0.33 ^b
COBB	20	75.75±2.72 ^c	80.65±2.85 ^b	41.97±0.19	8.64±0.24	41.23±0.16 ^a
ROSS	20	76.75±3.18 ^b	82.60±2.47 ^b	41.96±0.12	8.62±0.45	41.48±0.17 ^a
SEX						
MALE	40	78.90±2.23 ^a	82.38±1.82 ^a	41.00±0.11	41.51±0.10 ^a	8.81±0.24
FEMALE	40	73.95±2.04 ^b	81.12±2.02 ^b	41.80±0.12	40.55±0.20 ^b	8.34±0.23

^{abc} = Means occupying the same column having different superscripts are significantly different (P< 0.05).

OBS = Number of observations, **GEN** = Genotype, **AA** = Arbor Acre, **AAP** = Arbor Acre Plus, **COBB** = Cobb 500, **ROSS** = Ross 308, **RR** = Respiratory rate, **PR** = Pulse rate, **RT** = Rectal temperature, **ST** = Skin temperature and **HSI** = Heat Stress Index.

The mean values of interaction effect of genotype and sex on physiological response parameters are represented in Table 4, 5 and 6 at week 4, 8 and 12 respectively. There was a significant (P<0.05) interaction of genotype and sex effect on RR and PR at week 4. An interaction effect was also observed in RR, PR, RT and HSI at week 8 and RR, PR, RT and ST at week 12. AA female had the highest RR while AAP male had highest PR at week 4. Ross female was observed with highest RR while AA female had the highest PR at week 8. At week 12, Ross male exhibited the highest RR and PR.

The mean values of genotype effect on the heamatological parameters Arbor Acre, Arbor Acre Plus, Cobb and Ross at 12 weeks of age are presented in Table 7. The results showed that genotype had significant (P<0.05) effect on packed cell volume (PCV), haemoglobin (Hb), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin

concentration (MCHC), white blood cell (WBC), neutrophils (N), lymphocytes (L), monocytes (M), basophils (B), eosinophils (E) and platelet (PLT) except for red blood cell. Arbor Acre had the highest values of PCV, HB, B and E. Cobb had exhibited highest values of MCH, MCHC and N. Arbor Acre Plus had the highest value of WBC, L and M while the highest value PLT was observed in Ross.

The mean values of sex effect on haematological parameters of AA, AAP, Cobb and Ross chickens at week 12 are presented in Table 8. The result revealed that sex had significant (P<0.05) effect on packed cell volume PCV, HB, MCV, MCH, MCHC, WBC, L and PLT except for RBC, E and B. The values for Hb, MCV, MCH, MCHC, WBC, N and M in each parameter was higher in female chickens when compared to male except for PVC, L and PLT that were higher in male chickens.

Table 3: Mean values of physiological response parameters as affected by sex of broiler genotypes at week 12

GEN	OBS	RR (breath/min)	PR (beat/min)	RT (T°C)	ST (°C)	HSI
AA	18	84.10±3.29 ^b	83.65±3.03 ^b	41.99±0.17 ^b	9.27±0.21	40.99±0.16 ^b
AAP	20	76.35±3.74 ^c	75.50±3.08 ^c	42.07±0.15 ^a	9.30±0.15	40.99±0.16 ^b
COBB	20	80.00±3.59 ^b	78.30±3.68 ^c	42.06±0.11 ^a	9.50±0.26	41.16±0.17 ^a
ROSS	15	90.05±3.99 ^a	87.20±3.09 ^a	42.07±0.12 ^a	9.46±0.15	41.03±0.17 ^a
SEX						
MALE	33	84.15±3.21 ^b	82.08±2.42 ^a	42.08±0.11	41.09±0.12 ^a	9.42±0.13
FEMALE	40	81.10±2.88 ^a	80.25±2.36 ^b	42.02±0.09	40.99±0.10 ^b	9.34±0.15

^{abc} = Means occupying the same column having different superscripts are significantly different (P< 0.05).

OBS = Number of observations, **GEN** = Genotype, **AA** = Arbor Acre, **AAP** = Arbor Acre Plus, **COBB** = Cobb 500, **ROSS** = Ross 308, **RR** = Respiratory rate, **PR** = Pulse rate, **RT** = Rectal temperature, **ST** = Skin temperature and **HSI** = Heat Stress Index.

Table 4: Interaction effect of genotype and sex on physiological parameters of broiler chickens at week 4

GEN	OBS	RR (breath/min)	PR (beat/min)	RT (T°C)	ST (°C)	HSI
ROSS MALE	10	72.20±3.53 ^c	76.70±3.34 ^c	41.70±0.09	41.49±0.16	8.64±0.13
ROSS FEMALE	10	75.80±2.22 ^b	78.60±2.93 ^b	41.48±0.17	41.37±0.18	8.84±0.10
AA MALE	10	72.50±2.29 ^c	77.60±2.33 ^b	41.63±0.15	41.53±0.12	8.58±0.19
AA FEMALE	10	77.10±3.21 ^a	79.50±3.63 ^a	41.75±0.12	41.65±0.11	8.88±0.13
COBB MALE	10	73.00±3.11 ^c	75.80±3.17 ^c	41.84±0.11	41.68±0.09	8.90±0.07
COBB FEMALE	10	72.80±2.77 ^c	76.00±3.15 ^c	41.67±0.09	41.70±0.12	8.76±0.12
AAP MALE	10	72.10±2.28 ^c	80.90±3.13 ^a	41.75±0.14	41.74±0.14	8.75±0.16
AAP FEMALE	10	74.20±1.96 ^b	77.70±2.35 ^b	41.76±0.11	41.42±0.24	8.74±0.11

^{abc} = Means occupying the same column having different superscripts are significantly different (P< 0.05).

OBS = Number of observations, **GEN** = Genotype, **AA** = Arbor Acre, **AAP** = Arbor Acre Plus, **COBB** = Cobb 500, **ROSS** = Ross 308, **RR** = Respiratory rate, **PR** = Pulse rate, **RT** = Rectal temperature, **ST** = Skin temperature and **HSI** = Heat Stress Index.

Table 5: Interaction effect of genotype and sex on physiological parameters of broiler chickens at week 8

GEN	OBS	RR (breath/min)	PR (beat/min)	RT (T°C)	ST (°C)	HSI
ROSS MALE	10	84.20±3.62 ^a	84.20±3.86 ^a	42.25±0.12 ^a	40.71±0.26 ^b	9.33±0.76
ROSS FEMALE	10	89.30±4.85 ^a	80.60±3.17 ^b	41.68±0.15 ^b	40.25±0.20 ^b	9.92±0.40
AA MALE	10	78.30±3.29 ^b	84.30±2.69 ^a	41.69±0.23 ^b	40.57±0.22 ^b	8.45±0.28
AA FEMALE	10	79.00±3.87 ^b	85.10±2.70 ^a	41.86±0.22 ^b	40.37±0.34 ^b	8.57±0.27
COBB MALE	10	76.60±2.26 ^b	80.50±2.59 ^b	42.02±0.25 ^a	40.16±0.17 ^b	8.78±0.40
COBB FEMALE	10	74.90±2.58 ^c	80.80±3.64 ^b	41.92±0.28 ^b	40.29±0.29 ^b	8.50±0.29
AAP MALE	10	76.50±2.26 ^b	80.10±3.47 ^b	42.03±0.27 ^a	40.61±0.16 ^b	8.69±0.38
AAP FEMALE	10	72.60±2.15 ^c	78.00±2.17 ^c	41.73±0.33 ^b	41.28±0.63 ^a	8.49±0.31

^{abc} = Means occupying the same column having different superscripts are significantly different (P< 0.05).

OBS = Number of observations, **GEN** = Genotype, **AA** = Arbor Acre, **AAP** = Arbor Acre Plus, **COBB** = Cobb 500, **ROSS** = Ross 308, **RR** = Respiratory rate, **PR** = Pulse rate, **RT** = Rectal temperature, **ST** = Skin temperature and **HSI** = Heat Stress Index.

Table 6: Interaction effect of genotype and sex on physiological parameters of broiler chickens at week 12

GEN	OBS	RR (breath/min)	PR (beat/min)	R T (T ^o c)	S T (^o c)	HSI
ROSS MALE	5	94.00±4.18 ^a	89.70±4.01 ^a	42.21±0.08 ^a	41.25±0.25 ^a	9.59±0.24
ROSS FEMALE	10	86.10±3.85 ^b	84.70±4.55 ^b	41.93±0.20 ^b	40.81±0.21 ^b	9.32±0.20
AA MALE	8	88.20±3.95 ^b	87.30±4.89 ^a	42.00±0.32 ^a	41.11±0.26 ^a	9.28±0.23
AA FEMALE	10	80.00±3.95 ^b	80.00±4.57 ^b	41.98±0.15 ^b	40.86±0.18 ^b	9.25±0.35
COBB MALE	10	77.70±2.43 ^c	75.20±3.59 ^c	41.99±0.17 ^b	41.19±0.19 ^a	9.57±0.03
COBB FEMALE	10	82.30±3.09 ^b	81.40±4.82 ^b	42.13±0.15 ^a	41.13±0.27 ^a	9.44±0.41
AAP MALE	10	76.70±2.81 ^c	76.10±3.10 ^c	42.13±0.22 ^a	40.80±0.28 ^b	9.24±0.20
AAP FEMALE	10	76.00±2.15 ^c	74.90±3.82 ^c	42.02±0.22 ^a	41.17±0.15 ^a	9.35±0.25

^{abc} = Means occupying the same column having different superscripts are significantly different (P< 0.05).

OBS = Number of observations, **GEN** = Genotype, **AA** = Arbor Acre, **AAP** = Arbor Acre Plus, **COBB** = Cobb 500, **ROSS** = Ross 308, **RR** = Respiratory rate, **PR** = Pulse rate, **RT** = Rectal temperature, **ST** = Skin temperature and **HSI** = Heat Stress Index.

Table 7: Mean values of genotype effect on the haematological parameters of chickens at 12 weeks of age

PARAMETERS (n=24)	GENOTYPE			
	AA	AAP	COBB	ROSS
PCV (%)	22.00±2.69 ^b	23.67±2.16 ^a	16.67±1.91 ^d	19.17±2.24 ^c
HCT (%)	0.22±0.03	0.22±0.02	0.17±0.02	0.19±0.02
Hb (g/dL)	15.00±13.20 ^a	13.83±8.60 ^c	9.17±14.78 ^d	14.67±8.8 ^b
RBC (x10 ⁶ /μL)	1.66±0.33	1.87±0.16	1.58±0.15	1.57±0.13
MCV (fL)	107.33±13.33 ^b	119.17±17.27 ^a	107.67±13.46 ^b	119.83±17.34 ^a
MCH (pg)	84.50±24.56 ^b	61.33±22.19 ^d	85.33±20.70 ^a	70.00±22.95 ^c
MCHC (g/dv)	508.17±80.55 ^d	552.83±74.18 ^c	643.00±95.03 ^a	640.00±82.65 ^b
WBC (x10 ³ /μL)	98.67±10.10 ^b	106.83±5.19 ^a	66.67±19.67 ^d	94.83±7.94 ^c
N (x10 ³ /μL)	19.17±4.08 ^d	26.83±5.68 ^c	32.67±3.30 ^a	28.67±4.31 ^b
L (x10 ³ /μL)	65.17±4.42 ^b	69.17±5.71 ^a	61.33±5.52 ^c	60.33±6.07 ^d
M (x10 ³ /μL)	5.83±2.02 ^b	6.50±1.84 ^a	4.17±0.96 ^c	6.33±1.28 ^a
B (x10 ³ /μL)	6.33±1.18 ^a	4.17±1.62 ^b	1.17±0.65 ^d	2.67±0.42 ^c
E (x10 ³ /μL)	3.50±1.06 ^a	3.33±1.57 ^a	1.67±0.33 ^c	2.00±0.93 ^b
PLT (x10 ³ /μL)	41.88±12.21 ^d	56.67±18.91 ^c	65.50±9.51 ^b	70.67±45.01 ^a

^{abcd} = Means occupying the same row having different superscripts are significantly different (P<0.05).

PCV= Packed Cell Volume, HCT=Haematocrit, Hb= Haemoglobin, RBC= Red Blood Cell, MCV= Mean Corpuscular Volume, MCH= Mean Corpuscular Haemoglobin MCHC= Mean Corpuscular Haemoglobin Concentration, WBC= White Blood Cell, N= Neutrophils L= Lymphocytes, M= Monocytes, B= Basophils, E= Eosinophils, PLT= Platelet

Table 8: Pool mean values of sex effect on the haematological parameters of chickens at 12 weeks of age

PARAMETERS (n=24)	SEX	
	MALE	FEMALE
PCV (%)	20.17±1.64 ^a	19.58±1.68 ^b
HCT (%)	0.20±0.02	0.19±0.02
HB (g/dL)	99.33±8.05 ^b	109.50±9.05 ^a
RBC (x10 ⁶ /μL)	1.67±0.12	1.67±0.16
MCV (fL)	122.92±8.44 ^a	104.08±9.13 ^b
MCH (pg)	74.92±10.39 ^b	75.67±12.16 ^a
MCHC (g/dL)	558.08±54.3 ^b	613.92±61.82 ^a
WBC (x10 ³ /μL)	82.92±9.47 ^b	100.58±8.60 ^a
N (x10 ³ /μL)	21.58±2.66 ^b	27.08±4.02 ^a
L (x10 ³ /μL)	67.17±4.07 ^a	60.83±3.32 ^b
M (x10 ³ /μL)	5.25±0.92 ^b	6.17±1.19 ^a
B (x10 ³ /μL)	3.75±1.12	3.42±0.67
E (x10 ³ /μL)	2.25±1.24	2.50±0.69
PLT (x10 ³ /μL)	44.83±13.70 ^a	42.50±12.01 ^b

^{ab} = Means occupying the same row having different superscripts are significantly different (P<0.05).

PCV= Packed Cell Volume, HCT=Haematocrit, HB= Haemoglobin, RBC= Red Blood Cell, MCV= Mean Corpuscular Volume, MCH= Mean Corpuscular Haemoglobin MCHC= Mean Corpuscular Haemoglobin Concentration, WBC= White Blood Cell, N= Neutrophils L= Lymphocytes, M= Monocytes, B= Basophils, E= Eosinophils, PLT= Platelet

Genetic makeup significantly influences the physiological traits of broilers such as rectal temperature, skin temperature, respiration rate and pulse rate (Lakurbe *et al.*, 2018). The study observation on physiological study revealed differences among the four broiler strains indicating a strong genetic basis for these traits as reported by Sunmola *et al.* (2019). The results of this experiment confirmed that physiological responses of chicken are genotype-dependent, aligning with the findings of Adedeji *et al.* (2015), who reported that genotype had a significant impact on all physiological parameters in chickens.

The rectal temperature was quite unstable throughout the experiment which ranges from 40°C at 4th week to 42°C at 12th week which supports the works of Arogbodo *et al.* (2020). However, the increased rectal temperature at high ambient temperature, considerably affected the physiological responses of all broiler strains which showed increased respiratory rates and rectal temperatures, suggesting heat stress response.

This finding is in agreement with Yahav *et al.* (1997), who documented increased panting and elevated body temperatures in broilers under heat stress conditions, irrespective of genetic background, although the severity of response varied by strain.

The skin or body temperature remained within the limit of 41°C throughout the experiment. However, the skin temperature corresponded with the study of Teeter *et al.* (1992) that normal skin temperature of the chickens is 41°C and also Justin (2009) reported that body temperature of the birds must remain within the narrow limits of 41°C. The rectal temperature at 4th and 8th week was in line with the work of Isidahomen *et al.* (2012) which observed values for rectal temperature within the limits of 41°C on the locally adapted chickens raised in the southern part of Nigeria. The result also showed an agreement with Abioja *et al.* (2014) in which temperature of the rectum was used as a major indicator of heat stress in poultry.

Arbor Acre Plus had the lowest respiratory and pulse rate at 8th and 12th weeks which disagreed to the findings of Ayo *et al.* (2011), that Ross showed the lowest respiratory rate indicating that the strain had a better adaptability at high ambient temperature. The differences in respiratory rates among genotypes could be attributed to genetic variation affecting the metabolic efficiency and stress resilience as affirmed by Adedeji *et al.* (2015). At 12th week, Ross genotype exhibited the highest respiratory rate with a reduction in feed intake at high temperature of about 38°C which was in agreement with Olukomaiya *et al.* (2015) who observed that Ross broilers with significant decreased feed intake and weight gain when exposed to high ambient temperatures as a representative of summer. Higher pulse rate in Ross could be an indicative of increased metabolic activities therefore, the lower pulse rate in AAP suggests better adaptability compared to other genotypes at early age (Olanrewaju *et al.*, 2010).

Haematological examination contributes immensely to detection of some changes in the health status of birds that may not be obvious at the time of physical examination but undoubtedly affect the fitness of the birds (Lakurbe *et al.*, 2018). Having its knowledge can be used to assess the health as well as the physiological status of farm animals. They are also useful diagnostic tool for the nutritional, physiological and health status of livestock (Adeyemi *et al.*, 2016; Odhaib *et al.*, 2018). Haematological parameters such as PCV, Hb and WBC also showed significant variation among the four strains. This suggests inherent genetic control over hematopoiesis and immune response efficiency.

The packed cell volume or haematocrit measures the volume or percentage of RBC in the blood, and is a reliable indicator of stress in livestock (Altan *et al.*, 2000). PCV values in this experiment were within the range recorded by Subhadarsini *et al.* (2020) in indigenous Vanaraja and Broiler chicken. However, it negates the findings of

Nosike *et al.* (2017) which state that genotype had no significant effect. El-Safty *et al.* (2006) reported that higher PCV values are usually due to a higher weight gain as well as reduction in heat load. However, this did corroborate with the current study because AA had the least body weight but with the highest PCV values. The haematological values for Cobb and Ross reported for packed cell value (PCV) were lower than the recommendation of Baudouin *et al.* (2021) and Benerjee (2008). Jain, (1993) recommended the PCV of 22 – 35% for avian species to be healthy which actually agreed with the PCV results of AA and AAP in this study. Ilo *et al.* (2019) also had the same range of PCV value for broiler chickens in their study, this also agreed with the values reported in this study.

Haemoglobin present in the RBC carries oxygen from the lungs to body tissues, and transports carbon dioxide from the tissue to the lungs (MVM, 2016). Since haemoglobin is responsible for cellular respiration which is important in metabolic reactions (Mc Donald *et al.*, 2002), a decrease in haemoglobin is an important determinant of anaemia which may probably lead to reduction in the oxygen carrying capacity of blood. Haemoglobin concentration in the blood has been associated with availability of nutrient to the animal (Esonu *et al.*, 2001; Iheukwumere and Herbert, 2002; Egu and Ukpabi 2015). These values of haemoglobin obtained in this research were within the normal range reported by Banerjee (2007) but higher than what Iheukwumere *et al.* (2006) reported for Nigerian indigenous chickens. Higher Hb levels in AA possibly indicating a superior oxygen-carrying capacity, which may contribute to better growth and resilience. These results correspond with the findings of Oke *et al.* (2017), who reported breed-specific differences in haematological indices in broilers, pointing to genetic influence on blood physiology.

Similarly, Taha and Abd El-Hack (2018) highlighted that improved haematological profiles in certain strains are often genetically driven and can be used as indicators of overall health and performance

potential. The Red Blood Cell values obtained in this study were not within the range of reported Subhadarsini *et al.* (2020) for indigenous Vanaraja and broiler chicken. Haemoglobin values were in line with the recommendation of Sunmola *et al.* (2019) for avian blood. The values for RBC were in line within the range reported by Arogbodo *et al.* (2020) but lower than that of Baudouin *et al.* (2021). The MCV as observed in this study were higher than the recommended values (Bounous and Stedman 2000). Mean corpuscular volume and white blood cell were lower than the range reported by Subhadarsini *et al.*, (2020)

for indigenous Vanaraja and broiler chicken. The values of RBC obtained were in line with the range reported by Arogbodo *et al.* (2020) but lower than Baudouin *et al.* (2021). Haemoglobin values were in line with Sunmola *et al.* (2019) for avian blood. The MCV as observed in this study were higher than the recommended values (Bounous and Stedman, 2000). The MCV and WBC obtained were lower than the range reported by Subhadarsini *et al.* (2020) for indigenous Vanaraja and broiler chicken except for MCH, MCHC, lymphocytes, monocytes and eosinophils (Subhadarsini *et al.*, 2020). Furthermore, the WBC and its components, play a phenomenal role in the immune system, as they protect the body against foreign bodies that can threaten its functionality (Odhaib *et al.*, 2018).

Heat stress can induce haematological changes irrespective of genetic strain. The current study observed a general reduction in WBC count during peak temperature periods, suggesting stress-induced immunosuppression across all strains. The neutrophils and lymphocytes were higher and lower respectively and disagreed with the work of Arogbodo *et al.* (2020) for broiler chickens. There was a significant difference in the values of monocytes obtained in this study which were lower than the value reported by Sebastian *et al.* (2012). The range of values obtained for basophils was higher than the value reported for broiler chicken by Nemi

(1993) but was within the range recorded by Asaniyan and Akinduro (2020). The range of value obtained for eosinophils was within range documented by Asaniyan and Akinduro (2020) and also similar to the values reported by Nemi (1993) for broiler chickens. The basophils and eosinophils are not within the range reported by Arogbodo *et al.* (2020). Furthermore, Mignon-Grasteau *et al.* (2005) emphasized that selection programmes in poultry breeding should consider environmental adaptability in addition to growth performance, as physiological and haematological stability under variable conditions is crucial for overall productivity.

Conclusion and Recommendation

This study showed that genotype and sex significantly affect physiological response in four strains of broiler. AAP exhibited better heat tolerance with low and stable respiratory rate and pulse rate as the age increased indicating that this genotype had greater thermal adaptability in high ambient environment. Male chickens had a slightly higher respiratory rate and pulse rate compared to females; this could be an indication that male chickens were struggling to adapt to high temperature as the age increased. The interaction between genotype and sex was evident, where Ross males and females had a slightly higher HSI compared to other strains, this could be an indication that Ross chickens were struggling to regulate their body temperature.

There was a significant effect of genotype and sex on all haematological parameters except red blood cell count and haematocrit suggesting that genetic makeup affects the overall health and immune status of the birds. Arbor Acre Plus exhibited highest PCV and WBC indicating absence of anaemia and healthy immune system. Based on their superior heat tolerance, stable physiological responses and strong immune profile, Arbor Acre Plus (AAP) chickens are recommended for production in high ambient temperature environments.

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