BODY WEIGHT AND LINEAR MORPHOMETRIC RELATIONSHIP OF THREE EXOTIC AND TWO LOCAL IMPROVED STRAINS OF CHICKEN NATURALLY INFECTED WITH *EIMERA TENELLA* OOCYSTS

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ABSTRACT

Research has established the impact of coccidial infection on the general well-being and body weight (BWT) of chickens. This study was conducted to establish the relationship between BWT and linear morphometric traits of five chicken strains infected with coccidial oocytes. 500-day-old chicks of Arbor Acres, Hubbard, Marshall, Noiler and FUNAAB-Alpha were used for this study. Body morphometric data was collected weekly for eight weeks and subjected to appropriate statistical methods. Correlation coefficient values revealed that the highest positive correlation (0.84) for Marshall strain was between BWT and body circumference (BCF), followed by 0.70 obtained between the drumstick length (DSL) and the shank length (SHL). The Noiler strain had its highest (0.95) correlation between wing length (WGL) and nose-shoulder length (NSL), while the WGL and BCF had a value of 0.90. FUNAAB-Alpha strain had the highest value between BWT and shank weight (0.91) and the least (0.03) between SHL and NSL. The correlation between WGL and nose-to-shoulder length (0.83) was highest in the Abor Acre strain, while the lowest was between BCF and SHL (0.23). Hubbard strain had a correlation of 0.66 between circumference and BWT. All strains exhibited varying patterns of correlation values under diseased conditions. However, the Noiler strain demonstrated robust positive correlations between BWT and linear morphometric traits, which implies that improvements in one trait can lead to enhancements in other correlated traits, providing opportunities for genetic manipulation and selective breeding.

Keywords: Correlation, Coccidiosis, *Eimeria tenella*, Morphometric traits, Indigenous improved chicken, Linear morphometric model

INTRODUCTION

Commercial broiler production has undergone tremendous development over the years, including genetic improvement and breeding, a shorter generation interval, an improved feed conversion rate, the ability to thrive under environmental stress and produce quality meat within six weeks (Ikusika *et al.*, 2020). Some of the improved strains include Arbor Acre, Marshall, Hubbard, Anak, Cobb, Cobb 500, and Ross, among others. However, recent research in the Nigerian poultry industry has focused on improving and developing chicken breeds that are adaptive to tropical regions and survive under harsh conditions. Noiler and FUNAAB-Alpha chickens are recent dual-purpose breeds developed in Nigeria. The Noiler chicken genotype is an improved local strain developed by Amo Farm Sieberer Hatchery Limited, Nigeria, addressing the problems of low feed conversion rate and poor meat and egg return associated

with indigenous birds, while retaining the high tolerance to stress and disease synonymous with indigenous birds (Oyebanji *et al.,* 2018; Dudusola *et al.,* 2020; Dogara *et al.*, 2021). Similarly, FUNAAB-Alpha is a hybrid chicken produced after successfully crossing a male broiler with an exotic pullet (AGRIKHUB, 2018). The breed was developed at the Federal University of Agriculture, Abeokuta, Nigeria, using the Naked and Frizzled Feather chicken genotype (broiler type) aimed at maximizing growth and productive performance (Adebambo *et al.*, 2018).

However, the incidence of the disease is one of the pressing challenges militating against the poultry industry, which has affected their productivity and the role they play in providing valuable meat to the ever-growing human population (Mesa-Pineda *et al.*, 2021). Coccidiosis is an enteric disease that affects the digestive tracts of poultry birds, reducing nutrient malabsorption, growth rate, body conformation, and increased mortality (Chapman, 2014). The virulence of this disease is subject to the species of oocysts, the age, strain, and sex of the host (chicken), as genetic makeup influences the rate of establishment and pathogenicity of this disease. This disease has been reported to affect the overall weight and body formation of birds, hence decreasing their market value (Mesa-Pineda *et al.*, 2021).

Studies have established the use of body weight (BWT) and body morphometric measurements in assessing the rate of growth and estimating the market value of livestock (Siddiqui *et al.,* 2015). Amao *et al.* (2012) highlighted morphometric traits such as; shank length (SHL), breast width (BRW), kneel length (KNL), wing span (WGS), chicken height (CHH), body length (BDL), body circumference (BCF) can positively correlate with the BWT of chickens. Chineke (2005) suggested that these variables can provide valuable information and can be used to determine body conformation, live weight, relationships among economic traits, reproductive performance, and established interactions between genetics and environment. Thus, used for selection and breeding purposes, as correlations between these traits may be essential for predicting changes in dependent traits resulting from the direct selection of principal traits (Laxmi, 2006). The magnitude and direction of correlated selection responses depend on genetic correlations and variances within the relevant traits, but this may be greatly influenced or affected by genetic makeup and diseased conditions. Therefore, the objective of the study is to determine the relationship between BWT and linear morphometric traits of five strains of chickens naturally infected by coccidial oocytes.

MATERIALS AND METHODS

Location of the Study: The study was carried out at the Poultry Unit of the Teaching and Research Farm of the Federal University of Technology, Akure, Ondo State, Nigeria between April 12 – June 7, 2023 (8 weeks). The farm is located on Latitude 07° 161 and 07° 181 N and Longitude 05° 091 and 05° 111 E. There is a bimodal rainfall pattern which starts from March – July and September – November with about 1556 mm per annum in the state. The average ambient temperature is about 30 – 32°C and the relative humidity of 80% (Daniel, 2015).

Pre-Experimental Management: Before the arrival of the chicks, the pens were cleansed, disinfected and partitioned according to the design of the experiment. All necessary materials for brooding were provided. On arrival, the chicks were tagged individually in the wings for ease of identification, weighed and distributed based on strains and sexes. All routine and occasional management practices were strictly adhered to during the period of this study which lasted for 8 weeks. The study had two phases the starter and finisher that each lasted for 4 weeks.

Ethics: All birds used for the experiment were handled according to the EU Directives 2010/63/EU for laboratory animal experiments (European Union, 2010).

Experimental Layout and Feeding: A total of 500-day-old chicks were purchased from Obasanjo Farms, Abeokuta (Marshall strain), Amo Farm Sieberer Hatchery, Oyo (Arbor Acre and Noiler strains), Futuns Farms, Abeokuta

(Hubbard strain), and Federal University of Agriculture, Abeokuta (FUNAAB-Alpha strain), consisting of 100 birds per strain were purchased and used for the experiment. Upon arrival, each strain was divided into five replicates with 10 birds per replicate in a completely randomized design experiment. Ultima Super Starter (21% crude protein and 3000 KJ/kg) and Ultima Super Finisher (20% crude protein and 2800 KJ/kg) pellets were purchased from a reputable outlet and fed during the experimental phase of this study.

Data Collection: BWT and body linear morphometric parameters of birds were determined weekly. The body morphometric traits were measured using tailor's tape (cm), while BWT was determined using a weighing scale. The parameters measured were:

Body weight (BWT): BWT (live weight) was measured weekly using a top-loading 20 kg scale with a sensitivity of 1.00 g.

Shank length (SHL): SHL was taken as the distance from the beginning of the hock joint to the last ring before the tarsal or meta-tarsal digit.

Drumstick length (DSL): This was taken as the length of the femur bone.

Wing length (WGL): This was taken as the distance between the tip of the phalanges and the coracoids-humerus joint

Shoulder-tail length (STL): This is the distance from the point of the shoulder to the pin bone or the end of the coccygeal vertebrae.

Nose-shoulder length (NSL): This is the distance from the nose to the point of the shoulder.

Body circumference (BCF): This is measured as the breast girth just behind the wing.

Statistical Analysis: Data collected were pulled and statistically analysed using a statistical package for Social Science (SPSS Version 25). The correlation coefficient of BWT to each of the body parameters was done to determine the linear direction of the relationship between these parameters. the actual significant differences were used either approximated as $p<0.05$ or $p<0.01$ and considered as significant and highly significant respectively.

RESULTS

The correlation coefficients between BWT and morphometric traits of the Marshall strain of chicken infected with *Eimeria tenella* oocytes indicated that the morphometric traits assessed had linear values from low to high positive correlation coefficients with BWT except for NSL and BCF (-0.01), which had low negative correlation values. However, the highest positive correlation was observed between BWT and BCF with a value of 0.84, followed by 0.70 obtained between the DSL and SHL found to be highly significant ($p<0.01$) (Table 1).

Presented in Table 2 are the correlation coefficients between BWT and linear morphometric traits of the Noiler strain of chicken infected with *E. tenella* oocytes. The Noiler strain had the highest linear morphometric traits between WGL and NSL (0.95) followed by WGL and BCF (0.90). However, there were no negative correlation values but the least correlation coefficients were obtained between BWT and STL (0.35), while other parameters had high positive correlation values.

The correlation coefficients between BWT and linear morphometric traits of the FUNAAB-Alpha strain of chicken are shown in Table 3. Values obtained were from low to very high positive correlation values. The highest values were obtained between BWT and SHL (0.91), followed by DSL and SHL (0.90). However, the lowest correlation values were obtained between SHL and NSL (0.03), STL, BCF (0.10) and SHL and WGL (0.11)

The correlation between BWT and linear morphometric traits of the Arbor Acre strain of chicken showed that all correlation values were between low and high positive values (Table 4).

Table 1: Correlation coefficients between body weight and linear morphometric traits of Marshall strain of chicken infected with *Eimeria tenella* oocytes

Trait	BWT	SHL	DSL	WGL	NSL	STL	BCF
BWT	1.00						
SHL	0.41	1.00					
DSL	0.62**	0.70*	1.00				
WGL	0.14	0.29	0.35	1.00			
NSL	0.32	0.43	0.29	0.55**	1.00		
STL	0.20	0.44	0.36	0.44	0.57**	1.00	
BCF	0.84**	0.40	0.62**	0.06	0.17	-0.01	1.00

*** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level, BWT = Body weight, SHL = Shank length, DSL = Drumstick length, WGL = Wing length, NSL = Nose-shoulder length, STL = Shoulder-tail length, BCF = Body circumference*

Table 2: Correlation coefficients between body weight and linear morphometric traits of Noiler strain of chicken infected with *Eimeria tenella* oocytes

Trait	BWT	SHL	DSL	WGL	NSL	STL	BCF
BWT	1.00						
SHL	0.35	1.00					
DSL	0.63**	0.65**	1.00				
WGL	0.65**	0.76**	0.87**	1.00			
NSL	0.64**	0.73**	0.78**	0.95**	1.00		
STL	0.53**	0.71**	0.67**	0.87**	0.87**	1.00	
BCF	0.72**	0.65**	0.83**	0.90**	0.86**	0.74**	1.00

*** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level, BWT = Body weight, SHL = Shank length, DSL = Drumstick length, WGL = Wing length, NSL = Nose-shoulder length, STL = Shoulder-tail length, BCF = Body circumference*

Table 3: Correlation coefficients between body weight and linear morphometric traits of FUNAAB-Alpha strain of chicken infected with *Eimeria tenella* oocytes

Trait	BWT	SHL	DSL	WGL	NSL	STL	BCF
BWT	1.00						
SHL	0.18	1.00					
DSL	0.82**	0.16	1.00				
WGL	0.68**	0.11	0.67*	1.00			
NSL	0.20	0.03	0.29	0.23	1.00		
STL	0.91**	0.14	0.90**	0.74**	0.32	1.00	
BCF	0.49	0.20	0.27	0.34	0.19	0.10	1.00

*** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level, BWT = Body weight, SHL = Shank length, DSL = Drumstick length, WGL = Wing length, NSL = Nose-shoulder length, STL = Shoulder-tail length, BCF = Body circumference*

Table 4: Correlation coefficients between body weight and linear morphometric traits of Arbor Acres strain of chicken infected with *Eimeria tenella* oocytes

Trait	BWT	SHL	DSL	WGL	NSL	STL	BCF
BWT	1.00						
SHL	0.70**	1.00					
DSL	0.42	0.66**	1.00				
WGL	0.38*	0.44	0.51*	1.00			
NSL	0.48*	0.45	0.59**	0.84**	1.00		
STL	0.39	0.47*	0.46	0.62**	0.73**	1.00	
BCF	0.48*	0.23	0.35	0.53**	0.60**	0.37	1.00

*** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level, BWT = Body weight, SHL = Shank length, DSL = Drumstick length, WGL = Wing length, NSL = Nose-shoulder length, STL = Shoulder-tail length, BCF = Body circumference*

The highest positive correlation was observed between WGL and NSL (0.84), followed by a correlation between NSL and STL (0.70). There were no negative values between the BWT and other linear traits for this strain. The correlation between BWT and linear morphometric traits Hubbard strain of chicken indicated that all parameters ranged from low to high positive correlation (Table 5).

Table 5: Correlation coefficients between body weight and linear morphometric traits of Hubbard strain of chicken infected with *Eimeria tenella* oocytes

Trait	BWT	SHL	DSL	WGL	NSL	STL	BCF
BWT	1.00						
SHL	0.51*	1.00					
DSL	0.58*	0.59*	1.00				
WGL	0.54*	0.43	0.52*	1.00			
NSL	0.32	0.43	0.29	0.34	1.00		
STL	0.27	0.20	0.23	0.25	0.26	1.00	
BCF	0.66**	0.41	0.58*	0.16	0.17	0.09	1.00

*** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level, BWT = Body weight, SHL = Shank length, DSL = Drumstick length, WGL = Wing length, NSL = Nose-shoulder length, STL = Shoulder-tail length, BCF = Body circumference*

A significant high positive correlation was observed between BCF and BWT (0.66). Positive correlations were also observed between DSL and SHL (0.59), BWT and SHL (0.58), and DSL and BCF (0.58).

DISCUSSION

Evaluating the strength and direction of correlation coefficients between live weight and linear body conformations are vital parameters that can be used by farmers and breeders to develop strains with high body conformation to weight (Saleh *et al*., 2022). A high positive correlation coefficient between BWT and linear body traits of chicken indicates high predictability among the variables and the BWT can be determined just by knowing linear body measurements (Ajayi *et al*., 2008).

A study conducted by Atansuyi *et al*. (2017) revealed that the Marshall broiler had the highest and best BWT prediction values among the four genotypes of broiler strains considered in their study. Notably, in the Marshall strain, BCF exhibited the highest coefficient of correlation (0.84), this may signify that it was the most reliable predictor of BWT. With mid to high correlation values across the other variables, improvements in one trait will lead to enhancements of the other correlated traits when subjected to direct selection, thus providing a base for genetic manipulation and improvement (Yakubu *et al*., 2009).

Obike *et al.* (2016) posseted that there exists an interaction between BWT and linear morphometric estimates in Noiler chickens which are very useful in breeding as a tool for predicting potential response to selection. It was observed that the correlated values obtained were all positive and from mid to high correlation which shows that they were highly correlated and reliable for use in the selection of an improved breed (Oleforuh-Okoleh *et al.,* 2017) in their study on Nigerian indigenous chickens. A strong positive association between BWT and growth traits measured is an indication of pleiotropism (traits are under the same gene action which indicates that improvement in one trait will lead to improvement of the other traits correlated indirect selection) and provides the basis for possible genetic manipulation and improvement of Nigerian local chickens (Yakubu *et al*., 2020). This result suggests that both sexes of the Noiler strain used in this study had a strong correlation value between BWT and linear morphometrics, similar to the report of Momoh and Kershima (2008) for Nigerian indigenous chicken strains.

Like other improved local strains, positive correlations were observed among the body morphometric traits of the Noiler strain in this study. However, higher genetic correlation coefficient values were obtained for the FUNAAB-Alpha strain, similar to the observation of Sanda *et al*. (2022). Notably, strong and positive correlations were observed between BWT and BCF (0.91) and between BWT and DSL (0.82). It can therefore be deduced that DSL, SHL, WGL and NSL contributed significantly to the overall BWT. From this, it is evident that FUNAAB-Alpha chickens possessed great potential for genetic improvement through systematic breeding plans and policies.

There were no negative correlation values obtained for the Abor Acre strain, and all values ranged from low to high positive correlation coefficients between BWT and linear morphometric traits which indicated a high correlation between these traits, thus suggesting

that any of these traits can be used to predict the other trait (Adeleke *et al*., 2004). This result is in agreement with the reports of Adebambo (2015), hence indicating a pleiotropic effect, which suggests that the traits were controlled by the same set of genes (Adeleke *et al*., 2004).

There was a significantly negative correlation between STL and BCF (0.01) which implies that these two values do not contribute and cannot be used to estimate the BWT of Marshall strains while other morphometric parameters were positive, with low to high positive values which indicated that the linear morphometric measurements are reliable and can be used in predicting the entire BWT of the animals. The indication of these is that the improvement in BWT and morphometric traits will lead to a corresponding improvement in overall weight gain which will translate to better carcass yield of this broiler strain. The result of this positive correlation coefficient between BWT and morphometric traits agreed with the findings of Udeh and Ogbu (2011) who reported positive and highly significant traits in this strain of chicken. These results were also in agreement with the report of Ige *et al*. (2016) who observed that BWT was positively and significantly correlated with all body measurements in both male and female Arbor Acres and Hubbard strains

Conclusion: Noiler and Abor Acre strains exhibited the highest and most reliable BWT prediction values among the five strains considered. Noiler strain demonstrated very strong positive correlations between BWT and linear morphometric traits, with significant contributions from traits like DSL, SHL, WGL and NSL. Additionally, the presence of pleiotropic effects implies that improvements in one trait can lead to enhancements in other correlated traits, providing opportunities for genetic manipulation and selective breeding to develop strains with desired characteristics. For researchers and farmers, further study and breeding programs aimed at improving BWT and related morphometric traits should be considered for other strains to potentially increase the overall performance and carcass yield of these strains, ultimately benefiting the poultry industry.

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REFERENCES

ADEBAMBO, O. A. (2015). *From PEARL project to ACGG in Nigeria*. Paper Presented at the First ACGG Nigeria Innovation Platform Meeting in Ibadan, Nigeria, July 20 – 22, 2015.

ADEBAMBO, O. A., IKEOBI, C. O. N., OZOJE, M. O., ADEBAMBO, A. O., PETERS, S. O., ADELEKE, M. A., WHETO, M. Y., OJOAWO, H. T., OSINBOWALE, D. A., OGUNPAYIMO, O., BAMIDELE, O., SONAIYA, E. B. and DESSEI, T. (2018). Indigenous chicken straining in Nigeria. *Proceedings of 43rd Annual Conference of the Nigeria Society for Animal Production*, March 18th – 22nd 2018, Federal University of Technology, Owerri, Nigeria.

ADELEKE, M. A., OZOJE, M. O., OLUFUNMILAYO, A. A., PETERS, S. O. and BAMGBOSE, A. M. (2004). Estimation of body weight from linear body measurements among crossbred egg-type chickens. Pages 88 – 91. *In: Proceedings of the 29th Annual Conference of the Genetics Society of Nigeria,* University of Agriculture, Abeokuta, Ogun State, Nigeria.

AGRIKHUB (2018). *All You Need to Know About Noilers*. https://agrikhub.com/2018/06/29/all-you-need-to-know-about-Noilers/ Accessed April 12, 2024.

AJAYI, F. O., EJIOFOR, O. and IRONKWE, M. O. (2008). Estimation of body weight from linear body measurements in two commercial meat-type chicken. *Global Journal of Agricultural Sciences*, 7(1): 57 – 59.

AMAO, S. R., OJEDAPO, L. O., OYEWUMI, S. O. and OLATUNDE, A. K. (2012). Body conformation characteristics of Marshall strain of commercial broiler chickens reared in derived savanna environment of Nigeria. *Proceedings of the 37th*

Nigerian Society of Animal Production Conference, 37: 1 – 3.

ATANSUYI, A. J., LASORE, C. O. and CHINEKE, C. A. (2017). Growth performance characteristics and linear body measurements of four-chicken genotypes raised under intensive management system in South-Western Nigeria. *Applied Tropical Agriculture*, 22(1): 122 – 127.

CHAPMAN, H. D. (2014). Milestones in avian coccidiosis research: a review. *Poultry Science*, 93(3): 501 – 511.

CHINEKE, C. A. (2005). The relationships among body weights and linear dimensions in rabbit breeds and crosses. *Journal of Animal and Veterinary Advances,* 4(9): 775 – 784.

DANIEL, O. A. (2015). Urban extreme weather: a challenge for a healthy living environment in Akure, Ondo State, Nigeria. *Climate*, 3(4): 775 – 791.

DOGARA, M. U., KALLA, D. J. U., MANCHA, Y. P. and SHUAIBU, A. (2021). Evaluation of egg production and egg quality traits of Noiler chickens. *Nigerian Journal of Animal Science*, 23(2): 100 – 113.

DUDUSOLA, I., BASHIRU, H. A. and ADELEKE, O. E. (2020). Effect of laying age and plumage colour on internal and external quality characteristics of Noiler chicken eggs. *Slovak Journal of Animal Science*, 53(4): 192 – 198.

EUROPEAN UNION (2010). Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes (text with EEA relevance). *Official Journal of the European Union*, 276: 33 – 79.

IGE, A. O., RAFIU, B. R. and MUDASIRU, I. T. (2016). Effect of genotype on growth traits characteristics of two commercial broiler chickens in a derived savannah zone of Nigeria. *International Journal of Research Studies in Agricultural Sciences (IJRSAS)*, 2(6): 26 – 32.

IKUSIKA, O. O., FALOWO, A. B., MPENDULO, C. T., ZINDOVE, T. J. and OKOH, A. I. (2020). Effect of strain, sex and slaughter weight on growth performance, carcass yield and quality of broiler meat. *Open Agriculture*, 5(1): 607 – 616.

LAXMI, P. J. (2006). Correlations among various egg quality traits in White Leghorn. *Indian Veterinary Journal*, 83(1): 59 – 62.

MESA-PINEDA, C., NAVARRO-RUÍZ, J. L., LÓPEZ-OSORIO, S., CHAPARRO-GUTIÉRREZ, J. J. and GÓMEZ-OSORIO, L. M. (2021). Chicken coccidiosis: from the parasite lifecycle to control of the disease. *Frontiers in Veterinary Science*, 8: 787653. https://doi.org/10.3389/fvets.2021.787653

MOMOH, O. M. and KERSHIMA, D. E. (2008). Linear body measurements as predictors of body weight in Nigerian local chickens. *ASSET: An International Journal (Series A),* 8(2): 206 – 212.

OBIKE, O. M., NWACHUKWU, E. N. and ONWUCHEKWA, J. U. (2016). Phenotypic correlations of body weight and linear body traits in heavy, medium and low body weight lines of Sigmond strain of Japanese quails in humid rainforest zone of Nigeria. *Nigerian Journal of Animal Production*, 43(1): 1 – 9.

OLEFORUH-OKOLEH, V. U., KURUTSI, R. F. and IDEOZU, H. M. (2017). Phenotypic evaluation of growth traits in two Nigerian local chicken genotypes. *Animal Research International*, 14(1): 2611 – 2618.

OYEBANJI, B. O., OYEWUMI, O. C. and FADOPEMU, O. C. (2018). Effect of turmeric rhizome (*Curcuma longa*) powder and coconut oil mixture on growth performance, haematological and biochemical parameters of Noiler birds. *Journal of Animal Science and Veterinary Medicine*, 3(4): 118 – 124.

SALEH, A. A., RASHAD, A. M., HASSANINE, N. N., SHARABY, M. A. and ZHAO, Y. (2022). Morphological body measurements, body indices, and their genetic background for several Chinese goat breeds. *Tropical Animal Health and Production*, 54: 204. https://doi.org/10.1007/s11250-022-03203-w

SANDA, A. J., BEMJI, M. N., WHETO, M., OSO, A. O., SANDA, M. O. and OLOWOFESO, O.

(2022). Genetic and phenotypic correlation coefficients of quantitative traits in two chicken genotypes. *Genetika*, 54(1): 307 – 328.

SIDDIQUI, M. U., LATEEF, M., BASHIR, M. K., BILAL, M. Q., MUHAMMAD, G. and MUSTAFA, M. I. (2015). Estimation of live weight using different body measurements in Sahiwal cattle. *Pakistan Journal of Life and Social Sciences*, 13(1): 12 – 15.

UDEH, I. and OGBU, C. C. (2011). Principal component analysis of body measurements in three strains of broiler chicken. *Science World Journal*, 6(2): 11 – 14.

YAKUBU, A., BAMIDELE, O., HASSAN, W. A., AJAYI, F. O., OGUNDU, U. E., ALABI, O., SONAIYA, E. B. and ADEBAMBO, O. A. (2020). Farmers' choice of genotypes and trait preferences in tropically adapted chickens in five agro-ecological zones in Nigeria. *Tropical Animal Health and Production*, 52: 95 – 107.

YAKUBU, A., IDAHOR, K. O. and AGADE, Y. I. (2009). Using factor scores in multiple linear regression models for predicting the carcass weight of broiler chickens using body measurement. *Revista Científica Udo Agrícola,* 9(4): 963 – 967.