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Heritability, Repeatability and Association of Linear Body Traits of Nigerian Guinea Fowl at Different Ages

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Target audience: Animal breeders, Geneticists, Poultry Scientists, Farmers

Abstract

This research was designed to estimate heritability, repeatability and association of body weight and linear body traits (LBTs) of Nigerian guinea fowl. A Total of 717 keets obtained from a mating between 48 dams and specific sires were used for the study. Heritability and repeatability estimates were obtained from sire variance components; Pearson correlation and stepwise multiple regression analyses were carried out among linear traits [breast length (BL), shank length (SL), thigh length (TL) and body circumference (BC)]. Data was collected at 4, 8 and 12 weeks of age. Results showed that heritability and repeatability estimates for BW, BC and BL were highest at 12 weeks and lowest at 4 weeks. Heritability estimates for BW recorded were 0.45 and 0.86 at weeks 8 and 12, respectively, and 0.82 for BC at 12 weeks. Repeatability estimates varied between 0.18 to 0.46 at 8 and 12 weeks of age respectively. Coefficient of determination of BW by LBTs was high at weeks 8 and 12 of age. The combination of BC, BL and SL were the best predictors of BW (R^2 = .848). Findings of this research show that guinea fowls can be selected by employing mass selection from 8 weeks of age. Estimates of heritability and repeatability obtained in this research can serve as a reference point for the selection and improvement of this bird. Selecting guinea fowls at 12 weeks of age based only on BC, BC and BL, and BC, SL, and TL will yield high genetic improvements.

Keywords: guinea fowl; heritability; repeatability; regression; correlation; genetic improvement

Description of problem

The guinea fowl ranks second in number after the domestic fowl in prevalence in Nigeria [1]. Despite the large numbers, its genetic potentials have not been adequately explored and given the wide application afforded its counterpart, the local chicken. Genetic parameter estimates such as heritability, repeatability and genetic correlation are important procedures used in characterizing animals. Akporhuarho and Obodoagwu [2] opined that repeatability is the amount of total phenotypic variance in several measurements of a trait attributable to external differences among individuals. Selection for traits can be made by observations of recurrent phenotypes relying on their repeatability estimates to compute adjusted means fit for telling individuals with different numbers of records [2]. Sanda *et al*. [3] noted that repeatability is important as its magnitude gives an idea of the extent to which selection carried out at any phase will affect subsequent flock performance.

Accurate estimates of variances and genetic parameters for quantitative traits upon which selection and breeding decisions are made are key to the success of genetic improvement programs for livestock species. Sanda *et al*. [3] observed that heritability foretells the phenotypic value as a guide to the breeding value or the degree of agreement between phenotypic value and breeding value. Its magnitude determines choices of many breeding decisions. Ajayi [4] described heritability for a trait as the amount of superiority of the parents above their contemporaries, which is transferred to the progeny. Linear body traits are heritable and form a basis for the consequent carcass yield of the animal [5]. Heritability estimates for body weight range of 0.35 to 0.49 had been reported for guinea fowl by previous authors [6; 7].

Researches has employed linear body trait data to predict livestock animal liveweight and anticipated expected yields [8 and 9]. Prediction and improvement of carcass yield of birds can be achieved by exploiting multiple traits in the regression analysis as it gives more accurate results than single trait. The relationship existing between body weight and linear body traits have been indicated to reflect on feed efficiency and performance of birds [10 and 11].

This study aimed to predict body weight, establish any relationships among the different body traits, and estimate the heritability and repeatability of the linear body traits and body weight in Nigerian guinea fowls. Knowledge obtained from the result of this research will help inform breeding choices and genetic improvement of the Nigerian guinea fowl.

Materials and methods

The research was conducted at the Poultry Unit of the Teaching and Research Farm, University of Calabar, Nigeria. Calabar is located at latitude 4° 57´32.15´´N and longitude 8°19´37.02´´E [12]. Seven hundred and seventeen (717) guinea fowl keets obtained in six hatches from the mating of 48 dams to specific sires in a nested experimental design were used for the study. Offspring were identified along their sire lines. Data on BW, BC, BL, TL and SL were collected at 4, 8 and 12 weeks of age according to the method of Ebegbulem and Asuquo [13]. Body weight of individual birds was taken using a top loader scale calibrated in grammes while breast length, shank length, thigh length and body circumference were measured using tailor's tape and recorded in centimeters.

Statistical analyses: Data collected was subjected to Analysis of Variance in a Randomized Complete Block Design using SAS [14] computer application program. Pearson correlation analysis, employing the CORR procedure, was done to determine the phenotypic correlations between body weight and linear body traits. Stepwise multiple regression analysis using PROC REG of SAS [14] was equally carried out. Percentage of reliability of regression models were described based on the magnitude of their Pearson correlation coefficient (r). The following linear model was used to analyze the data:

$Y_{ijk} = \mu + A_i + S_{j+} e_{ijk}$

Where Y_{ik} = individual observation for the $_{ik}^{th}$ bird

μ = overall mean

A_i = effect of the $_i^{th}$ age (i=1--3)

S_j = effect of the j^{th} sire

e_{ijk} = random error

Multiple regression analysis with stepwise forward selection was done using the model:

$Y = a + b_1x_1 + b_2x_2 + ----b_kx_k$

Where Y = dependent variable (BW)

a = intercept (the value of the dependent variable when the independent variable is zero)

b = regression coefficient associated with independent variable

X_k = independent variables (LBT)

Heritability estimation:Heritability was estimated on sire variance components (σ^2_s) and error(σ^2_w). The variance components were determined from the expected mean square of the analysis of variance. Heritability was computed using the model:

$$h^2 = \frac{4\sigma_s^2}{\sigma_s^2 + \sigma_w^2}$$

Where:

h^2 = heritability (narrow sense)

σ^2_s = sire variance component

σ^2_w = error variance component

Standard error of heritability was computed using the formula:

$$SE = \sqrt{\frac{2(1-t)^2 + (1+(K-1)t)^2}{K(k-1)(N-1)}}$$

Where

$$t = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_w^2}$$

K = number of measurements per mating group = (150)

N = number of mating groups = 8

Repeatability estimation:

Repeatability was estimated from the variances according to the method of Becker (1984) and computed using the model:

$Y_{ij} = \mu + S_i + e_{ij}$

Where

Y_{ij} = record of the jth sire on the i^{th} individual

μ = population mean

S_i = Sire effect

e_{ij} = random error

$$\text{Repeatability} = \frac{\sigma s^2}{\sigma s^2 + \sigma w^2}$$

$$SE = \sqrt{\frac{2(1-R)^2[1+(K-1)R]^2}{K(k-1)(N-1)}}$$

Results

The descriptive statistics of body weight and linear body traits of Nigerian guinea fowl are presented in Table 1. All parameters studied increased with age from 4 – 12 weeks of age. Body weight ranged from 185.67 to 952.64 g while BC ranged from 14.20 to 26.21 cm during the period.

Table 1: Means (±SE) of body parameters of Nigerian guinea fowl

Age (weeks)	Parameter				
	Body weight (g)	BC (cm)	SL (cm)	TL (cm)	BL (cm)
4	185.67±2.86	14.2±0.81	4.02±0.30	9.01±0.07	8.09±0.06
8	480.19±8.06	20.52±0.15	5.71±0.03	13.16±0.07	11.42±0.09
12	952.64±9.82	26.21±0.13	7.01±0.04	15.02±0.07	15.02±0.07

SE = standard error, BC = Breast circumference, SL = shank length, TL = thigh length, BL = breast length, cm = centimeter, g= gramme

Heritability estimates of the birds' body weight and linear body traits are presented in Table 2. Heritability estimates for BW were negative at 4 weeks of age. However, low but positive values were recorded for BL, SL, and TL at this age. Breast circumference was shown to be highly heritable (0.64 – 0.82) from four weeks of age all through to 12 weeks of age. Heritability for BW and LBTs were however positive and high at ages 8- 12 weeks old.

Table 2: Heritability (±SE) of body traits of Nigerian guinea fowl

Age(weeks)	BW	BC	BL	TL	SL
4	-0.01 ± 0.06	0.66 ± 0.38	0.02 ± 1.62	0.004 ± 0.03	0.01 ± 0.04
8	0.45 ± 0.28	0.74 ± 0.39	0.57 ± 0.34	0.74 ± 0.40	0.37 ± 0.27
12	0.86 ± 0.41	0.82 ± 0.56	0.60 ± 0.36	0.29 ± 0.21	0.47 ± 0.32

BW = Body weight, BC = breast circumference, BL = breast length, TL = thigh length, SL = shank length, SE = standard error

Table 3 shows the repeatability estimates of body weight and linear body traits of the guineafowls. Estimates were found to increase with the age of the birds. Just like in heritability, repeatability for BW was estimated to be negative at four weeks of age. Repeatability estimates for BC were steadily average to high, throughout the study.

Table 3: Repeatability estimates(±SE) of body parameters of Nigerian guinea fowl

Age(weeks)	BW	BC	BL	TL	SL
4	-0.01 ± 0.02	0.34± 0.19	0.04 ± 0.18	0.002 ± 0.02	0.03 ± 0.02
8	0.25 ± 0.14	0.39 ± 0.20	0.27 ± 0.17	0.39 ± 0.20	0.18 ± 0.14
12	0.4± 0.20	0.45 ± 0.25	0.3 ± 0.18	0.15 ± 0.10	0.27 ± 0.16

BW= body weight, BC= breast circumference, BL= breast length, TL= thigh length, SL= shank length, SE= standard error

The stepwise multiple regression of body weight on linear body traits of the guinea fowls is presented in Table 4. Breast length was the sole predictor of BW at 4 weeks of age. At eight weeks of age, BL and BC were the predictors of BW with coefficients of determination being 0.642, respectively. At 12 weeks of age, BC + BL + SL were the multiple predictors of BW with very high coefficient of determination (R^2= 0.848).

Table 4: Stepwise multiple regression of bodyweight on linear body traits of Nigerian guinea fowl

Age (weeks)	**Equation**	R-Square	r	SE
4	BW = -15.073 + 27.526BL	0.554	0.744	24.832
8	BW= -337.910+73.318BL	0.601	0.775	62.565
12	BW= -1018.250 + 75.437BC	0.713	0.844	61.61
12	BW = 1014.26 + 41.020BC + 30.047BL +66.01SL	0.848	0.921	45.912

BW=body weight, BC= breast circumference, SL= shank length, TL= thigh length, BL= breast length, SE= standard error, Regression coefficients were significant at (p<0.001)
R-Square = coefficient of determination, r = correlation coefficient

Table 5 shows the correlation coefficients between body weight and linear body traits of Nigerian guinea fowls. Result shows moderate to very strong and positive correlation coefficients between BW and LBTs (0.426 – 0.844). Though the correlation coefficients were generally high, but the highest values were recorded at age 12 weeks for all the measured variables.

Table 5: Correlation of body weight and linear body traits of Nigerian guinea fowl

Age		Correlating variables				
		BC	SL	TL	BL	Sig.
4weeks	BW	0.65	0.676	0.709	0.744	**
8 weeks	BW	0.773	0.426	0.585	0.775	**
12 weeks	BW	0.844	0.837	0.701	0.754	**

**Correlation significant at p<0.01, BW=body weight, BC= breast circumference, SL= shank length, TL= thigh length, BL=breast length*

Discussion

Heritability is a very important determinant of breeding decisions taken by the animal breeder vis a vis the selection of parents for next generation. It gives a clear indication of the genetic worth of a parent which is transmittable to its progeny.

The negative heritability estimates for BW obtained at week 4 in this study is an indication a negative fluctuation at this age on the trait. Similarly, very low estimates obtained for BL, TL and SL at this age is indicative of very low genetic but majorly environmental influence on the traits. Selection for improvement based on the afore-mentioned traits is therefore discouraged at this age. The heritability for BW and LBTs in this research generally increased with age. This observation is line with the report of [14]. High heritability estimates were obtained at ages 8 and 12 weeks old in the present study, therefore substantial genetic gain can be achieved by selecting individuals employing mass selection method for the traits involved at these ages. It is equally hoped that progeny will perform better in the traits of interest than their parents [3]. The steadily high heritability estimates obtained for breast circumference in this study suggest that it is a very important trait in the guinea fowl. It is therefore advocated that selection for the guinea fowl can be made based on BC from as early as four weeks of age for a guaranteed maximal productivity.

Repeatability is another important variable which determines the performance of individual animals. High repeatability estimates are desirable as it indicates the ability of the individual to repeat and maintain its performance in subsequent records. Repeatability for BW and LBTs were generally low at 4 weeks of age. This observation negates the report of [16] and [17]. Highest repeatability estimates for BW and LBTs were obtained 12 weeks of age while the lowest were at four weeks of age. This trend corroborates the report [18]. The low to moderate repeatability estimates obtained in this study portends that larger number of records are required to estimate the potential of Nigerian guinea fowl and to realize a high expected response from selection. This is in tandem with report of Falconer [19] that in order to realize a high expected response from selection fewer number of records are required for traits with high heritability estimates, whereas larger number of records are required for traits with low repeatability estimates. Repeatability therefore remains a useful tool for predicting performance of individuals, especially at young age, and as a selection guide.

Significant ($p<0.001$) coefficients of determination were recorded from four to 12 weeks of age. At the fourth week of age, BL was the best predictor of BW accounting 55.4 % of total variability. This implies that selection for BW made at this age based on BL will yield significant genetic improvement. At the eight weeks of age, BL alone in a linear regression model accounted for 60.10% variability in BW with 77.5% accuracy. The magnitude of the coefficient of determination for each linear body trait in the regression equations showed the relative contribution of each LBT to the BW. The addition of BC to the prediction model raised the percentage of determination to 64.2 % with 80.1% reliability. At 12 weeks of age BC; BC+BL; and BC+BL+SL predicted BW at 71.3, 82.7 and 84.8% respectively. The trend of high regression coefficients obtained by BC, BL and SL in the present study could be attributed to high linear correlations between BW and these traits at this age. This trend is in tandem with the reports of [20] in chickens and [21] in guinea fowl. Improvement in BW can be achieved by selection based on the aforementioned traits solely or in combination. Findings of this research corroborates reports by previous authors that breast circumference, Breast length and Thigh length are good predictors of body weight of different poultry species [8, 22]. It is also worthy to note that coefficients of determination of BW by linear body traits increased with age.

Steady increase in correlation coefficients between BW and BC with age was observed in the present study. Results of high and positive degrees of association between BW and LBTs indicates that selection can be at any age from 4 to 12 weeks of age based on any of these traits for a corresponding improvement of BW. The observation of high positive association between BW and linear body parameters of the present research are in consonance with the reports of [14] in chickens, [1] in guinea fowls and [9] in turkeys. Ogah [21] and Momoh and Kershima [20] reported very high association between BW and BC (r = 0.75 and 0.74) in guinea fowls and Nigerian indigenous chickens respectively.

Conclusion and application:

1. Selection for the guinea fowl can be made based on breast circumference from as early as four weeks of age for a guaranteed maximal productivity.
2. High heritability estimates were obtained at ages 8 and 12 weeks old, therefore substantial genetic gain can be achieved by selecting individuals employing mass selection method for body weight, breast length or thigh length at these ages. To this end, the values of heritability estimates obtained in this study will serve as reliable tools to the selection and improvement of the Nigerian guinea fowls at ages four to 12 weeks.
3. Body weight of the guinea fowls had very high coefficients of correlation with all the body traits studied from 4 – 12 weeks of age.
4. Findings from this research can serve as veritable source of information for the genetic improvement of the Nigerian guinea fowl.
5. The information of correlations between body weight and linear body traits in this study can guide consumers in making a choice of guinea fowl to purchase in the market in the absence of a weighing scale.

References

1. Ogah D. M. (2011). In-vivo prediction of liveweight and carcass traits using body measurements in indigenous guinea fowl. *Biotechnology in Animal Husbandry,* 27(4): 1827-1836.

2. Akporhuarho, P. O. and Obodoagwu, E. (2020). Estimates of repeatability for body weight and conformation traits in three breeds of grower pigs. *Nigerian Journal of Animal Production*, 47(1): 47-52.

3. Sanda, A. J., Bemji, 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.

4. Ajayi, F. O. (2010). Nigerian indigenous chicken: A valuable resource for meat and egg production. *Asian J*ournal *of Poultry Science*, 4(4): 164-172.

5. Ebegbulem, V. N. and Ekwere, O. N. (2021). Haemoglobin type, haematology and morphometric characteristics of Muscovy ducks reared in Calabar, Nigeria. *Annual Research and Review in Biology, 36(8):53-58*. DOI: 10.9734/arrb/2021/v36i830410

6. Ayorinde, K.L. and Ayeni, J. S. O. (1986). The reproductive performance of the guinea fowl (*Numida meleagris*) during different seasons in Nigeria. *Nigerian Journal of Animal Science Research,* 6(2): 127-140.

7. Sanjeev, K., Harpreet, S., Sharma, R. D., Kumar, S. and Singh, H. (1997). Prediction of annual egg production on the basis of past egg production in guinea fowl. *Indian Journal of Poultry Science,* 32(2): 122-125.

8. Durosaro, S. O., Oyetade, M. S. Illori, B.M., Adenaike, A.S., Wheto, M., Amusan, S. A. and Ozoje, M.O. (2012). Estimation of body weight from linear body measurements at 4, 8 and 12 weeks of age among Nigerian local turkeys. In: *Proceeding 36th Annual Conference of Genetics Society of Nigeria*. 15-18 October, University of Calabar, Nigeria. 25-29.

9. Amin, E. M. (2014). Using step-wise multiple regression models to predict body weight and some measurements at early age in turkeys. *Egyptian Poultry Science Journal,* 34(3): 809-830.

10. Ubani, E. O. A., Adeyinka, I. A., Nwagu, B. I., Abeke, F. O., Sekoni, A. A., Out, M.O. and Iyiola-Tunji, A. O. (2011). Estimates of repeatability for some growth traits in naked neck broiler chickens. In: *Proceeding of 36th Annual conference of Nigerian society for Animal Production*, 13-16th March, University of Abuja, Nigeria. 48-50.

11. Ebegbulem, V. N., Archibong, E. E., Kperun, T. N., Izuki, E. D. and Udayi, M. A. (2023). Impact of phase feeding programs on performance of broiler chickens in Nigeria. *Online Journal of Animal and Feed Research,* 13(2): 111-115. ISSN 2228-7701. DOI: dx.doi.org/10.51227/ojafr.2023.17

12. Tageo (2024). Geography population map cities coordinates location. https://.tageo.com

13. Ebegbulem, V. N. and Asuquo, B.O. (2018). Growth performance and carcass characteristics of the black and pearl guinea fowl (*Numida meleagris*) and their crosses. *Global Journal of Pure and Applied Sciences,* 24: 11-16. ISSN 1118-0579.

14. SAS (2010). Statistical Analysis System, User's Guide Statistical Analysis Institute, Inc, Cary, North Carolina.

15. Adeleke, M.A., Peters, S. O., Ozoje, M.O., Ikeobi, C. O. N., Bamgbose, A. M. and Adebambo, O. A. (2011). Genetic parameter estimates for body weight and linear body measurements in pure and cross bred progenies of Nigerian indigenous chickens. *Livestock Research for Rural Development,* 23(1): 1-7.

16. Obike, O. M., Obi, O. C. and Onwuchekwa, J. U. (2016). Repeatability estimate of growth traits in sigmoid strain of Japanese quails reared in humid tropics.

*Nigerian Journal of Agriculture, Food and Environment,*12(1): 99-102.

17. Ojedapo, L. O. (2013). Evaluation of body weight and other linear parameters of Marshal broiler for repeatability estimate. *International Journal of Applied Agriculture and Apicultural Research,* 9(1&2): 175-181.

18. Kabir, M., Akpa, G. N. and Yakubu, H. (2010). Repeatability estimates for body weight and body linear measurements in broiler chickens. *Nigerian Journal of Animal Science,* 12: 7-14.

19. Falconer, D.S. (1989). Introduction to quantitative genetics. 3rd Edition, London, Longman Scientific and Technical publishers.

20. Momoh, O. M. and Kershima, D. E. (2008). Body measurements as predictors of body weight in Nigerian local chickens. *Asset Series,* 8(2): 206-212. ISSN 1595-9694.

21. Ogah, D.M. (2013). Variability in body shape characters in an indigenous guinea fowl (*Numida meleagris L.*). *Slovak journal of Animal Science,* 46 (3): 110-114. ISSN 1337-9984.

22. Banrjee, S. (2011). Prediction of carcass cuts using some non-invasive predictors on broiler ducks reared in hot and humid climate of Eastern India. *World Applied Sciences Journal,* 12 (5): 642-651.