Short Note [Nota corta]

GENETIC PARAMETERS AND CORRELATIONS OF EARLY WEIGHT TRAITS IN A NIGERIAN INDIGENOUS HEAVY X LIGHT ECOTYPES POPULATION OF CHICKENS †

[PARÁMETROS GENÉTICOS Y CORRELACIONES DE RASGOS DE PESO TEMPRANO EN UNA POBLACIÓN DE POLLOS INDIGENAS DE NIGERIA DE ECOTIPOS PESADOS X LIGEROS]

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SUMMARY

Background: Improvement of the Nigerian indigenous chickens is desirable because of its socioeconomic important. **Objective**: To estimate the heritability, genetic and phenotypic correlations among body weight, body length, wing length and shank length of the mating of heavy ecotype cocks with light ecotype hens of Nigerian indigenous chickens. **Methodology**: The mating design was such that one heavy ecotype cock mated with 10 light ecotype hens in twenty replicate pens. The mating produced 752 chicks from ten batches of hatch. The estimates of variance components were obtained from paternal half sib analysis using the average information restricted maximum likelihood of BLUPF90 family of programs. **Results**: The heritability of body weight ranged from 0.20 to 0.44 from 6 to 12 weeks of age. Similarly, the heritability of body length, wing length and shank length ranged from 0.39 to 0.63, 0.51 to 0.71 and 0.31 to 0.54 respectively from 6 to 12 weeks of age. The genetic correlations among the early growth traits measured were negative to positive in magnitude and ranged from -0.99 to 0.66 while the phenotypic correlations ranged from -0.15 to 0.91. **Implication**: The results imply that early growth traits of light and heavy ecotype Nigerian indigenous chicken could be improved through mass selection. **Conclusion**: It is concluded from this study that the heritability of early growth traits were moderate to high in magnitude and the genetic and phenotypic correlations mostly positive.

Key words: Additive genes; ecotype; heritability; paternal half sib; pleiotropic effects; selective breeding.

RESUMEN

Antecedentes: La mejora de los pollos autóctonos de Nigeria es deseable debido a su importancia socioeconómica. **Objetivo:** Estimar la heredabilidad, las correlaciones genéticas y fenotípicas entre el peso corporal, la longitud corporal, la longitud del ala y la longitud de la caña del apareamiento de gallos de ecotipo pesado con gallinas de ecotipo ligero de pollos indígenas nigerianos. **Metodología:** El diseño de apareamiento fue tal que un macho de ecotipo pesado se apareó con 10 gallinas de ecotipo ligero en cada corral y se contó con un total de veinte corrales. El apareamiento produjo 752 pollitos de diez lotes de eclosión. Las estimaciones de los componentes de la varianza se obtuvieron a partir del análisis de medios hermanos paternos utilizando la información promedio restringida de máxima verosimilitud de la familia de programas BLUPF90. **Resultados:** La heredabilidad del peso corporal varió de 0.20 a 0.44 de 6 a 12 semanas de edad. De manera similar, la heredabilidad de la longitud del cuerpo, la longitud del ala y la longitud del tarsometarso osciló entre 0.39 y 0.63, 0.51 y 0.71 y 0.31 y 0.54, respectivamente, entre las 6 y las 12 semanas de edad. Las correlaciones genéticas entre los rasgos de crecimiento temprano medidos fueron de negativa a positiva en magnitud y oscilaron entre -0.99 y 0.66, mientras que las correlaciones fenotípicas oscilaron entre -0.15 y 0.91. **Implicacioes:** Los rasgos de crecimiento temprano del ecotipo ligero y pesado del pollo autóctono nigeriano podrían mejorarse a través de la selección masiva. **Conclusión:** La heredabilidad de los rasgos de crecimiento temprano fue de moderada a alta en magnitud y las correlaciones genéticas y fenotípicas en su mayoría positivas.

Palabras clave: Genes aditivos; ecotipo; heredabilidad; medio hermano paterno; efectos pleiotrópicos; crianza selectiva.

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INTRODUCTION

It is estimated that local chicken constitutes 80% of poultry production in sub-saharan countries (Desha *et al*, 2016 cited by Manyelo *et al*, 2020). Nigeria has the highest number of local chicken with an estimated population of 180 million (Pym *et al.*, 2006). The indigenous chickens are reared for meat and egg which serve as good sources of protein for humans. It is believed that the heavy ecotype which is predominant in Northern Nigeria benefitted from the upgrading programmes by the exotic chicken introduced by the colonial masters in the early days before Nigerian independent. The heavy ecotype Nigerian indigenous chickens are usually heavier than the light ecotype found predominantly in southern Nigeria. The indigenous chickens are preferred over the exotic type because of their succulent meat and taste (Manyelo *et al*, 2020). However, the size of the indigenous chicken is smaller than the exotic type. If there is improvement in the body size and meat yield of the indigenous chicken, the protein requirements stipulated by the FAO which is 0.75g per kg per day could be attained. In order to carry out genetics improvement estimation of genetic parameters is needed. Study of genetic parameters in Nigerian indigenous ecotype chickens is scanty. However, Momoh and Nwosu (2008) reported heritability estimates for body weight, body weight gain and feed conversion ratio from 0 to 20 weeks of age in Nigerian indigenous chickens that ranged from 0.17 to 0.43, 0.03 to 0.19 and 0.13 to 0.41 respectively. Udeh and Omeje (2011) reported heritability range of 0.07 to 0.33 for body weight of Nigerian Indigenous Chicken from 4 to 20 weeks of age estimated through intra sire regression of offspring on dam. Similarly, Udeh (2017) reported heritability range of 0.08 to 0.80 for body weight, 0.03 to 0.69 for shank length and 0.22 to 0.47 for wing length in a population of Nigerian indigenous chickens through fitting dyadic mixed models. Genetic parameters vary from population to population and from environment to environment as well as estimation methods (Visscher *et al*, 2008). The essence of this study was to estimate genetic parameters for early growth traits in a Nigerian indigenous ecotype chicken population through paternal half sib analysis.

MATERIALS AND METHODS

The study area

The study was conducted at the poultry unit of the teaching and research farm of the Department of Animal Science, Delta State University, Asaba Campus, Asaba, Nigeria. Asaba is located in Oshimili south local government area of Delta State. It lies in rain forest agro-ecological zone. Asaba has a mean temperature of 23.3ºC to 37ºC. It has a relative humidity of 68-80%, and monthly sunshine of 4-8bars (Meteorological station, 2016).

Experimental birds

Two hundred (200) light ecotype hens and twenty (20) heavy ecotype cocks aged 22 to 23 weeks maintained in the poultry unit of the farm was used for the study. The two ecotype groups were acquired from the teaching and research farm of University of Nigeria Nsukka and maintained as closed populations prior to the study. The experimental birds have mature body weight ranging from 0.68 to 1.5 kg for light ecotype hens and 0.9 to 2.5kg for the heavy ecotype cocks.

Mating design and Management

The light ecotype hens were divided into twenty (20) mating groups and randomly assigned into pens. A heavy ecotype cock was introduced into each group giving a mating ratio of 1:10. Each mating group was fed *ad libitum* commercial layer mash. Water was made available to the birds all time. Fertile eggs were collected daily and numbered according to sire group using a permanent marker. The eggs were hatched in ten batches using very efficient locally fabricated incubators. A total of 752 chicks were produced from the ten batches of hatch. The chicks were identified with wing tags according to sire groups, brooded for 6 weeks and raised to 12 weeks of age by adhering to standard husbandry procedures described by Oluyemi and Roberts (2000). Sexes were separated at 7 weeks of age. The chicks were fed with starter mash from day old to 6 weeks of age and grower mash from 6 to 12 weeks of age. Daily routines such as washing of drinkers, cleaning of feeders and sweeping of the poultry house were carried out. The birds were vaccinated against Newcastle disease, infectious bursal disease and fowl pox disease at the appropriate ages.

Traits measured

The following traits were measured in order to provide the data necessary for achieving the objectives of the study.

Body weight (g): The body weights of the chicks were taken at day old and subsequently at weekly interval from 1 to 12 weeks of age using a sensitive balance. Reading of the weight was taken to the nearest 0.01g.

Body length (cm): This was taken 6 to 12 weeks of age from the tip of the beak to the longest toe without the nail using a tape (Molenaar *et al*, 2008).

Shank length (cm): The shank length was taken weekly from 6 to 12 weeks of age with aid of a tape as the distance from the head of the shank to the base of the smallest tassel (Sadick *et al,* 2020).

Wing length (cm): This was measured from 6 to 12 weeks of age by stretching the wing and running the tape from the armpit of the bird to the end of the wing (Sadick *et al*, 2020).

Statistical analysis

The variance and covariance components were estimated using paternal half-sib model described by Becker (1992). The model in matrix notation is stated accordingly:

$$y = Xb + Zs + e$$

Where: y is the vector of observation, b = the vector of fixed effect of batch and sex, s = vector of random sire effect and e = random residual effects. X and Z are design matrices associating records to fixed effect and random sire effect respectively. It is assumed that E(y) = Xb; E(s) = E(e) = 0 where: E stands for expectation (Mrode and Thompson, 2005). It is also assumed that residual variance, which include random environmental and gene combination variances are independently distributed with variance σ^2e. Therefore, var(e) = $I\sigma^2e = R$, var(s) = $A\sigma^2s$ and var(y) = $ZAZ'\sigma^2s + R$, where: A is the numerator relationship matrix for sires, $\sigma^2s = 0.25\sigma^2a$. Estimates of sire components of variance and covariance were used to estimate genetic and phenotypic correlations. The bivariate model in matrix notation is stated accordingly:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} x_1 & 0 \\ 0 & x_2 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} z_1 & 0 \\ 0 & z_2 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

where: for trait i (i = 1, 2), yi = vector of observations, bi = vector of fixed effect of batch and sex, ai = vector of random direct effect, ei = vector of random residual effect, xi and zi are design matrices relating observations to fixed and direct additive genetic effects (Mrode and Thompson, 2005). Data analysis was done using the average information restricted maximum likelihood (AIREMLF90) in the BLUPF90 family of programs written by Misztal *et al* (2018).

RESULTS AND DISCUSSION

Table 1 presents the mean, standard deviations, minimum and maximum of body weight, body length, wing length and shank length of the progenies of mating between heavy ecotype cocks and light ecotype hens of Nigerian indigenous chickens. The mean body weight ranged from 210.91g at 6 weeks to 601.84g at 12 weeks of age. The standard deviations for body weight increased with age. The mean body length ranged from 19.82 cm at 6 week to 29.30 cm at 12 weeks. The mean wing length and shank length also increases with age. Body weight was the most variable trait, followed by body length, wing length and shank length.

The heritability, genetic and phenotypic correlations among bodyweight, body length, wing length and shank length of heavy ecotype cocks mated with light ecotype hens of Nigerian indigenous chickens from 6 to 12 weeks of age are presented in table 2. The heritability of body weight at 6 to 12 weeks is moderate in size and ranged from 0.20 to 0.41. Similarly, the heritability of body length, wing length and shank length are moderate to high in magnitude and ranged from 0.39 to 0.63, 0.51 to 0.71 and 0.31 to 0.54 at 6 to 12

Table 1. Mean, standard deviation, minimum and maximum of body weight, body length, wing length and shank length of the progenies heavy ecotype x light ecotypes of Nigerian indigenous chickens.

Trait	Mean	Sdev	Minimum	Maximum	Nrec.
BWT6, g	210.91	65.57	108.00	402.00	714
BWT8, g	343.07	123.01	127.00	720.00	708
BWT10, g	504.37	128.96	262.00	805.00	703
BWT12, g	601.84	174.52	337.00	1180.00	700
BL6, cm	19.82	2.91	14.50	25.00	714
BL8, cm	23.59	2.71	16.00	30.00	708
BL10, cm	27.98	4.49	17.50	39.00	703
BL12, cm	29.30	6.01	18.50	40.50	700
WL6, cm	11.14	2.58	5.50	16.50	714
WL8, cm	13.02	2.43	7.50	18.00	708
WL10, cm	15.69	1.67	11.00	20.00	703
WL12, cm	16.27	1.50	12.00	22.00	700
SHL6, cm	5.46	1.52	4.00	8.00	714
SHL8, cm	6.42	1.09	4.05	9.00	708
SHL10, cm	8.03	0.96	5.60	10.00	703
SHL12, cm	8.21	0.98	6.00	10.50	700

Note: Sdev = Standard deviation., Nrec = Number of records.

Table 2. Heritability, genetic and phenotypic correlations of growth traits of light and heavy ecotype Nigerian indigenous chickens from 6 to 12 weeks of age *.

Week6	Body weight	Body length	Wing length	Shank length
Body weight	**0.30(0.05)**	0.45(0.16	0.43(0.20)	0.14(0.05)
Body length	0.08(0.10)	**0.63(0.11)**	0.44(0.10)	0.30(0.08)
Wing length	0.03(0.05)	0.39(0.12)	**0.51(0.15)**	0.30(0.06)
Shank length	-0.38(0.11)	0.28(0.35)	0.66(0.23)	**0.38(0.18)**
Week8				
Body weight	**0.41(0.10)**	0.94(0.11)	0.12(0.05)	0.91(0.09)
Body length	-0.75(0.20)	**0.62(0.08)**	0.40(0.12)	0.45(0.07)
Wing length	0.01(0.10)	0.33(0.15)	**0.61(0.16)**	0.22(0.08)
Shank length	-0.75(0.20)	0.52(0.09)	0.16(0.06)	**0.47(0.20)**
Week10				
Body weight	**0.38(0.05)**	0.24(0.12)	0.35(0.11)	0.54(0.06)
Body length	0.31(0.06)	**0.39(0.12)**	-0.15(0.12)	0.05(0.05)
Wing length	-0.99(0.10)	-0.09(0.01)	**0.71(0.10)**	0.19(0.08)
Shank length	-0.98.00(0.25)	-0.60(0.02)	0.15(0.05)	**0.54(0.08)**
Week12				
Body weight	**0.20(0.12**)	0.05(0.06)	0.41(0.13)	0.50(0.09)
Body length	0.04(0.02)	**0.60(0.09)**	-0.09(0.06)	0.04(0.05)
Wing length	-0.99.00(0.20)	-0.07(0.01)	**0.61(0.12)**	0.42(0.13)
Shank length	-0.98.00(0.15)	-0.23(0.10)	0.42(0.10)	**0.31(0.09)**

* Note: Heritability in bold, genetic correlations on lower diagonal and phenotypic correlations on upper diagonal. Standard errors are in parentheses.

weeks of age respectively. This imply that an appreciable amount of additive genetic variance exist in the Nigerian indigenous chicken population and could be exploited in the improvement of early growth traits.

Tongsiri *et al* (2017) reported heritability for body weight traits (BWT0, 4, 8, 12, 16 and 20 weeks) in Thailand local chicken that ranged from 0.10 to 0.51 which fall within the range observed in the current study. El-Attrouny *et al* (2021) reported that heritability estimates for body weight traits in four Egyptian strains of chickens were between 0.24 to 0.41 which fell within the range obtained in the current study. In a similar study, Udeh (2017) reported heritability of BWT, SHL and WL at 4 to 20 weeks of age that ranged from 0.08 ± 0.11 to 0.80 ± 0.17, 0.03 ± 0.11 to 0.69 ± 0.15 and 0.22 ± 0.47 ± 0.11 respectively. Ebangi and Ibe (1994) reported that heritability estimates for body weight, shank length and breast width at 6 weeks of age from sire, dam and combined sire and dam components of variance were 0.41, 0.66, 0.36; 0.58, 0.14, 0.36 and 0.58, 0.36 and 0.48 respectively. Ebangi and Ibe (1994) and Udeh (2017) share similar opinion with the current study that additive genetic variance for growth traits abound in the local chicken populations waiting to be exploited in the improvement of body weight and other body parameters. Genetic improvement of growth traits in Nigerian indigenous chicken could be achieved through selective breeding. Mass selection involves ranking the animals according to their estimated breeding value (EBV). In order to estimate breeding value, the phenotypic differences or phenotypic deviations among animals for the trait is used. With this information available, EBV is estimated as heritability of the trait multiply by the phenotypic deviation in unit of measurements. The genetic correlations were mostly positive and range from -0.38 ± 0.11 to 0. 66 ± 0.23, -0.75 ± 0.20 to 0.52 ± 0.09, -0.99 ± 0.10 to 0.60 ± 0.02 and -99 ± 0.20 to 0.42 ± 0.10 at 6, 8, 10 and 12 weeks of age respectively. Positive genetic correlations imply correlated responses of traits as a result of pleiotropic effects of genes (Falconer and Mackay, 1996). Negative genetic correlations imply different set of genes governing the trait to the effect that the traits are liable to evolve in opposite directions resulting in substantial change in shape (Norry *et al*., 2000). Udeh (2017) reported that the genetic correlations among BWT, SHL and WL at 4 to 20 weeks of age range from -0.06 ± 0.07 to 0.96 ± 0.05 which fall within the genetic correlation estimates in this study. The consequences of mating heavy ecotype cocks to light ecotype hens are that crossbred progenies with variable heterotic effect on the trait will be produced. Heterosis is the favourable departure from additivity in a crossbred population and usually results from directional dominance and increase in heterozygosity among the crossbreds. Works on heterosis in body weight and short term egg production traits between local and exotic chickens have been reported by Udeh and Omeje (2001, 2005) and Udeh (2011). The authors reported substantial heterosis for body weight and short term egg production (henday rate of production and total egg mass) in the F_1 crosses and residual heterosis in the back crosses of local and exotic chickens. Phenotypic correlations among the growth traits were mostly positive and ranged from -0.15 ± 0.12 to 0.94 ± 0.11 implying that any of the traits could be used to predict the others. This range of phenotypic correlations was slightly outside the range of 0.10 to 0.91 reported earlier by Udeh (2017).

CONCLUSION

It is concluded from this study that the heritability of body weight, body length, wing length and shank length were moderate to high in magnitude and the results of genetics and phenotypic correlations mostly positive. Therefore early growth traits of progenies of heavy x light ecotype Nigerian Indigenous chickens could be improved through selection programmes.

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Compliance with ethical standard. The authors complied with the Department of Animal Science, Delta State University, Abraka welfare guidelines for the care and management of birds.

Data availability statement. The data obtained during this study are available with the corresponding author on reasonable request.

Author contribution statement (CRediT). I. Udeh: Conceptualization, data curation, methodology, project administration, supervision, visualization and editing. O. B. Ighobesuo: Conceptualization, data curation, fund acquisition, writing original draft.

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