FUNCTIONAL RESPONSES OF FIVE-CHICKEN GENOTYPES RAISED DURING DRY PERIOD IN HUMID TROPICAL CLIMATE

ATANSUYI, Adewale Johnson
Animal Breeding and Genetics Unit, Department of Animal Production and Health,
The Federal University of Technology, Akure, Ondo State, Nigeria
E-mail: ajatansuyi@futa.edu.ng; Tel: +2348034832175

ABSTRACT
The study was conducted to evaluate the effect of genotype and sex on the physiological responses of 5-chicken genotypes raised during dry period of the year in humid tropical environment. Five hundred chicks comprising 5 genotypes at 100 each were raised for eight weeks. Each genotype was further divided into two, based on their sexes and replicated 5 times at 10 birds per replicate. Physiological data via ambient and rectal temperatures, heartbeat rate, relative humidity and temperature-humidity index were collected to determine the health performance of the birds using appropriate statistical software. Results showed that the average relative humidity, ambient temperature and temperature humidity index (THI) during the experimental period were 62.43%, 23.57°C and 25.05 respectively. The heartbeat rate and rectal temperature were significantly ($p<0.05$) different amongst genotypes in the morning and evening while these values were higher in males than females in the morning. However, there was no difference in the physiological responses between the sexes in the evening. The study concluded that Arbor-Acre chickens performed better and possessed better innate thermoregulatory mechanisms for adaptability in tropical environment than the other imported genotypes. The birds should be considered in areas with high temperature humidity index. The result of this study may be used to design breeding plans for better adaptability and improvement in the health performances of avian species, especially the exotic stocks, when an unexpected rise in environmental temperature occurred.
Keywords: Temperature, relative humidity, broilers, improvement, indigenous chickens,

INTRODUCTION

Poultry production is considered one of the most popular options in reducing the incidence of protein malnutrition and its attendant deficiency symptoms in the diets of Nigerian populations (Obasoya *et al.,* 2005). Researches to improve the potential of broiler genotypes to provide high-quality meat at a lower cost within the shortest time possible has been going-on till date (Kemp and Kenny, 2003). In this wise, many genotypes of broiler chickens have been imported into the country and the performances of these birds are affected by either or combination of genotype and genotype-environment interactions. Genotype and its interaction with the environment may cause loss of fitness traits for those genotypes not suited to a particular environment. Apart from genotype, the sex of broiler chickens has a significant effect on their performance traits including body weight, weight gain, feed intake and feed conversion ratio (Shahin and Elazeen, 2005; Ajayi and Ayorinde, 2009; Ajayi and Ejiofor, 2009).

High ambient temperature, whether 'acute' or 'chronic' in nature, significantly hinders the functional performance of animals. Reduced growth has been considered a problem of reduced feed intake (Azad *et al.*, 2021). Feed intake is inversely related to environmental temperature in chickens where reduced efficiency is a common phenomenon in hot conditions (Khan *et al.*, 2011). The increase in mitochondrial reactive oxygen species (ROS) production in acute heat-stressed birds may lead to decreased growth (Mujahid *et al.*, 2009; Ortega, 2018). This assumption was supported by a study that cyclic high temperature (28^0C–34^0C) slightly increased mitochondrial ROS generation and Malondialdehyde (MDA) contents in breast muscle and suppressed growth performance because both increments were not found in pair-fed broiler chickens groups kept at 24^0C (Ortega, 2018). Heat-induced ROS formation could therefore be responsible for growth retardation in chickens (Azad *et al.*, 2010). Mujahid *et al.* (2009) showed that 'acute' heat stress increased mitochondrial ROS production and oxidative damage in the skeletal muscle of broiler chickens (Cobb).

Reports about the effects of 'chronic' heat stress on broilers have mainly focused on growth performance, biochemical indices (Ahmed-Farid *et al.*, 2021) and pathological damage to tissue such as heart, liver, and kidney (Xu *et al.*, 2018). There were few reports on the comparative effects of chronic heat stress on oxidative stress in different strains of chickens. Therefore, this study was designed to examine the functional responses of five-chicken genotypes raised during dry period of the year in humid tropical climate with the view to findings the best genotype to rear in high-temperature seasons.

MATERIALS AND METHODS

Experimental Site

This research work was carried out at the Poultry Unit of the Teaching and Research Farm (Livestock Section) of the Federal University of Technology, Akure, Nigeria. Akure is situated on Latitude 7° 15'N and Longitude 5° 12' E in the humid rain forest zone of Western Nigeria which is characterized by two rainfall peaks and high humidity during the raining season (Agbelade and Akindele, 2013). The mean annual rain fall is about 1500mm and the rains last for about nine months usually March to November of every year. The mean annual relative humidity is over 75% while the mean annual temperature is about 25^0C.

Experimental Animal and Management

Five hundred (500) 1-day-old chicks of Arbor Acre, Hubbard, Marshall, Noiler and FUNAAB Alpha, consisting of 100 birds per genotype were purchased from reputable hatcheries in Ibadan and Abeokuta, Oyo and Ogun States, Nigeria. On arrival, the birds were weighed, divided into their sex at 50 chicks and randomly allotted into 5 replicates at 10 birds per replicate. Fresh feed and clean water were supplied *ad-libitum* daily for the 8 weeks period the experiment lasted. All routine and occasional practices were strictly adhered to during the period of this study.

Determination of Physiological Parameters

Rectal temperature (RT): The rectal temperature of the birds were taken twice daily at 6:00 GMT and 6:00 GMT in the morning and evening. A clinical thermometer was inserted into the cloaca of the bird gently and tilted to the side to touch the mucus membrane of the cloaca for a proper record. The thermometer was allowed to remain until a click sound was made from the thermometer.

Ambient temperature (T): The environmental temperature was taken daily in the morning and evening using a wall thermometer. **Heartbeat rate (HR)**: The heartbeat rates of the birds were taken using the stethoscope and recorded appropriately. **Relative humidity (RH)**: This was measured using a digital hygrometer and was recorded appropriately. **Temperature-humidity index (THI)**: From previous data, the respective THI for the morning and evening readings were calculated according to the model of Mack *et al*. (2013) for non-sweating animals i.e. THI = t – [0.31 – 0.31(RH/100)(t-14.4)]. Where: RH = Relative humidity; t = Dry bulb temperature (ambient temperature).

Data Analysis

All data collected were subjected to analysis of variance in a 2 × 5 factorial arrangements using the statistical software package SAS (2008) and Duncan Multiple Range Test (DMRT) of the same statistical package were used for mean separation at probability value of 0.05. The Results were depicted as Mean ± Standard Error of Mean. Statistical model specification: $Yijk = \mu + Gi + Sj + (GS)ij + \varepsilon_{ijk}$

Where: $Yijk$ = Individual observation, μ = General mean, Gi = Effect of Genotype, Sj = Effect of Sex, ε_{ijk} = Experimental error

RESULTS

The effects of genotype and sex on physiological responses of experimental birds is presented in Table 1. It was observed that all parameters examined in the morning were lower than that of the evening except the environmental temperature. The effect of genotype did not significantly influence (p>0.05) the parameters except the heartbeat rate (HR) and rectal temperature (RT) both for the morning and evening records. From the morning records, it was observed that the highest (306.76) HR was obtained from the Arbor Acre strain while the least (299.49) was recorded for the Noiler chickens. The evening HR was in the range of 309.61 to 310.97 from the least to the highest respectively. The highest (41.32) and least (41.04) RTs were obtained in α-FUNAAB and Hubbard chickens respectively. Similarly, it was observed that sex significantly (p<0.001) influenced the HR and RT both at morning and in the evening. The female birds were observed to have higher value of HR and RT during the two periods of the day. Moreover, the interaction between genotype and sex was observed to significantly influence (p<0.001) the HR and RT in the evening with the values ranging from 305.94 to 326.40 and 41.11 to 41.55, respectively

Table 1: Effects of genotype and sex on physiological responses of experimental birds

			Morning					Evening				
Genotype	**Sex**	**Interaction**	**RH (%)**	**T (^{0}C)**	**THI**	**HR**	**RT (^{0}C)**	**RH (%)**	**T (^{0}C)**	**THI**	**HR**	**RT (^{0}C)**
Noiler			62.43	23.57	25.05	299.49^c	41.12^b	61.71	30.29	33.01	309.77^b	41.17^c
Marshall			62.43	23.57	25.05	301.55^c	41.08^{bc}	61.71	30.29	33.01	309.82^b	41.18^c
Hubbard			62.43	23.57	25.05	304.28^b	41.32^a	61.71	30.29	33.01	309.61^b	41.50^a
Arbor Acre			62.43	23.57	25.05	306.76^a	41.02^c	61.71	30.29	33.01	316.17^a	41.17^c
α-FUNAAB			62.43	23.57	25.05	306.01^{ab}	41.04^c	61.71	30.29	33.01	310.97^b	41.26^b
± SEM			0.14	0.22	0.26	0.69	0.02	0.13	0.11	0.13	0.90	0.02
P-Value			1.00	1.00	1.00	0.001***	0.001***	1.00	1.00	1.00	0.001***	0.001***
	Male		62.43	23.57	25.05	301.62^b	41.07^b	61.71	30.29	33.01	309.50^b	41.23^b
	Female		62.43	23.57	25.05	305.62^a 0.51	41.17^a	61.71	30.29	33.01	313.04^a	41.28^a
	± SEM		0.14	0.22	0.26		0.02	0.13	0.11	0.13	0.67	0.02
	P-Value		1.00	1.00	1.00	0.001***	0.001***	1.00	1.00	1.00	0.001***	0.036*
Genotype*Sex	Male	Noiler	62.43	23.57	25.05	300.06	41.09	61.71	30.29	33.01	311.26	41.11
		Marshall	62.43	23.57	25.05	302.14	41.06	61.71	30.29	33.01	311.54	41.16
		Hubbard	62.43	23.57	25.05	303.63	41.27	61.71	30.29	33.01	309.94	41.55
		Arbor Acre	62.43	23.57	25.05	297.89	40.99	61.71	30.29	33.01	305.94	41.15
		α-FUNAAB	62.43	23.57	25.05	304.37	40.93	61.71	30.29	33.01	308.80	41.18
	Female	Noiler	62.43	23.57	25.05	298.91	41.15	61.71	30.29	33.01	308.29	41.22
		Marshall	62.43	23.57	25.05	300.96	41.10	61.71	30.29	33.01	308.10	41.20
		Hubbard	62.43	23.57	25.05	304.93	41.367	61.71	30.29	33.01	309.29	41.44
		Arbor Acre	62.43	23.57	25.05	315.63	41.05	61.71	30.29	33.01	326.40	41.18
		α-FUNAAB	62.43	23.57	25.05	307.66	41.15	61.71	30.29	33.01	313.14	41.33
		± SEM	0.19	0.27	0.33	0.97	0.03	0.26	0.44	0.53	1.27	0.03
		P-Value	1.00	1.00	1.00	0.001***	0.15	1.00	1.00	1.00	0.001***	0.001***

* Significant at p < 0.05; *** Significant at p < 0.01; ^{a,b} Means with different superscripts down the column are significantly different; T = Temperature; HR = Heart Rate; RT = Rectal Temperature, RH = Relative Humidity; THI = Temperature Humidity Index

DISCUSSION

Effects of strain and sex on physiological responses of experimental birds

Chickens are more sensitive to heat stress than other animals because they lack sweat glands, possess a high metabolic rate and their bodies are covered with feathers which hinder direct air penetration and cooling of the skin surface by convention (Park *et al.,* 2022). Environmental temperature, temperature-humidity index, rectal temperature and heart beat rate are often used as conventional means and markers to access heat stress (Goel *et al*., 2023). In this experiment, these parameters are highly influenced by environmental factors such as temperature, humidity and other weather conditions. Also, all physiological parameters evaluated in this study were lower in the morning except for the relative humidity as compared to the evening period in this study which could be linked to the variation in heat energy caused as a result of sunrise, solar radiation coupled with the earth cooling mechanism overnight which transit to lower temperature in the morning and higher relative humidity (Ettah *et al*., 2015). The thermo-neutral temperature for optimum performance is between 18-22^{0}C and 55 – 85% humidity for growing broilers (Charles, 2002). The ambient temperatures recorded in this study for morning and evening were higher than the values earlier reported (Charles, 2002). Poultry birds when in 'thermo-neutral zone', do not suffer from heat stress as body temperature is held constant and the birds lose heat at a controlled rate using normal behavior (Goel *et al*., 2023). However, any deviation from the thermo-neutral zone Results in heat stress, causing a negative balance between net amount of energy flowing from the bird's body to its surrounding environment and the amount of heat energy produced by the bird (Charles, 2002). The result obtained in Table 1 showed that the birds used for this study are under heat stress. It is expected that the growth and health performances of these birds would be negatively affected. It has been reported that thermo-neutral range are usually affected be season and period of the day (Park *et al.,* 2022).

To further evaluate the physiological responses of these birds, rectal temperature was also used in conjunction with temperature-humidity index (THI) as indices of heat stress. The THI is an example of indices developed to assess the impact of the thermal environment on the thermoregulatory status of animals (Purswell *et al*., 2012). Internal body temperature, as reflected by rectal temperature (RT), was significantly different among the five genotypes used in this study which was contrary to the report of Mutibvu *et al*. (2017). Measurement of heart rate suggest thermoregulatory efforts (panting and CO_2 elimination) has been reported to vary in livestock as a result of environmental factor, genetic variation, diseased condition and age difference (Robertshaw, 2006). Evaporative heat loss through panting is the most important mechanism used to control body temperature under heat stress (Robertshaw, 2006).

It was observed that the Arbor acres chickens had the highest (306.76) heartbeat rate which indicated that the environmental temperature had high impact on their gaseous exchange, increase the rate of panting and elimination of CO_2 as compared to other breeds like noiler which had the low heart rate value. This variation is traceable to the adaptability of the local breeds to the tropical environment while the exotics such as Arbor acres used in this study were neither indigenous nor adapted to the environmental elements in this region. Thus, this study reaffirm the fact that foreign breeds are more susceptible to heat stressors compared to the local or indigenous counterparts (Nawaz *et al*., 2021). The result obtained in this study may be the reflection of the consequences of an increased metabolic demand in heavier and exotic stocks (Korte *et al*., 1999). It is a fact that the body size affects tolerance to heat stress, the exotic chickens are less tolerant to heat stress than the tropically adapted chickens. This assertion corroborates the findings of this study. More so, crossbreeding might have led to reduced thermo-tolerance of the Noiler chickens. In addition, DEFRA (2003) opined that body weight, species and breed affected the heat production by poultry, thus, increase in ambient temperature led to increase panting rate consequently increases the respiratory rates. Besides, the observed changes in physiological parameters by the acute heat stressed birds could indicate an attempt to maintain thermal equilibrium. Thus, it was observed from this study that the birds were growing under heat stressed condition which could be regarded as moderate-chronic heat inducement due to the period of the year. This is capable of declining the growth performance of the birds. Conversely, birds tend to decrease their heat production by limiting feed consumption (Collin *et al*., 2012) leading to reduction in body weight gain.

CONCLUSION AND RECOMMENDATION

The Results obtained from this study revealed and reaffirmed earlier studies on physiological capabilities of chickens that genotype and sex significantly influenced overall performances of poultry birds. The male chickens had better physiological performances to heat stress than their female counterparts. The exotic birds had poorer response to heat stress as they were observed to have high rectal temperature and heart rate as compared to the improved indigenous genotypes with better thermoregulatory mechanisms and tolerate higher environmental temperatures.

It can be recommended from this study that the information provided can be utilized in breeding programmes for the adaptability of imported poultry stocks to tropical climate and improvement of the α-FUNAAB Nigerian chickens. Farmers can skillfully select best genotype of interest based on performance record provided and his/her market target. Further research on molecular classification and genotype identification is therefore recommended to investigate physiological traits that can be used to classify and distinguish the available genotypes of broiler chickens in Nigeria market as these information are dearth.

REFERENCES

Agbelade, A.D. and Akindele, S.O. (2013). Land use mapping and tree species diversity of Federal University of Technology, Akure. *American International Journal of Contemporary Research*, 3(2), 104-113.

Ahmed-Farid, A.O., Salah, A.S., Nassan, M.A. and El-Tarabany, M.S. (2021). Effects of chronic thermal stress on performance, energy metabolism, antioxidant activity, brain serotonin, and blood biochemical indices of broiler chickens. *Animals,* 11(9), 2554.

Ajayi, F. O., and Ayorinde, K. L. (2009). Effect of Sex on some Growth Criteria and carcass Yield in Cobb Broiler strain. *Nigerian Journal of Animal Production*, 36(1), 28-33.

Ajayi, F.O., and Ejiofor, O. (2009). Effects of genotype*sex interaction on growth and some development characteristics of Ross and Anak broiler strains in. *Asian Journal of Poultry Science*, 3(2), 51-56.

Azad, K.M., Kikusato, M., Hoque, A.M. and Toyomizu, M. (2010). Effect of chronic heat stress on performance and oxidative damage in different strains of chickens. *Journal of Poultry Science,* 47(4), 333-337.

Azad, M.A.K., Kikusato, M., Zulkifli, I., Rahman, M.M., Ali, M.S., Hashem, M.A. and Toyomizu, M. (2021). Comparative study of certain antioxidants-electrolyzed reduced water, tocotrienol and vitamin E in heat-induced oxidative damage and performance in broilers. *Meat Research,* 1(1).

Charles, D.R. and Walker, A.W. (2002). Poultry environment problems: a guide to solutions. Nottingham University Press.

Collin, A., Loyau, T., Bedrani, L., Berri, C., Metayer-Coustard, S., Praud, C. and Mignon-Grasteau, S. (2012). Adaptive response of chickens to hot environments induced by changing incubation temperature. In 24th World Poultry Congress. WPSA.

DEFRA (2003): Heat stress in poultry: Solving the problem. www.defra.gov.uk/animal/welfare/pdfhstress05.

Ettah, E., Ushie, P., Obiefuna, J., and Nwachukwu, N. (2015). Comparative study of the effects of relative humidity on solar electricity generation in UYO and Port-Harcourt, Nigeria. International *Journal of Mathematics and Physical Sciences Research*, 3(2), 66-70.

Goel, K., Kundu, P., Sharma, P. and Zinta, G. (2023). Thermosensitivity of pollen: a molecular perspective. *Plant Cell Reports*, 1-15.

Kemp, C., and Kenny, M. (2003). Feeding the modern broiler for more. *International Hatchery Practice,* 17, 11-13.

Khan, R.U., Naz, S., Nikousefat, Z., Tufarelli, V., Javdani, M., Rana, N. and Laudadio, V. (2011). Effect of vitamin E in heat-stressed poultry. *World's Poultry Science Journal,* 67(3), 469-478.

Korte, M., Sgoifo, A., Ruesink, W., Kwakernaak, C., Van Voorst, S., Scheele, C. W. and Blokhuis, H.J. (1999). High carbon dioxide tension (PCO2) and the incidence of cardiac arrhythmias in rapidly growing broiler chickens. *Veterinary Record,* 145(2), 40-43.

Mack, L.A., Felver-Gant, J.N., Dennis, R.L. and Cheng, H.W. (2013). Genetic variations alter production and behavioral responses following heat stress in 2 strains of laying hens. *Poultry Science*, 92(2), 285-294.

Mujahid, A., Akiba, Y. and Toyomizu, M. (2009). Olive oil-supplemented diet alleviates acute heat stress-induced mitochondrial ROS production in chicken skeletal muscle. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, 297(3), R690-R698.

Mutibvu, T., Chimonyo, M. and Halimani, T.E. (2017). Physiological responses of slow-growing chickens under diurnally cycling temperature in a hot environment. *Brazilian Journal of Poultry Science*, 19, 567-576.

Nawaz, A.H., Amoah, K., Leng, Q.Y., Zheng, J.H., Zhang, W.L. and Zhang, L. (2021). Poultry response to heat stress: Its physiological, metabolic, and genetic implications on meat production and quality including strategies to improve broiler production in a warming world. *Frontiers in Veterinary Science*, 8, 699081.

Obasoya, D.O., Bamgbose, A.M. and Omoikhoje, S.O. (2005). Blood profile of broilers fed diets containing different animal proteins feedstuff. In 10th Annual Conference of Animal Science Association of Nigeria (pp. 176-178).

Ortega, E. (2018). Consequences of heat stress on broilers experimentally challenged with Eimeria maxima oocysts and treated with monensin or nicarbazin (Doctoral dissertation, MS thesis, University of Georgia).

Park, J. S., and Shim, K. S. (2022). Proteomic changes in broiler liver by body weight differences under chronic heat stress. *Poultry Science*, 101(5), 101794.

Purswell, J. L., Dozier III, W. A., Olanrewaju, H. A., Davis, J. D., Xin, H., and Gates, R. S. (2012). Effect of temperature-humidity index on live performance in broiler chickens grown from 49 to 63 days of age. In 2012 IX International Livestock Environment Symposium (ILES IX) (p. 3). American Society of Agricultural and Biological Engineers.

Robertshaw, D. (2006). Mechanisms for the control of respiratory evaporative heat loss in panting animals. *Journal of Applied Physiology,* 101(2), 664-668.

Shahin, K.A. and Elazeem, F.A. (2005). Effects of breed, sex and diet and their interactions on carcass composition and tissue weight distribution of broiler chickens. *Archives Animal Breeding*, 48(6), 612-626.

SAS (2008). Statistical Analysis System User's Guide, version 13 for windows. Statistical Analysis Institute, Inc., SAS Camp Drive Cary, North Carolina U.S.A.

Xu, Y., Lai, X., Li, Z., Zhang, X., and Luo, Q. (2018). Effect of chronic heat stress on some physiological and immunological parameters in different breed of broilers. *Poultry Science,* 97(11), 4073-4082