EFFECT OF BREED AND SEX ON PHENOTYPIC TRAITS IN MARSHALL AND NOILER CHICKENS NATURALLY INFECTED WITH COCCIDIAL OOCYSTS

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ABSTRACT

The negative impact of coccidiosis on the growth performance of chickens is very devastating on farmers. Hence, this study was conducted to characterize the effect of breed and sex on growth and linear body morphometry of two sexed chicken breeds naturally infected with coccidial oocysts. 200 birds comprising two breeds of equal numbers were raised for eight weeks, and each breed was further divided into two based on their sexes. Growth morphometric data were collected weekly. At the end of the experimental period, some birds were randomly selected for the collection of carcass and organ data. Statistical analysis was carried out on the data collected using SPSS (Version 25). Analytical results showed that the breed effect was significant (p<0.001) where Marshall breed recorded higher body weight and linear growth dimensions than Noiler chickens. However, the sex effect was not significant (p>0.05) for all parameters measured with the exception of drumstick length and tail length, gizzard, heart, and lung weight. Male birds recorded higher drumstick length (11.88 ± 0.14 vs. 11.33 ± 0.14 cm) and tail length (3.10 ± 0.03 vs. 3.00 ± 0.03 cm). The interaction effect was significant (p<0.05) in this experiment. The result obtained in this study may be used to design breeding plans for better improvement in the growth performance of Noiler chickens in case of unexpected coccidial outbreak. The study concluded that Marshall Chickens possessed appreciable innate immunity against coccidial infection than their Noiler counterparts. Hence, be considered in areas with high coccidiosis prevalence.

Keywords: Growth performance, Coccidiosis, Breeding plans, Poultry species, Indigenous chickens' improvement

INTRODUCTION

Poultry, particularly chickens are the most widely kept livestock species in the world supplying a variety of needs such as meat, eggs, feather, employment, income, etc. (Moreki *et al.,* 2010). In terms of eggs and meat, poultry production is one of the best ways to provide high biological value animal protein (Yakubu *et al.*, 2007). The chicken industry accounts for a quarter of the Nigerian economy's agricultural domestic products (Chete *et al.,* 2014). Nigeria produces over 550,000 metric tons of poultry meat and 770,000 metric tons of eggs each year (Chete *et al.,* 2014). In Nigeria, poultry meat and eggs account for 30% of overall livestock output with eggs accounting for more than 80% (Fayeye *et al.*, 2005). Poultry production, according to Ogundipe and Sanni (2002), contributes significantly to both the country's income and nutritional status.

The poultry industry plays an important role in providing quality diets for the consumption of rural and urban people. As a result, the problem of malnutrition especially among the children below the age of five years in Nigeria populations and other developing countries are being gradually eliminated. Although, indigenous chicken species are said to be slow converter of feed to flesh and poor producers of eggs (Wong *et al.*, 2017), they generally have a short production cycle with desirable meat value, as well as generating desirable meat value in a short period of time. Broiler and Noiler chickens were developed as a result of research on the primitive *Gallus gallus* (Sanda *et al.*, 2022). The Marshall broiler are specifically developed chickens for meat production, while the Noiler is a dual-purpose tropical chicken breed developed by Amo Farm Sieberer Hatchery Limited, Awe, Oyo State, Nigeria for small-scale farmers to solve food insecurity and financial dependent challenges among rural populations, particularly women (Sonaiya *et al.*, 2022). The importance of introducing tropically adapted genotype with good performance to resource-constrained poultry farmers has been advocated (Yakubu and Ari, 2018).

To achieve good growth performance in chickens, a number of health challenges, notably coccidiosis should be brought under control substantially. Coccidiosis, caused by *Eimeria* is an intestinal parasitic organism of high economic importance in poultry and it's capable of causing significant economic losses to poultry farmers worldwide (Kawahara *et al.,* 2014). There are several *Eimeria* species with different degrees of prevalence, pathogenicity and orientation (Debbou-Iouknane *et al.,* 2018). The predilection site of *Eimeria* is the epithelium of gastrointestinal tract where they cause inflammation, degradation of the mucosa, systemic effects which includes sepsis, blood loss and even death in severe cases (Conway and McKenzie, 2007).

One of the two major approaches to deal with the constraints of high chicken production and productivity by smallholder farmers in the tropics is to focus research efforts in the area of genetics and breeding which has been in practice for the past three decades (Sonaiya, 2016) and this has led to the development of chicken genotype that are adapted to the prevailing tropical conditions (Adebambo *et al.,* 2018). The other approach is to control diseases within the flock among which coccidiosis is one. Coccidiosis control measures vary but include the use of in-feed prophylactic medication, management strategies to reduce infection and vaccination (Dalloul and Lillehoj, 2006; Livingston *et al.,* 2020). Due to the animal welfare and economic impact of coccidiosis, the need for the control of *Eimeria* parasite remains essential. However, it has been reported that proper identification of appropriate chicken breeds that will be suitable to a particular environment or agro-ecological zone in Nigeria is required for the growth and development of the poultry sector (Yakubu *et al.*, 2020). Researchers can also attempt the use of molecular technology by manipulating the genome of coccidial organism in order to circumvent their resistance to drugs and vaccines and save farmers production cost.

Therefore, selection of tropically adapted chicken breed with improved body morphometry which is an indicator of good performance is an extremely important subject for researchers in this field. Based on the foregoing, this research was embarked upon to determine the effect of breed and sex on linear body morphometric performance of chickens naturally infected with coccidia oocysts.

MATERIALS AND METHODS

Location of the Study: The study was carried out between October 22nd to December 17th 2021 at the Poultry Unit of the Teaching and Research Farm, The Federal University of Technology Akure, Ondo State, Nigeria located between longitude 4.944055°E and 5.82864°E latitude 7.491780°N with the mean annual rainfall of 1,500 ± 250 mm and annual daily temperature ranging between 27 and 38°C (Ogunrayi *et al.*, 2016).

Source of Experimental Birds, Layout and Feeding: A total of 200 birds comprising two breeds of Marshall and Noiler (a dual purpose) chickens were used for the experiment at 100 birds per breed. The two-chicken breeds were obtained from Funtis Hatchery in Abeokuta, Ogun State, Nigeria. In the experiment that lasted 8 weeks, the birds were divided into two groups based on their breed and each breed was further divided into two according to their sexes and raised for four weeks. After the 4th week, the chickens were further divided into ten replicates of 10 birds per replicate and 50 birds per sex and the birds were raised to 8th week. Conventional feed containing 21% CP to 3000 KJ/kg and 20% CP to 2800 KJ/Kg at starter and finisher stages respectively were fed to the birds throughout the period of the study. Feed and clean water were given *ad-libitum* to the birds during the experimental period. All birds were placed on standard vaccination and medication programme, but were not given any anticoccidial medication. Weekly measurement of body weight (g) and linear dimension changes (cm) were taken using an electronic sensitive scale and flexible measuring tape.

The design of the experiment was 2 × 2 factorial in completely randomized design arrangement where the breed constitute the main effect and the sex was the random effect. The experimental model adopted was $Yij = \mu + Ai + Bj + ABij + \varepsilon_{ijk}$, where: Yij = individual observation, μ = general mean, Ai = breed effect, Bj = sex effect, $Abij$ = interaction effect of breed and sex and ε_{ijk} =error variability.

Inoculation of Birds with Coccidial Oocysts: The avian species are natural hosts to *Eimeria* spp. and the birds used for this experiment were not treated against the invasion of this organism. Hence, they naturally came down with coccidial infection at 3 weeks of age.

Determination of the Body Morphometric, Carcass and Organ Characteristics of Experimental Birds: Measurements of body weights and the linear body dimensions such as shank, wing, trunk, nose-to-shoulder, chest circumference, tail length and drumstick length were done weekly. The body weight was measured in grams using an electronic sensitive scale (5 kg capacity). Data generated were used to evaluate the chicken breeds for growth or body weight changes and linear body characteristics. A total of twenty birds at ten chickens per breed and five per sex were randomly selected at end of the experiment for carcass and organ evaluation. The selected chickens were faster overnight, weighed and de-feathered manually before evisceration. The whole carcasses were carefully dissected along the joints to obtain the weights of the different body parts. The carcass parts studied were head, neck, wing, breast, shank, drumsticks, thigh and back using a sensitive weighing scale (5 kg capacity), while the weights of organs such as the heart, lungs, liver, intestine, proventriculus, spleen and gizzard were also measured.

Statistical Analysis: All data collected were subjected to analysis of variance (ANOVA) using the SPSS Version 25 to analyze the chickens for the effect of breed, sex and their interactions on body weight, linear body dimensions, carcass and organ characteristics. Significant means between Noiler and Marshall breeds, and male and female sexes were separated using t-test of the same statistical package.

RESULTS

The morphometric traits of Marshall and Noiler chicken breeds naturally infected with coccidial oocysts revealed that Marshall chicken breed recorded significantly higher ($p<0.001$) morphometric traits than the Noiler chicken breed (Table 1). However, the sex effect was not significant ($p>0.05$) for all parameters measured with the exception of drumstick length and tail length, where the male birds recorded longer drumstick length (11.88 ± 0.14 cm) and tail length (3.10 ± 0.03 cm) respectively than their female counterparts with (11.33 ± 0.14 cm) and (3.00 ± 0.03 cm) respectively. Furthermore, the interaction between breed and sex was not significant (p>0.05) for all parameters measured except for body circumference and tail length.

The carcass characteristics of Marshall and Noiler chickens raised under the same environmental condition showed that the Marshall (a meat-type chicken breed) recorded significantly higher weight (p<0.001) for all measured carcass parameters with the exception of the neck weight (Table 2). Furthermore, the effect of sex and the interactive effect between breed and sex were not significant (p>0.05) for all parameters examined.

The organ weight of Marshall and Noiler chicken breeds naturally infected with coccidial oocysts indicated that the Marshall chicken breed had significantly heavier (p<0.05) internal organs than the locally improved Noiler breed in organs such as gizzard (40.83 ± 3.57 g), proventriculus (6.83 ± 0.34 g), spleen (2.33 ± 0.18 g), liver (27.58 ± 0.73 g) and lungs (7.67 ± 0.36 g). Also, the sex effect was significant (p<0.05) in gizzard (68.58 ± 3.75 vs. 58.35 ± 3.75 g), heart (5.26 ± 0.25 vs. 6.33 ± 0.25 g) and lungs (7.29 ± 0.35 vs. 6.07 ± 0.35 g).

DISCUSSION

The live weight of chicken varied from 0.989 to 1.427 kg which is lower than weights reported by Hussein *et al.* (2019) and Nweke-Okorocha *et al.* (2020) in their study on the effects of stock, sex, and muscle type on carcass characteristics and meat quality of parent broiler breeders and broiler chickens. Fernandes *et al.* (2013) reported higher carcass weights with values ranging from 3139.52 to 3242.54 g in different breeds of chicken. The lower live weight observed in this study was a reflection of the improvement done on the Marshall breeds considered as compared to the unimproved Nigerian local chickens in the case of the Noiler breed. This may be because the Noiler breed was developed as a dual-purpose breed compared to the Marshall breed which was developed basically for meat production. Kettunen *et al.* (2001) reported that the coccidia effect did not reduce the weight gain but increased the intestinal length of the birds. Kettunen *et al.* (2001) also reported that *Eimeria maxima* proliferated distal jejunum and proximal ileum and severely damaged structures of the intestinal mucosa thereby reducing nutrient absorption which is compensated for by the increase in intestinal length (Chapman, 2014).

Breed significantly affected (p<0.05) all morphometric parameters and carcass parameters except for neck weights and internal organ weight except intestine and heart. This variation may be attributed to the genetic makeup of these chicken breeds. Ojedapo *et al.* (2015) in their study on the relation of genotypes and age of slaughtered chicken on carcass indices observed a significant effect of the breed but recorded higher live weight at 8 weeks than those reported in this study. A similar finding was reported by Kryeziu *et al.* (2018) in their study on the effects of different stocking densities and sex on the carcass traits of broilers.

Ojedapo *et al.* (2015) also reported a significant variation of dressing weight due to breed effect where they observed that Cobb chicken had higher dressing weight (2664.00 g) than the Marshall counterparts (1854.15 g). These values were however higher than those reported in this study. A similar trend was observed for eviscerated weight reported by Ojedapo *et al.* (2015). The breast weight values reported in this study were lower than those reported by Kryeziu *et al.* (2018), but however, Hussein *et al.* (2019) reported higher values than those observed in this study. Significant breed effect on shank weight, thigh weight and back weight has been reported by Ojedapo *et al.* (2015), Kryeziu *et al.* (2018), Hussein *et al.* (2019), and Nweke-Okorocha *et al.* (2020). Their values were however higher than those reported in this study.

A significant effect of sex on carcass traits has been reported by Bogosavljevic-Boskovic *et al.* (2006) and Kryeziu *et al.* (2018) unlike in this study. Males had higher mean weights for all the carcass parameters except the neck and breast weights. The values in this study disagreed with those reported by Ojedapo *et al.* (2015), Kryeziu *et al.* (2018) and Hussein *et al.* (2019) who observed that the carcass

Table 1: Effects of breed, sex and interaction on linear body morphometry in two-chicken breeds infected with coccidial oocysts

Factor	Breed	Variation	LW (kg)	DWT (kg)	SL (cm)	DSL (cm)	WL (cm)	NTS (cm)	STL (cm)	CC (cm)	TL (cm)
Breed		Marshal	1.43±0.05***	1.25±0.04***	10.50±0.15***	12.33±0.14***	20.30±0.32***	18.65±0.26***	19.30±0.28***	27.85±0.52***	3.50±0.03***
		Noiler	0.99±0.05	0.79±0.04	8.70±0.15	10.88±0.14	17.96±0.32	17.38±0.26	17.63±0.28	22.55±0.52	2.60±0.03
Sex		Male	1.24±0.05	1.08±0.04	9.70±0.15	11.88±0.14**	19.43±0.32	18.28±0.26	18.65±0.28	25.38±0.52	3.10±0.03*
		Female	1.17±0.05	0.96±0.04	9.50±0.15	11.33±0.14	18.80±0.32	17.75±0.26	18.28±0.28	25.03±0.52	3.00±0.03
Breed * Sex	Marshal	Male	1.46±0.07	1.27±0.06	10.50±0.21^{b}	12.50±0.20^{c}	20.40±0.45^{b}	18.70±0.37^{b}	19.30±0.39	27.20±0.73^{b}	3.50±0.04^{b}
		Female	1.39±0.07	1.24±0.06	10.50±0.21^{b}	12.15±0.20^{bc}	20.20±0.45^{b}	18.60±0.37^{b}	19.30±0.39	28.50±0.73^{b}	3.50±0.04^{b}
	Noiler	Male	1.02±0.07	0.88±0.06	8.90±0.21^{a}	11.25±0.20^{b}	18.45±0.45^{ab}	17.85±0.37^{ab}	18.00±0.39	23.55±0.73^{a}	2.70±0.04^{a}
		Female	0.96±0.07	0.69±0.06	8.50±0.21^{a}	10.50±0.20^{a}	17.40±0.45^{a}	16.90±0.37^{a}	17.25±0.39	21.55±0.73^{a}	2.50±0.04^{a}

*LW = Live Weight; DWT = Dress Weight; SL = Shank Length; DSL = Drumstick; WL = Wing Length; NTS = Nose to Shoulder Length; STL = Shoulder to Tail Length; CC = Chest circumference; TL = Tail Length, Asterisk (*) = significant mean thus; * = $p<0.05$, ** = $p<0.01$ and *** = $p<0.001$. $^{a-c}$ = Means on the same column for breed and sex interactions with different superscript letters are significantly different ($p<0.05$)*

Table 2: Effects of breed and sex on carcass characteristics in Marshal and Noiler chicken breeds infected with coccidial oocysts

Factor	Breed	Variation	Head (g)	Neck (g)	Wing (g)	Back (g)	Breast (g)	Drumstick (g)	Thigh (g)	Shank (g)
Breed		Marshal	46.00±1.44*	72.92±16.20*	117.33±3.82***	255.25±14.19***	263.92±17.69***	146.08±6.18***	146.50±5.31***	69.08±1.46**
		Noiler	39.29±1.44	39.51±16.20	84.37±3.82	146.71±14.19	142.91±17.69	101.91±6.18	93.03±5.31^{b}	58.39±1.46
Sex		Male	43.62±1.37	48.05±15.61**	103.41±3.68***	204.71±13.67*	199.88±17.05	125.63±5.96*	125.10±5.12**	65.54±1.40*
		Female	41.67±1.37	64.38±15.61	98.30±3.68	197.25±13.67	206.95±17.05*	122.37±5.96	114.43±5.12	61.93±1.40
Breed * Sex	Marshal	Male	46.67±2.01^{b}	51.67±22.91^{c}	115.67±5.41^{c}	254.00±20.07^{c}	244.33±25.03^{c}	141.83±8.74^{c}	145.33±7.51^{c}	70.50±2.06^{c}
		Female	45.33±2.01^{b}	94.17±22.91^{d}	119.00±5.41^{d}	256.50±20.07^{c}	283.50±25.03^{d}	150.33±8.74^{d}	147.67±7.51^{c}	67.67±2.06^{bc}
	Noiler	Male	40.57±2.01^{ab}	44.43±22.91^{b}	91.14±5.41^{b}	155.43±20.07^{b}	155.43±25.03^{b}	109.43±8.74^{b}	104.86±7.51^{b}	60.57±2.06^{b}
		Female	38.00±2.01^{a}	34.60±22.91^{a}	77.60±5.41^{a}	138.00±20.07^{a}	130.40±25.03^{a}	94.40±8.74^{a}	81.20±7.51^{a}	56.20±2.06^{a}

*Asterisk (*) = significant mean thus; * = $p<0.05$, ** = $p<0.01$ and *** = $p<0.001$, $^{a-d}$ = Means on the same column for breed and sex interactions with different superscript letters are significantly different ($p<0.05$)*

Table 3: Effects of breed and sex on organ weight characteristics in two-chicken breeds infected with coccidial oocysts

Factor	Breed	Variation	INT (g)	GIZ (g)	PROV (g)	HAT (g)	SPL (g)	LIV (g)	LUNG (g)
Breeds		Marshal	68.33±3.89**	40.83±3.57*	6.83±0.34***	6.17±0.25	2.33±0.18*	27.58±0.73***	7.67±0.36***
		Noiler	58.60±3.89	27.40±3.57	4.00±0.34	5.43±0.25	1.80±0.18	22.20±0.73	5.69±0.36
Sex		Male	68.58±3.75**	39.33±3.44*	5.50±0.33	5.26±0.25	2.17±0.17	25.42±0.70	7.29±0.35*
		Female	58.35±3.75	28.90±3.44	5.33±0.33	6.33±0.25*	1.97±0.17	24.37±0.70	6.07±0.35
Breed * Sex	Marshal	Male	73.17±5.51^{c}	46.67±5.05^{c}	7.00±0.48^{b}	5.67±0.36^{b}	2.33±0.26	26.83±1.03^{a}	8.00±0.52^{c}
		Female	63.50±5.51^{b}	35.00±5.05^{b}	6.67±0.48^{b}	6.67±0.36^{c}	2.33±0.26	28.33±1.03^{a}	7.33±0.52^{b}
	Noiler	Male	64.00±5.51^{b}	32.00±5.05^{b}	4.00±0.48^{a}	4.86±0.36^{a}	2.00±0.26	24.00±1.03^{b}	6.57±0.52^{b}
		Female	53.20±5.51^{a}	22.80±5.05^{a}	4.00±0.48^{a}	6.00±0.36^{b}	1.60±0.26	20.40±1.03^{b}	4.80±0.52^{a}

*INT = Intestine, GIZ = Gizzard, PROV = Proventiculus, HAT = Heart, SPL = Spleen, LIV = Liver, LUNG = Lungs. Asterisk (*) = significant mean thus; * = p<0.05, ** = p<0.01 and *** = p<0.001.*
$^{a-c}$ = Means on the same column for breed and sex interactions with different superscript letters are significantly different (p<0.05)

yield of male indigenous chickens was significantly higher than those of their female counterparts. However, these results were in agreement with those reported by Ejiogu *et al.* (2013) and Nweke-Okorocha *et al.* (2020) who observed that yield of the carcass was not significantly different (p>0.05) for all carcass traits measured.

A significant effect (p<0.05) of breed on organ weight was observed in this study with the exception of the intestine and heart. Ojedapo *et al.* (2015) observed that Cobb broilers had significantly higher (p<0.05) proventriculus weight (65.20 g) than Marshall chickens (60.50 g) which were higher than observed in this study (6.83 ± 0.34 g). Kwiecień *et al.* (2018) also reported breed effect on gizzard, liver and bile weights in their study on the effect of breed and caponisation on the growth performance, carcass composition and fatty acid profile in the muscles of Greenleg Partridge and Polbar breed of chickens. Kwiecień *et al.* (2018) also reported sex effect on organ weight. They reported that males had higher values in gizzard weight this conformed with the findings of this study. However, female chickens in this study had higher heart weights.

Hot season has been reported by Peek and Landman (2011) to be detrimental to the proliferation of coccidia oocyst. Peek and Landman (2011) also reported that multiplication of *Eimeria* spp. cannot be manipulated by influencing the climatic environment of the chicken house because *Eimeria* spp. thrives in atmospheric conditions that are beneficial to the birds as well. However, in order for *Eimeria* spp. to become effective, it must sporulate after excretion in the feaces. The degree and rate of sporulation of excreted oocyst depend on temperature alongside humidity and aeration (Peek and Landman, 2011; Attree *et al.*, 2021). Temperature between 24 – 28 °C favours sporulation, while temperature above 35 °C was reported to be lethal for oocysts (Bachaya *et al.*, 2012; Lawal *et al.*, 2016). Due to the fact that the ideal sporulation temperature is within the range of temperature in the poultry environment and that high temperatures are detrimental to the birds, the temperature is not a factor that can be used to control parasite multiplication (Peek and Landman, 2011; Mesa *et al.*, 2021).

Conclusion: In this study, the breed significantly influenced all body measurements and carcass parameters measured except neck and organ weight with the exception of intestine and heart. Also, the sex effect was significant for drum stick length, tail length, gizzard weight, heart weight, and lung weight. The information provided in this study may be used to improve the Noiler breed of chicken. The study recommends Marshall as against Noiler breed since its performance was better when infected with coccidial oocyst during the hot season for either of the sexes. Also, the Marshall breed is recommended to farmers whose farm is endemic to coccidial infection.

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REFERENCES

ADEBAMBO, O., ADEBAMBO, A., ADELEKE, M., ADELEYE, A., ADETUNJI, A., AJAYI, F., AKINOLA, W., ALABI, O., BAMIDELE, O., DESSIE, T., IKEOBI, C., OGUNDU, U., OJOAWO, H., OSINBOWALE, D., OZOJE, M., PETERS, S., SONAIYA, B., WHETO, M. and YAKUBU, A. (2018). Genetic conservation through effective utilization of the improved indigenous chicken breeds by rural households in Nigeria. Paper Number 1117, Pages 11 – 16. *In: Proceedings of the World Congress on Genetics Applied to Livestock Production.* Auckland, New Zealand, February 11 – 16, 2018.

ATTREE, E., SANCHEZ-ARSUAGA, G., JONES, M., XIA, D., MARUGAN-HERNANDEZ, V., BLAKE, D. and TOMLEY, F. (2021). Controlling the causative agents of coccidiosis in domestic chickens; an eye on the past and considerations for the future. *CABI*

Agriculture and Bioscience, 2: 37. https://doi.org/10.1186/s43170-021-00056-5

BACHAYA, H. A., RAZA, M. A., KHAN, M. N., IQBAL, Z., ABBAS, R. Z., MURTAZA, S. and BADAR, N. (2012). Predominance and detection of different Eimeria species causing coccidiosis in layer chickens. *The Journal of Animal and Plant Sciences*, 22(3): 597 – 600.

BOGOSAVLJEVIC-BOSKOVIC, S., KURCUBIC, V., PETROVIC, M. D. and RADOVIC, V. (2006). The effect of sex and the rearing system on carcass composition and cut yields of broiler chickens. *Czech Journal of Animal Science*, 51(1): 31 – 38.

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

CHETE, L. N., ADEOTI, J. O., ADEYINKA, F. M. and OGUNDELE, O. (2014). *Industrial Development and Growth in Nigeria: Lessons and Challenges*. WIDER Working Paper No. 2014/019, The United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki, Finland. https://doi.org/10.35188/UNU-WIDER/2014/740-0

CONWAY, D. P. and MCKENZIE, M. E. (2007). *Poultry Coccidiosis: Diagnostic and Testing Procedures*. John Wiley and Sons, Hoboken, New Jersey, USA.

DALLOUL, R. A. and LILLEHOJ, H. S. (2006). Poultry coccidiosis: recent advancements in control measures and vaccine development. *Expert Review of Vaccines*, 5(1): 143 – 163.

DEBBOU-IOUKNANE, N., BENBAREK, H. and AYAD, A. (2018). Prevalence and aetiology of coccidiosis in broiler chickens in Bejaia province, Algeria. *Onderstepoort Journal of Veterinary Research*, 85(1): a1590. https://doi.org/10.4102/ojvr.v85i1.1590

EJIOGU, G., OKOLI, I., ANYANWU, G., OPARA, M., OKORO, C. and OKORO, V. M. (2013). Growth and carcass characteristics of the indigenous and exotic cockerel released on free range as influenced by age, strain and location of farmers in South Eastern Nigeria. *Albanian Journal of Agricultural Sciences*, 12(2): 309 – 313.

FAYEYE, T. R., ADESHIYAN, A. B. and OLUGBAMI, A. A. (2005). Egg traits, hatchability and early growth performance of the Fulani-ecotype chicken. *Livestock Research for Rural Development,* 17(8): 94. http://www.lrrd.org/lrrd17/8/faye17094.htm

FERNANDES, J. I. M., BORTOLUZZI, C., TRIQUES, G. E., GARCEZ NETO, A. F. and PEITER, D. C. (2013). Effect of strain, sex and age on carcass parameters of broilers. *Acta Scientiarum. Animal Sciences*, 35: 99 – 105.

HUSSEIN, E. O. S., SULIMAN, G. M., AL-OWAIMER, A. N., AHMED, S. H., ABUDABOS, A. M., ABD EL-HACK, M. E., TAHA, A. E., SAADELDIN, I. M. and SWELUM, A. A. (2019). Effects of stock, sex, and muscle type on carcass characteristics and meat quality attributes of parent broiler breeders and broiler chickens. *Poultry Science*, 98(12): 6586 – 6592.

KAWAHARA, F., ZHANG, G., SUZUKI, T., IWATA, A., NAGAMUNE, K. and NUNOYA, T. (2014). Characterization of *Eimeria brunetti* isolated from a poultry farm in Japan. *Journal of Veterinary Medical Science*, 76(1): 25 – 29.

KETTUNEN, H., TIIHONEN, K., PEURANEN, S., SAARINEN, M. T. and REMUS, J. C. (2001). Dietary betaine accumulates in the liver and intestinal tissue and stabilizes the intestinal epithelial structure in healthy and coccidia-infected broiler chicks. *Comparative Biochemistry and Physiology Part A: Molecular and Integrative Physiology*, 130(4): 759 – 769.

KRYEZIU, A. J., KAMBERI, M., MUJI, S., MESTANI, N. and BERISHA, S. (2018). Carcass traits of broilers as affected by different stocking density and sex. *Bulgarian Journal of Agricultural Science*, 24(6): 1097 – 1103.

KWIECIEŃ, M., KASPEREK, K., TOMASZEWSKA, E., MUSZYŃSKI, S., JEŻEWSKA-WITKOWSKA, G., WINIARSKA-MIECZAN, A., GRELA, E. R. and KAMIŃSKA, E. (2018). Effect of breed and caponisation on the growth performance, carcass composition, and fatty acid profile in the muscles of Greenleg Partridge and Polbar breeds.

Brazilian Journal of Poultry Science, 20(03): 583 – 594.

LAWAL, J. R., GULANI, I. A., ALI, A. M., BELLO, A. M., ABADAM, F. A., MUSTAPHA, M., DAUDA, J., ADAMU, L. and BIU, A. A. (2016). Dry season prevalence of avian Coccidia infection in domesticated chickens (*Gallus domesticus*) in Jere Council, Borno State, Nigeria. *Journal of Animal Science and Veterinary Medicine*, 9(6): 653 – 659.

LIVINGSTON, M. L., COWIESON, A. J., CRESPO, R., HOANG, V., NOGAL, B., BROWNING, M. and LIVINGSTON, K. A. (2020). Effect of broiler genetics, age, and gender on performance and blood chemistry. *Heliyon*, 6(7): e04400. https://doi.org/10.1016/j.heliyon.2020.e04400

MESA, C., GÓMEZ-OSORIO, L. M., LÓPEZ-OSORIO, S., WILLIAMS, S. M. and CHAPARRO-GUTIÉRREZ, J. J. (2021). Survey of coccidian on commercial broiler farms in Colombia: frequency of *Eimeria* species, anticoccidial sensitivity, and histopathology. *Poultry Science*, 100(8): 101239. https://doi.org/10.1016/j.psj.2021.101239

MOREKI, J., POROGA, B., DIKEME, R. and SEABO, D. (2010). Ethnoveterinary medicine and health management in poultry in Southern and Western Districts, Botswana. *Livestock Research for Rural Development,* 22(6): 107. http://lrrd.cipav.org.co/lrrd22/6/more2206cit.htm

NWEKE-OKOROCHA, O. G., AGAVIEZOR, B. O. and CHINEKE, C. A. (2020). Carcass traits variation in Nigerian local and improved chickens as influenced by breed and sex. *Animal Research International*, 17(1): 3565 – 3571.

OGUNDIPE, S. O. and SANNI, S. A. (2002). Economics of poultry production in Nigeria. *In:* GEFU, J. O. (Ed.). *Poultry Production in Nigeria: A Training Manual.* National Animal Production Research Institute, Ahmadu Bello University, Shika, Zaria.

OGUNRAYI, O. A., AKINSEYE, F. M., GOLDBERG, V. and BERNHOFER, C. (2016). Descriptive analysis of rainfall and temperature trends over Akure, Nigeria. *Journal of Geography and Regional Planning*, 9(11): 195 – 202.

OJEDAPO, L. O., AMAO, S. R., OGUNSOLA, O. O., OUERGHI, F., RHOUMA, A., ALOUI, S., RASSAA, N., HENNACHI, I. and NASRAOUI, B. (2015). Variation of meat-type chickens in relation to genotypes and age of slaughter on carcass indices. *Journal of New Sciences*, 14(6): 473 – 478.

PEEK, H. W. and LANDMAN, W. J. M. (2011). Coccidiosis in poultry: anticoccidial products, vaccines and other prevention strategies. *Veterinary Quarterly*, 31(3): 143 – 161.

SANDA, A. J., BEJI, M. N., WHETO, M., OSO, A. O., SANDA, M. O. and OLOWOFESO, O. (2022). Heritability and repeatability estimates of growth traits in FUNAAB Alpha and Noiler chicken genotypes. *Nigerian Journal of Animal Science*, 24(2): 1 – 17.

SONAIYA, E. B. (2016). Science, technology and innovations for smallholder poultry development. *In: First World Congress on Innovations for Livestock Development.* Sentrim Elementaita Lodge, Nairobi-Nakuru Highway, Nakuru, Kenya, held June 26 – 30, 2016. https://knowledge4food.net/event/world-congress-innovations-livestock-development/

SONAIYA, E. B., OGUNTADE, E. A. and ADESINA, A. A. (2022). Commercial poultry success stories in Nigeria: drivers, challenges, and lessons. *FARA Research Report*, 6(12): 1 – 49.

WONG, J. T., DE BRUYN, J., BAGNOL, B., GRIEVE, H., LI, M., PYM, R. and ALDERS, R. G. (2017). Small-scale poultry and food security in resource-poor settings: a review. *Global Food Security*, 15: 43 – 52.

YAKUBU, A. and ARI, M. M. (2018). Principal component and discriminant analyses of body weight and conformation traits of Sasso, Kuroiler and indigenous Fulani chickens in Nigeria. *The Journal of Animal and Plant Sciences*, 28(1): 46 – 55.

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., SALAKO, A. E. and IGE, A. O. (2007). Effects of genotype and housing system on the laying performance of chickens in different seasons in the semi-humid tropics. *International Journal of Poultry Science*, 6(6): 434 – 439.