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Genetic Parameter Estimates for Growth Traits in Indigenous Normal Feathered Chickens of Nigeria

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ABSTRACT

This study was conducted at Poultry Production Unit of the Ministry of Animal and Fisheries, Potiskum, Yobe State to determine heritability and repeatability estimates for growth traits in indigenous normal feathered chickens of Nigeria. Fifty (50) dams mated ten (10) sires in a nested experimental design produced progenies identified both sire and dam lines. The growth traits considered were body weight, chest girth, body length, thigh length, shank length, shank circumference, keel length and wing length, respectively. Data collected at 4, 8, 12, 16, 20 and 24 weeks of age were subjected to analysis of variance using Statistical System Analysis (SAS, Version 9.1). Results showed that heritability estimates for body weights using sire component ranged from 0.10 to 0.60 and those of dam ranged from 0.23 to 0.96. Similarly, those of body measurements ranged from 0.02 to 0.98 for both sire and dam components. Repeatability (R) estimates were moderate (0.20) to high (0.73) for body weights but ranged from low (0.05) to high (0.72) for body measurements. Generally, heritability and repeatability estimates for body weights and body measurements increased with age. The study concluded that mass selection could be employed from 8 to 12 weeks of age for the improvement of indigenous normal feathered chickens.

Key words: Indigenous Chickens, Heritability, Repeatability, Body Weight, Body Measurements

Introduction

Poultry, particularly chickens are the most widely kept domestic animals in the world and also the most numerous (Perry *et al*., 2002; Moreki *et al*., 2010). Nigeria has an estimated 175 million highly heterogeneous chicken population of which indigenous chickens' account for more than 60% (Fayeye, 2011). The Normal feathered chicken is by far the most common indigenous strain of fowl in Nigeria (Ajayi, 2010). They have straight feathers covering the entire skin and are subdivided into different ecotypes by size and locations (Olawunmi *et al*., 2008). They scavenge for food and produce eggs all the year round. They have genetic attributes that can be harnessed in different breeding strategies. Furthermore, these chickens have high genetic variability within their populations (Muchadeyi *et al*., 2007; Mwacharo *et al*., 2007; Hassen *et al*., 2009; Osei-Amponsah *et al*., 2010); indicating their high potential for genetic improvement through selective breeding (Dana *et al*., 2011). Traits of economic importance are largely controlled by many genes, each with a rather small effect on the trait, therefore, improvement depends on estimating genetic parameters such as heritability and repeatability which are then used as response to selection.

Heritability could indicate the amount of improvement that can be accomplished by selection (Momoh *et al*., 2014). It is a measure of strength of the relationship between repeated phenotypic records and one of the important genetic tools utilized by breeders for improvement purposes (Obike *et al*., 2016). The concept of repeatability is closely related with relative importance of heredity and permanent environment, affecting the variations for a trait. Therefore, the amount of progress that could be made in selection is partially limited by the repeatability of the trait as it reflects the upper limits of heritability (Haque *et al*., 2001). Falconer (1989) stated that repeatability estimates indicates the gain in accuracy expected from multiple measurements and predicts future performance from past records.

Genetic improvement of indigenous breed of poultry is highly important because of their adaptability to harsh environmental conditions of climate and disease relative to exotic breeds (Ajayi, 2010). The genetic resource base of indigenous chicken in Nigeria is rich and should form the basis for genetic improvement and development of new breeds (Fayeye *et al*., 2014). Hence, few studies have been carried out under the semi-arid environment to establish their performance and genetic variation required for their present improvement.

Materials and Methods

Experimental Site

The study was carried out at the Poultry Production Unit (PPU) in Potiskum Local Government Area, of Yobe State. Potiskum is located between latitudes 11^0 03' and $11^0$30' N, longitudes 11^0 50' and 11^0 51' E at an altitude of 427 m above sea level (Bunmi *et al*., 2016). It falls within the wet and dry Sudano-Sahelian Savannah belt of Nigeria, and it is characterized by fluctuating climatic and seasonal variations. Furthermore, the area has a short period (4-5 months) of rainfall, usually between June to October having an average rainfall of 700 mm/annum with a long dry season of about 7-8 months (NIMET, 2014). The ambient temperature is as low as 20^0C during the dry cold season especially in January being the coldest month and as high as 44^0C during the dry hot period. The hottest month of the year is April. Relative humidity is 45% in August which usually lowers to about 5% in December and January; day length varies from 11 to 12 hours.

Experimental Birds and Management

A total of 60 matured and healthy indigenous normal feathered chickens comprising of 50 females and 10 males of breeding age were used as parent stock to generate progenies for the experiment. The birds were purchased from households in Potiskum, Yobe State. Each batch of chickens bought were quarantined for two weeks and fed layers mash containing 18% CP and 2650 ME/kg. Prior to the arrival of the birds, pens were thoroughly cleaned, disinfected, and properly littered with wood shavings. The drinkers and feeders were also washed and cleaned.

After quarantine, the foundation population was divided in to ten (10) breeding groups; each group containing six (6) birds of five hens and one cock. They were randomly assigned into deep litter floor pens at 1:5 mating ratio. Laying boxes were provided for each pen for natural incubation. Feed and water were provided *ad libitum*. Eggs laid from each mating group of sire and dams were identified. Chicks hatched from each mating group were properly identified (wing tagged) and brooded artificially. Commercial diets were fed (chick mash 0-8 weeks, grower crumble 9-19 weeks and layer pellets at 20 weeks on ward) containing 20, 16 and 18% CP with 2780, 2600 and 2650 ME/kg respectively. All routine husbandry management practices were adhered strictly and maintained through-out the study period. The birds were vaccinated against the major poultry diseases prevalent in the area.

Data Collection

Growth traits which include body weight, body length, breast girth, shank length, shank circumference, keel length, wing and thigh length were taken at four weeks interval (4 to 24 weeks) of age. The body weight of each chicken was recorded individually using a weighing balance and linear body measurements were carried out using a simple tape rule calibrated in centimeters according to Adeleke *et al.* (2011) as follows: -

Chest girth: This was measured as the circumference of the breast region, through the anterior border of the breast bone crest and the central thoracic vertebra.

Body length: This was obtained through measuring the distance from the base of the neck, through the body trunk to the tip of the pygostyle.

Thigh length: The thigh length was taken as the distance between the hock joint and the pelvic joint.

Shank length: Shank length was taken as the distance between the hock joint to the tarsometatarsus.

Shank circumference: This was measured using tape rule in the middle of the left shank of each bird.

Wing length: This was measured as the distance between the tip of the phalanges and the coracoid-humerus.

Keel length: This was measured as the length of the sternum.

Statistical Analysis

The nested half-sib analysis was used for heritability estimates of body weights and body conformation traits with the aid of Statistical Analysis System (SAS, Version 9.1). The statistical model is as follows:

$Z_{ijk} = \mu + S_i + D_{ij} + W_{ijk}$

Where;

$Z_{ijk} =$ phenotype of k^{th} offspring from the family of the i^{th} sire,

μ = Overall population mean,

S_i = effect of i^{th} sire,

D_{ij} = effect of j^{th} dam mated to i^{th} sire,

$W_{ijk} =$ residual deviation (within full sib family deviation)

Heritability was estimated from sire and dam variance components as follows:

(i) Sire variance component

$$h^2_S = \frac{4\sigma^2_S}{\sigma^2_S + \sigma^2_D + \sigma^2_E}$$

(ii) Dam variance component

$$h^2_D = \frac{4\sigma^2_D}{\sigma^2_S + \sigma^2_D + \sigma^2_E}$$

Where:

h^2 = heritability,

σ^2_S = sire variance component,

σ^2_D = dam variance component,

σ^2_E = error variance component

(e) Repeatability coefficients were estimated using the expression below:

$$R = \frac{\sigma^2_B}{\sigma^2_B + \sigma^2_W}$$

Where;

R= repeatability coefficient,

σ^2_B = variance component due to differences between individuals

σ^2_W= variance component due to differences within individuals

Results and Discussion

Table 1 shows the heritability estimates of body weight at different ages. Generally, for sire component estimates for body weights were low to moderate while those of dam components were moderate to high. The estimates recorded for body weights using sire component ranged from 0.10 to 0.60 and those of dam ranged from 0.23 to 0.96. For sire component, though low estimates 0.10 to 0.12 for birds 4, 16, 20 and 24 weeks of age were recorded at the early and late ages, moderate to high 0.30 to 0.60 were recorded at mid ages of 8 and 12 weeks. Heritability estimates of 0.08 and 0.80 for body weights at 4 and 12 weeks of age, respectively reported by Osie-Amponsah *et al*. (2013) in Ghanaian native chicken which are similar to the results of the present study. Adedeji *et al*. (2015) also recorded low to high heritability estimates which ranged from 0.01 to 0.81 for body weights in normal feathered chickens aged from day old to 8 weeks. Similarly, Adeleke *et al*. (2011) reported low to high estimates (0.05 to 0.45) for body weights of normal feathered chickens aged 0 to 20 weeks of age. Differences in heritability estimates could be attributed to

Table 1: Heritability Estimates of Body Weights and Linear Body Measurements of Indigenous Normal Feathered Chickens at Different Ages (weeks)

		Age (weeks)					
Traits		**4**	**8**	**12**	**16**	**20**	**24**
Body weight	Sire	0.11±0.14	0.30±0.22	0.60±0.32	0.12±0.14	0.10±0.12	0.12±0.14
	Dam	0.55±0.30	0.33±0.23	0.50±0.29	0.23±0.20	0.69±0.34	0.96±0.40
Chest girth	Sire	0.12±0.14	0.81±0.38	0.58±0.31	0.42±0.26	0.91±0.39	0.15±0.16
	Dam	0.31±0.23	0.32±0.23	0.78±0.36	0.41±0.26	0.94±0.40	0.27±0.21
Body length	Sire	0.97±0.41	0.29±0.22	0.35±0.24	0.15±0.16	0.64±0.33	0.14±0.15
	Dam	0.81±0.37	0.33±0.23	0.43±0.27	0.10±0.13	0.49±0.29	0.14±0.15
Thigh length	Sire	0.51±0.29	0.64±0.33	0.97±0.40	0.76±0.36	0.65±0.33	0.07±0.11
	Dam	0.12±0.14	0.04±0.08	0.84±0.37	0.27±0.21	0.49±0.29	0.18±0.17

Shank length	Sire	0.71±0.34	0.15±0.16	0.62±0.32	0.05±0.09	0.27±0.21	0.18±0.17
	Dam	0.84±0.37	0.10±0.13	0.45±0.27	0.10±0.13	0.57±0.31	0.28±0.22
Shank circumference	Sire	0.56±0.31	0.73±0.35	0.52±0.29	0.09±0.12	0.27±0.21	0.02±0.06
	Dam	0.97±0.40	0.81±0.37	0.47±0.28	0.02±0.60	0.54±0.30	0.42±0.26
Wing length	Sire	0.19±0.18	0.58±0.31	0.48±0.28	0.26±0.21	0.28±0.22	0.09±0.12
	Dam	0.51±0.29	0.56±0.31	0.76±0.36	0.59±0.31	0.47±0.28	0.24±0.20
Keel length	Sire	0.79±0.36	0.68±0.34	0.04±0.08	0.36±0.24	0.51±0.29	0.16±0.16
	Dam	0.70±0.34	0.98±0.40	0.41±0.26	0.61±0.32	0.54±0.30	0.24±0.20

method of estimation, breed, environmental effect and sampling error due to small data set or sample size (Prodo-Gonzales *et al*., 2003).

The low estimates at the early age (4 weeks) and late (16 to 24 weeks) stage of growth in this study correspond with the lower estimates recorded by Adeleke *et al*. (2011) at 0 to 4 weeks and 20 weeks indicates that body weight is to a very large extent a function of environmental factors at these stages. Hence, selection for body weight may not result in any appreciable improvement. However, an appreciable change in weight can be achieved when selection is applied at mid ages (8 to 12 weeks).

The dam component heritabilities for body weights were moderate to high and tended to increase with age and it correspond with observation of Chambers (1990). Similar trend 0.20 to 0.77 was also observed by Badmus *et al*. (2015) in dam line of broiler chickens at 2 to 8 weeks of age and probably could be as a result of additive maternal effect. This shows that direct maternal and common environmental effects are important source of variation. Prodo-Gonzales *et al*. (2003) reported that maternal environmental effect is categorized into preovipositional and postovipositional (prehatch and posthatch). The posthatch maternal influence on chicken's growth was not significant in this study as the birds were raised independently of the dams. Consequently, preovipositional maternal components such as egg size, egg weight, shell quality and yolk composition may affect the chicken's growth (Aggrey and Cheng, 1993). The environmental effect entails influence on oviductal environment, non-additive gene action and any sire-dam interaction that may be present (Prodo-Gonzales *et al*., 2003). In another study, moderate to high heritability estimates for body weights ranged from 0.26 to 0.65 was reported by Rotimi *et al*. (2016) at 4 to 20 weeks for Nigerian local chickens.

Generally, the estimates for body measurements using sire component were low to high though, as observed for body weight, those of dam component were relatively higher. The high estimates recorded in dam may be due to maternal effect. The dam component gave highest value (0.98) for keel length while the lowest (0.02) was the sire component estimate for shank circumference. The sire component heritability estimates for chest girth were low to high ranging from 0.12 to 0.91 and those of dam component were moderate to high ranging from 0.27 to 0.94. Adedeji *et al*. (2004) reported low to high estimates ranging from 0.08 to 0.68 for breast girth in normal feathered chickens at 0 to 8 weeks of age. Moderate estimate for breast girth (0.36) was reported by Ebangi and Ibe (1994) in Nigerian local chickens at 6 weeks of age. Estimates for body length were low to high ranging from 0.14 to 0.97 and 0.10 to 0.81for sire and dam components, respectively. Similarly, Durusaro *et al.* (2016) reported heritability estimate for body length ranged 0.01 to 0.84 in Nigerian indigenous turkey at 0 to 20 weeks of age. Badmus *et al*. (2015) reported low to high ranged 0.08 to 0.75 in dam component of broiler line at 2 to 8weeks of age. Similar observation was made by Adeleke *et al*. (2011) in Nigerian local chickens at 0 to 20 weeks of age.

Heritability estimates for thigh length in this study were low to high for both sire (0.07 to 0.97) and dam (0.04 to 0.84) components. Badmus *et al*. (2015) recorded estimates for thigh length ranged 0.20 to 0.81 and 0.08 to 0.91 for both sire and dam components, respectively. Similarly, Ebegbulem and Okon (2018) observed moderate to high estimates for thigh length (0.26 to 0.75) in indigenous guinea fowl at 8 to 12 weeks of age. Shank length heritability estimates ranged from 0.05 to 0.71 for sire component and those of dam ranged 0.10 to 0.84. Durusaro *et al.* (2016) reported heritability estimates for shank length which ranged 0.01 to 0.25 in Nigerian indigenous turkey at 0 to 20 weeks of age. In another study, Ebangi and Ibe (1994) observed estimates in sire (0.58) and dam (0.14) components in Nigerian local chickens at 6 weeks of age. The heritability estimates for shank circumference ranged from low to high for sire (0.02 to 0.73) and dam (0.02 to 0.97) components.

Furthermore, the h^2 estimates for wing length at different ages in this study were low to high (0.09 to 0.58) in sire component and moderate to high (0.24 to 0.76) in dam component. Similarly, estimates reported by Udeh (2017) for wing length ranged 0.31 to 0.45 in Nigerian local chickens at 4 to 20 weeks of age. Low to high estimate for wing length (0.05 to 0.91) were reported by Durusaro *et al.* (2016) in Nigerian local turkey. The heritability estimates for keel length ranged from low to high (0.04 to 0.979) in sire component and those of dam were moderate to high (0.24 to 0.98). Similarly, Adeleke *et al*. (2011) reported low to high heritability estimate for keel length (0.10 to 0.63) in Nigerian local chickens at 0 to 20 weeks of age. Moderate estimate (0.34) was also observed by Ebangi and Ibe (1994) in Nigerian local chickens at 6 weeks of age.

Differences observed among the values reported could be attributed to the genetic structure of the populations, environmental factors and methods of estimation. Genetic variance is high in an unselected population. Peters (2000) stated that the amount of genetic variance in any population is largely a function of the level of selection that has taken place in that population, as selection depletes additive genetic variance. Getabalaw *et al*. (2019) reported that an increase in genetic variance reduces environmental variance with a consequential effect on numerical value of heritability. Inbreeding as a mating system also reduces genetic variance.

The estimated variance components and repeatability (R) of body weight and body measurements are shown in Table 2. Generally, repeatability estimates of body weights were moderate to high. Those of body measurements were also moderate to high except for few cases like chest girth at 4 weeks, body length and keel length at 8 weeks, shank circumference at 12 and 16 weeks and wing length at 16 weeks that were low. The R estimates for body weights ranged 0.21 to 0.73. Highest R estimate (0.73) observed at week 12 falls within the range of 0.62 to 0.87 reported by Obike *et al*. (2016) for Japanese quails. Ibe (1995) reported moderate repeatability estimates for body weight (0.21) which is similar to the value obtained at week 4. In a related study, Oguntade *et al*. (2020) reported moderate to high estimates (0.27 to 0.72) for body weights in improved Nigerian local chickens which are close to the values recorded in this study. Similarly, Ebegbulem and Okon (2018) reported moderate repeatability estimates for body weights which ranged from 0.20 to 0.40 in Nigerian guinea fowls of 4 to 12 weeks of age.

Repeatability estimates for linear body measurements ranged from 0.20 to 0.72 were observed in this study. Chest girth had R estimates which ranged from 0.13 to 0.69. These values are higher than the range of 0.33 to 0.42 reported by Ebegbulam and Okon (2018) in indigenous guinea fowl at 4 to 12 weeks of age. Sanda *et al*. (2014) recorded moderate to high repeatability estimates for breast girth which ranged from 0.20 to 0.62 in three broiler strains at 0 to 8 weeks. Body length exhibited low to high R estimates which ranged from 0.04 to 0.72. The values obtained in this study are lower than 0.63 to 0.85 observed in Japanese quails of 2-6 weeks of age by Obike *et al*. (2016) but higher than 0.01 to 0.29 reported by Ebegbulam and Okon (2018) in indigenous guinea fowl of 4 to 12 weeks of age. moderate to high R estimate for thigh length ranging from 0.35 to 0.65 were observed in this study.

The estimates were similar to 0.39 to 0.67 reported by Ojedapo (2013) for broiler chickens at 4 to 8 weeks. Oguntade *et al*. (2020) recorded high R estimate for thigh length (0.75 to 0.93) in improved indigenous chickens (FUNAAB alpha) at 2, 4, 6 8 and 10 weeks of age. Furthermore, shank length repeatability estimate ranged from 0.24 to 0.48 in the present study and the values are lower than 0.49 to 0.94 for Japanese quails as reported by Obike *et al*. (2016) at 2 to 6 weeks of age. Ibe (1995) reported moderate repeatability estimate for shank length (0.33) in Nigerian local chickens between 2-4 weeks of age. Repeatability estimate for shank circumference were low to high and ranged from 0.05 to 0.47. Wing length R estimates ranged from 0.14 to 0.43 and are lower than 0.32 to 0.68 reported by Obike *et al*. (2016) for Japanese quails of 2 to 6 weeks of age. Keel length recorded low to moderate R estimates ranging from 0.14 to 0.44 at 4 to 24 weeks age. Moderate to high estimates ranged from 0.46 to 0.90 for keel length were reported by Obike *et al*. (2016) for Japanese quails at 2 to 6 weeks of age.

Differences observed could be attributed to genotype, size of the data and environmental effects. The low to moderate R estimates for shank circumference, wing length and keel length observed could be due to effect of non- additive or high environmental effects. This implies that the ability of the indigenous normal feathered chickens to repeat their present performance regarding these traits is low, and hence, more number of measurements needs to be considered for any gain in accuracy to be achieved in selecting the birds (Haque *et al*., 2011). However, body weight, chest girth, body length, thigh length and shank length require few number of records for good response as their repeatability estimates were relatively higher than those of other measurements. This is in line with the assertion of Falconer (1989) that, in order to realize a high expected response from selection, fewer number of records required for traits with high repeatability estimates, while larger number of records are required for traits with low repeatability estimates.

Conclusion

The performance of indigenous normal feathered chickens was low in this study. However, more opportunities are available through mass selection. Body weights at the mid ages (8 to 12 weeks) can be used to improve weights through selection at later ages because of high heritability estimates and through indirect selection for linear body measurements especially body length. The high repeatability estimates recorded for most of the growth traits suggests few numbers of records are required for their improvement. The current study could provide base line information for the selection and improvement of indigenous normal feathered chickens.

Table 2: Variance Components and Repeatability Estimates for Growth Traits in Indigenous Normal Feathered Chickens at Different Age (weeks)

	Age(weeks)																	
	4			8			12			16			20			24		
Traits	σ^2_B	σ^2_w	**R**	σ^2_B	σ^2_w	**R**	σ^2_B	σ^2_w	**R**	σ^2_B	σ^2_w	**R**	σ^2_B	σ^2_w	**R**	σ^2_B	σ^2_w	**R**
BW	124.76	329.02	**0.27**	1857.77	2933.13	**0.39**	16129	5983.02	**0.73**	13639	15054	**0.47**	29643	1117	**0.21**	30867	20398	**0.60**
CG	0.4050	2.6657	**0.13**	0.4050	2.6557	**0.43**	0.4851	1.2145	**0.29**	0.5166	1.1211	**0.32**	0.5328	1.6020	**0.69**	1.4643	1.7708	**0.45**
BL	0.1296	0.5177	**0.20**	0.0273	0.6036	**0.04**	0.9366	1.3558	**0.41**	1.6703	4.0154	**0.29**	8.7450	3.4120	**0.72**	1.4640	4.8285	**0.23**
TL	0.8333	0.4544	**0.65**	0.4086	0.7602	**0.35**	0.7637	0.9784	**0.44**	0.9539	1.3681	**0.41**	1.1679	1.3968	**0.46**	0.8205	1.0169	**0.45**
SL	0.0887	0.1400	**0.39**	0.0457	0.1836	**0.20**	0.1986	0.2254	**0.47**	0.1731	0.3162	**0.35**	0.1217	0.1459	**0.45**	0.1663	0.1771	**0.48**
SC	0.0131	0.0229	**0.36**	0.0531	0.0151	**0.26**	0.00212	0.0373	**0.05**	0.0065	0.03892	**0.14**	0.0213	0.0236	**0.47**	0.0021	0.03830	**0.34**
WL	0.1969	0.2573	**0.43**	0.3701	0.6665	**0.36**	0.1480	0.4179	**0.26**	0.1016	0.6083	**0.14**	0.3289	0.6649	**0.33**	0.2290	0.6383	**0.26**
KL	0.0291	0.0932	**0.24**	0.0205	0.1211	**0.14**	0.0221	0.0300	**0.42**	0.0296	0.0502	**0.37**	0.0430	0.0557	**0.44**	0.0513	0.1061	**0.33**

BW=Body weight, CG=Chest Girth, BL=Body Length, TL=Thigh Length, SL= Shank Length, SC=Shank Circumference, WL=Wing Length, KL=Keel Length, σ^2_B = variance between, σ^2_w = variance within, R = Repeatability

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