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EVALUATION OF THE BODY WEIGHTS AND HERITABILITY ESTIMATES OF THE NIGERIAN HEAVY LOCAL CHICKEN ECOTYPE REARED IN NSUKKA

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Abstract

The proper age to select the Nigerian heavy local chicken ecotype (NHLCE) for fast body weight improvement has not been established, and efforts by Nigerian breeders have been on to establish an average age to select the birds for quick genetic improvement on productive traits. The study was conducted to evaluate the body weights and heritability estimates of the Nigerian Heavy Local Chicken Ecotype reared in Nsukka. A total of 350 and 345 day-old chicks for generations (G) 7 and G8, respectively, were used for the study. Generation G7 chicks were produced from the existing generation G6 parent stock, while G8 chicks were generated from G7 parents, in the Teaching and Research Farm, Department of Animal Science, University of Nigeria, Nsukka. Thirty (30) mature cocks and 90 mature laying hens were randomly chosen from the G6 parent stock, and divided into six breeding groups at mating ratio of 1 male: 3 females, to produce the G7 chicks. Fertile eggs were collected, incubated and hatched according to breeding groups to produce the chicks for the study. Similar protocol was applied to generate the chicks for G8 study. Feed and water were provided to the birds *ad libitum*. Data on body weight were collected at 4 week intervals. The study lasted for 24 weeks. The results showed varying body weight performances across the breeding groups and across the generations. Breeding group 1 had the highest body weight at hatch (40.38±0.58g), whereas, breeding group 3 in G8 was highest at 24th week of age (1846.15±32.93g). On the generation performance, the results showed that from hatch to 24 weeks of age, body weights (38.33±0.24g to 1605.67±18.13g) of generation G8 birds were significantly ($p<0.05$) higher than those (37.45±0.26g to 1352.11±17.39g) of generation G7 birds. The heritability estimate ranged from 0.12±0.19 to 0.84±0.88 and 0.12±0.35 to 0.49±0.74, in generations G7 and G8, respectively. The heritability estimates were highest at week 4 of age for both generations G7 and G8 birds. It was therefore concluded that selection for body weight in the Nigerian heavy local chicken ecotype is better carried out at 4 weeks of age.

Keywords: Body Weight, Heritability, Heavy Ecotype, Cocks, Laying Hens and Local Chicken.

INTRODUCTION

Poultry products are among the best sources of animal protein for human consumption, and offer a solution to animal protein shortage, especially in African countries (Hafez and Youssef, 2020). Currently, 333 million people, representing more than 25% of Africa's population, are considered to have extreme food insecurity (Fuentes-Nieva, 2022). According to the Food and Agriculture Organization (FAO) of the United Nations, more than one-third of children in Africa and South Asia are stunted, and under-nutrition is a significant issue for many of the world's poorer nations (WHO, 2021a).

Poor nutrition is thought to be one of the main causes of poor growth, both in the womb and in the delicate first years of life. According to a recent FAO study, poultry eggs and meat are so crucial in the fight against hunger and malnutrition in underdeveloped nations, Nigeria inclusive (WHO, 2021b). In Nigeria, poultry production has increased dramatically, but focus has been on raising of exotic chickens (Anosike et al. 2018), despite the fact that local chickens play significant roles in rural economies (Adedokun and Sonaiya, 2001; Adetayo and Babafunso, 2001; Momoh, 2005), and contribute substantially to the Gross Domestic Product (Abioja and Abiona, 2021).

The Nigerian heavy ecotype local chickens have some inherent qualities that can enable them reproduce, survive and provide food security to the country (Momoh et al. 2010). The Nigerian heavy local chicken ecotype is a dual purpose chickens (Udeh et al. 2018), bred to produce meat and eggs (Udeh et al. 2021) These birds are fast growing strain of local chickens developed and improved in the Department of Animal Science Teaching and Research farm, University of Nigeria, Nsukka (Udeh et al. 2021). They are pure indigenous chickens to Nigeria, obtained from the Fulani heavy ecotype and genetically improved through selection.

They are without any component of exotic chicken gene (Udeh et al. 2018). The birds are self-reliant and hardy with the capacity to withstand harsh weather condition and adaptation to adverse environment (Tlou et al. 2020). However, these indigenous chickens have small body size and poor egg production compared to the exotic chickens. This has led to increased importation of day-old exotic chicks for meat and egg production in Nigeria. Currently, the Nigerian poultry industry is at the mercy of the producer of exotic parent stock abroad.

This is gradually leading to the extinction of the indigenous chicken stock in Nigeria. There is therefore, need to improve on the body size of the Nigerian heavy local chicken ecotype (Udeh et al. 2022), in order to reduce importation of exotic birds and prevent extinction of the indigenous chickens in Nigeria, and also establish selection criteria. The aim of the study was to evaluate the body weights and heritability estimates to determine the appropriate age for selection to improve the body size of the Nigerian heavy local chicken ecotype (NHLCE).

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MATERIALS AND METHODS

Location of the study

The study was conducted at the Local Chicken Breeding Section, Poultry Unit of the Department of Animal Science Teaching and Research Farm, University of Nigeria, Nsukka. Nsukka lies in the derived Savannah region, and is located on longitudes 7^0 24^1E and latitudes 5^0 22^1N with annual rainfall range of 986 – 2098mm. The climate is of humid tropical setting with relative humidity range of 56.01-100%.

The average diurnal minimum temperature ranges between 20.99-370C (Okonkwo and Akubuo, 2007). Nsukka is characterized by two seasons of the year. The rainy season extends from April -October while the dry season spans from November-April with no sharp demarcation (Dateandtimeinfo, 2022).

Experimental birds, Management and Design

A total of 350 and 345 day-old chicks for generations (G) 7 and G8, respectively, were used for the study. Generation G7 chicks were produced from the existing generation G6 parent stock, while G8 chicks were generated from G7 parents, in the Teaching and Research Farm, Department of Animal Science, University of Nigeria, Nsukka. Thirty (30) mature cocks and 90 mature laying hens were randomly chosen from the G6 parent stock, and randomly divided into six breeding groups at mating ratio of 1 male: 3 females, to produce the G7 chicks. Artificial insemination was used to inseminate the hens. Semen collected from the males were used to inseminate the females according to the mating ratio and breeding groups.

The insemination was done on two days interval and lasted for two weeks. Fertile eggs were collected, incubated and hatched according to breeding groups to produce the contemporaneous aged chicks for the study. Similar protocol was applied to generate the chicks for G8 study. The two generations (G7 and G8) birds were studied independently. Generation G7 chicks were produced from G6 parents, while, G8 chicks were produced from G7 parents. Feed and water were provided to the birds *ad libitum*.

The birds were fed formulated diets: Chick mash (Protein 20%, Energy 2778kcal/kg ME), Grower mash (Protein 18%, Energy 2640kcl/kg ME) and Breeder mash (Protein 16.60%, Energy 2705kcl/kg ME) according to their growth phases. Routine management, medication and vaccination were provided as and when due. Data on body weight were collected at 4 week intervals. The study lasted for 24 weeks. The term generation G7 and G8 was used to describe birds that have been subjected to continuous selection by index for up to seven and eight generations.

Data Collection and Analysis

Data collected was subjected to analysis of variance (ANOVA), using statistical package for social science (SPSS 2007). Significances among treatment means were separated using Duncan's new multiple range test (Duncan, 1955).

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Statistical Model

$$X_{ij} = \mu + T_i + \varepsilon_{ij}\chi$$

Where,

X_{ij} = Individual observation,

μ = Population mean,

T_i = Treatment effect,

ε_{ij} = Experimental error

Heritability Estimate Model

$$h_S^2 = \frac{4\sigma_S^2}{\sigma_P^2}$$

Where,

h_S^2 = Heritability of sire,

σ_S^2 = Variance component of sire,

σ_P^2 = Total phenotypic variance

Independent T-Test Model

$$t = \frac{\bar{\chi} - \mu}{\sqrt{S^2 / n}}$$

Where

t = T- Score

$\bar{\chi}$ = Sample mean

μ = Population mean

S^2 = Sample variance

n = Number of sample

RESULTS AND DISCUSSION

Body Weight Performances

The Mean±SE of body weights of breeding groups from hatch to 24th week of age for generations G7 and G8 of the Nigerian heavy local chicken ecotype are presented in Table 1. The results showed significant ($p<0.05$) differences in the mean body weight of generations G7 and G8 and across breeding groups. At week 0 (hatch), the average body weights in generation G7 were significantly ($p<0.05$) higher than those in generation G8 across the breeding groups, except breeding group six.

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Table 1: Mean±SE of Body weights of Breeding Groups from hatch to 24th week of age for generations G7 and G8 of the Nigerian heavy local chicken ecotype

Age (Week)	Gen.	Breeding Groups					
		1	2	3	4	5	6
0 (Hatch)	G7	40.38±0.58^{a}	39.85±0.54^{ab}	37.23±0.61^{c}	36.39±0.61^{c}	40.25±0.43^{a}	37.52±0.54^{bc}
	G8	40.19±0.63^{a}	36.63±0.55^{b}	35.95±0.59^{b}	35.74±0.46^{b}	36.32±0.58^{b}	39.63±0.48^{a}
4	G7	151.60±5.97^{a}	137.32±3.69^{a}	107.21±5.76^{b}	83.24±2.90^{c}	86.36±3.47^{c}	96.00±3.94^{bc}
	G8	203.69±8.45^{b}	279.36±7.26^{a}	195.08±6.37^{b}	216.33±8.02^{b}	210.03±8.41^{b}	198.59±5.93^{b}
8	G7	341.54±11.51^{b}	262.83±11.30^{c}	399.80±14.45^{a}	325.79±8.39^{b}	273.79±6.89^{c}	197.08±8.46^{d}
	G8	438.62±15.59^{b}	508.39±12.32^{a}	457.26±12.85^{ab}	520.57±17.78^{a}	480.40±14.22^{ab}	522.83±17.16^{a}
12	G7	743.56±19.60^{a}	729.88±22.03^{ab}	726.36±15.59^{ab}	665.47±13.65^{b}	576.58±19.35^{c}	443.46±16.35^{d}
	G8	649.70±19.50^{c}	707.19±17.85^{c}	653.10±29.56^{c}	812.82±29.82^{ab}	715.32±33.07^{bc}	863.11±25.45^{a}
16	G7	1146.79±34.00^{a}	975.69±27.87^{b}	926.08±25.34^{bc}	865.03±19.50^{c}	825.90±24.60^{cd}	749.00±25.43^{d}
	G8	835.87±24.42^{d}	1040.03±35.02^{bc}	903.00±50.80^{cd}	1222.77±46.67^{a}	1038.73±52.14^{bc}	1139.68±34.62^{ab}
20	G7	1366.15±45.17^{a}	1115.69±28.91^{b}	1350.77±51.52^{a}	1230.06±38.47^{ab}	1132.76±43.50^{b}	924.98±37.44^{c}
	G8	1264.42±25.25^{c}	1354.09±53.09^{bc}	1384.18±44.41^{bc}	1593.97±41.51^{a}	1514.72±54.40^{ab}	1496.90±51.81^{ab}
24	G7	1407.45±41.97^{NS}	1376.38±37.33^{NS}	1362.06±50.14^{NS}	1338.21±40.90^{NS}	1346.49±44.65^{NS}	1266.74±37.66^{NS}
	G8	1536.39±21.58^{NS}	1643.72±42.08^{NS}	1846.15±32.93^{NS}	1704.14±48.88^{NS}	1639.57±46.01^{NS}	1606.17±54.74^{NS}

a, b, c, d, mean across rows = Significant difference ($p<0.05$) for Sire families, NS = Non significant difference ($p>0.05$), Tot = Total, Gen. = Generation, G7 = Generation seven population, G8 = Generation eight population

However, such trend did not extend beyond 3 weeks of age, as it could be observed that at week 4 and week 8 of age, generation G8 began to indicate superiority over generation G7 across the six breeding groups. Again, the trend was interrupted at week 12 of age, as it could be seen that breeding groups 1, 2 and 3 in generation G7 had higher body weight than those birds in generation G8. Similarly, at week 16, birds in breeding groups 1 and 3, and breeding group 1 at week 20 of age, recorded higher mean body weight in generation G7 than those birds in generation G8. Apart from these few indicated breeding groups, the rest groups had their generation G8 mean body weight higher than those in generation G7. The variations recorded on body weight across the breeding groups could be attributed to growth differentials usually observed in a population of organisms (Tonner et al. 2017).

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The hatch weights obtained in this study across the breeding groups were higher than values (25.86 to 31.13g) reported by Egahi et al. (2018) in hatch weight gain on outcross native chickens. The higher hatch weight obtained in this study could be attributed to genetic gain accrued over the years of genetic improvement through selection (Ogbu, 2010; Agbo, 2016).

The higher body weight obtained at hatch in generation G7 over generation G8 could be attributed to the egg size and egg weight of the G7 hens, which also correlated to the body weight and age of the hens (Payne et al. 1957). It has earlier been reported in literature that older and heavier hens produce large egg size, and large eggs size produce heavier chicks (Payne *et al*., 1957).

Thus, the heavier the hen, the heavier the eggs and consequently, the heavier the chicks (Ayorinde and Oke, 1975). It is important to note that generation G7 hens started laying at 23rd to 24th weeks of age (Udeh et al. 2020), whereas, generation G8 hens laid their first eggs at 19th weeks of age, hence, the variation in chicks' body weight at hatch. Body weights of the birds at 8th weeks of age in generation G8 in this study were in agreement with Udeh et al. (2021), who reported body weight of 400.21g at 8th weeks of age in the Nigerian heavy local chicken ecotype, but, it is slightly higher than the value 350g, reported by Momoh (2005).

The average body weights at 12th weeks of age in this study were higher than values 349 to 479g reported by Tandelle et al. (2003); 358g reported by Mafeni (1995); 371g reported by Momoh (2005); 547.10 to 695.33g reported by Ohagenyi (2009) and 352g reported by Teketel (1986) on different African indigenous chickens, at the same age. On the other hand, the body weights at week 20 of age across the breeding groups were lower than 1627.78g reported by Udeh et al (2021) at the same age. The results also, indicated that generation G8 birds manifested superior body weight over generation G7 birds at 24 weeks of age.

The body weight of G7 birds across the breeding groups ranged from 1266.74g to 1407.45g, while, the body weight performance of generation G8 birds ranged from 1536.39g to 1846.45g. Better performance of G8 birds could be attributed to accrued genetic gain due to selection. Breeding group 3 birds in G8 recorded the highest body weight (1846.45g), suggesting that broiler or meat type chicken line can be developed from this breeding group.

These body weights recorded in G8 at 24th week of age in this study were in the same range with body weights of indigenous Ethiopian chickens reported by Getiso et al. (2016), at the same age. In another study, Magonka et al. (2016) who studied four chicken ecotypes of Tanzanian indigenous chickens reported that 24 weeks body weights of the chickens were 1573g, 1738g, 1427g and 1100g for Horasi, Kuchi, Naked neck and Frizzle ecotypes, respectively, which were slightly below the values obtained in this study.

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The higher body weight exhibited by the Nigerian heavy local chicken ecotype could be attributed to the genetic gain accrued as a result of the continued generations of selection for eight generations. The body weight information obtained from this study would be useful for the mass selection of the cocks and hens for breeding programmes. The results also reveals that the selection applied is effective hence, generation G8 birds were superior compared to generation G7 birds. Ogbu (2010) stated that when the performance of future population under selection is better than the former, it implies that there is genetic gain/response as a result of the selection applied (Lehermeier et al. 2017).

The Mean±SE of body weights from hatch to 24th week of age for generations G7 and G8 of the Nigerian heavy local chicken ecotype are presented in Table 2. The result showed no significant ($p>0.05$) across generations G7 and G8 at hatch, while, from weeks4 of age, the body weight of generation G8 birds were significantly ($p<0.05$) higher than generation G7 birds.

The body weight performances as obtained for G7 and G8 at various ages were higher than those reported by Nwosu and Asuquo (1985), Adedokun and Sonaiya (2001) and Okpeku et al. (2003) for indigenous chickens from the derived savannah, Guinea savannah and rainforest zones of South-Eastern and Western Nigeria.

These birds containing variable numbers of the heavy and light ecotypes were lower in body weight than the selected heavy ecotype chickens that made up the G7 and G8 generations in this study. The results were also, higher than values reported for heavy ecotype local chickens by Momoh (2005) and Ndofor-Foleng et al. (2006). The body weights reported in this study were higher than values reported by Ogbu (2010), who studied generations G0, G1 and G2 of the Nigerian heavy local chicken ecotype. Similarly, the values were equally, higher than values reported by Agbo (2016), who studied generations G4, G5 and G6 of the Nigerian heavy local chicken ecotype.

Table 2: Mean±SE of Body weights from hatch to 24th week of age for generations G7 and G8 of the Nigerian heavy local chicken ecotype

Age (Week)	Generation		P-Value
	G7	**G8**	
0 (Hatch)	37.45±0.26	38.33±0.24	0.21
4	110.28±2.48	216.44±3.66	0.03
8	301.25±6.11	487.51±6.55	0.01
12	650.84±9.38	730.28±11.80	0.04
16	919.16±13.59	1028.96±19.40	0.00
20	1183.04±19.57	1434.29±19.79	0.02
24	1352.11±17.39	1605.67±18.13	0.00

Significant difference ($p<0.05$) for Total generational means, Non-significant difference ($p>0.05$), G7 = Generation seven population, G8 = Generation eight population

The superior performance of the G7 and G8 generations over the G0 to G6 generations in body weight across the ages are expected. This is due to the fact that G7 and G8 birds are descendants of selected parents from the G0 to G6 populations.

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The evident better performance across ages manifested realized selection responses in body weight due to selection applied in the generations G0 to G6 populations. The realized selection responses were favourable and manifested as increased body weight. The body weight performance of the G7 and G8 birds as obtained in this study reflected the cumulative effects of realized genetic gain as a result of positive responses to selection (Cervantes et al. 2016; Lehermeier et al. 2017).

Heritability Estimates for Body Weight at different ages

The heritability estimates and standard error (h^2±SE) of body weight from week 0 (hatch) to 24th weeks of age for generations G7 and G8 of the Nigerian heavy local chicken ecotype are presented in Table 3. The result indicated low to moderate and high heritability estimate across generations and at different ages.

Table 3: The heritability estimate and standard error (h^2±SE) for body weight from hatch to 24th weeks of age for generations G7 and G8 of the Nigerian heavy local chicken ecotype

Age (week)	Generations	
	G7 (h^2)	G8 (h^2)
0	0.14±0.56	0.19±0.65
4	0.84±0.88	0.49±0.74
8	0.55±0.89	0.3±0.49
12	0.51±0.88	0.22±0.66
16	0.39±0.82	0.25±0.69
20	0.29±0.74	0.17±0.59
24	0.12±0.19	0.12±0.35

h^2 = Heritability, G7 = Generation seven population, G8 = Generation eight population

The heritability estimates ranged from 0.12±0.19 at week 24 to 0.84±0.88 at week 4 of age in generation G7. Consequently, in generation G7, low heritability estimates were recorded at week 0 (hatch) and weeks 24 of age, while high heritability estimates were recorded at weeks 4, 8 and 12 of age. Weeks 16 and 20 recorded moderate heritability estimates. On the other hand, in generation G8, low heritability estimates were observed at weeks 0, 8, 20 and 24 of age, while moderate heritability estimate were recorded at weeks 4, 8, 12 and 16 of age.

The heritability estimates at hatch in this study were lower than the records of Ogbu (2010) who reported heritability estimates of 0.169±0.15, 0.230±0.14 and 0.291±0.24 at hatch for G0, G1 and G2, respectively, in the Nigerian heavy local chicken ecotype.

Similarly, the heritability estimates at hatch in this study were lower than values reported by Agbo (2016) at hatch (0.231±0.016 and 0.465±0.030) for generations G5 and G6 in the Nigerian heavy local chicken ecotype. In other studies, Osei-Amponsah (2013), recorded heritability estimate of 0.66±0.20 at week zero in local chickens of Ghana, while, Ohagenyi (2009) recorded heritability estimate of 0.21 at week zero in the heavy ecotype of the Nigerian chickens.

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Heritability estimate in G8, weeks 8, corroborates the report of (Udeh et al. 2022). Interestingly, heritabilities are not constant. Heritability can alter over time due to variations in genetic values, environmental factors, or variations in the relationship between genes and environment (Wray and Visscher, 2008). Genetic variations can occur due to change in allele frequencies which, consequently, could be as a result of selection or inbreeding.

New variants can enter the population through migration or mutation, or existing variants can only contribute to genetic variance after changes in the environment or genetic background (Wray and Visscher, 2008). All these changes contributes to differences in heritability estimates. Heritabilities can also, be changed by altering the variance caused by the environment (Giele et al. 2008). Understanding the mechanisms driving evolution in wild populations requires an understanding of how heredity evolves in response to environmental stressors (Charmantier and Garant, 2005).

However, the low heritability estimates recorded in generation G8 in this study may be attributed to the continued selection on this trait which could have led to reduced variations, homogeneity and gene fixation (Olson-Manning et al. 2012). It also implied that the variation in body weights of the birds were contributed more by environmental factors than genetic factors. Udeh et al. (2021) had earlier reported that when heritability is tending towards zero, it implies that the variation in the trait is more of environmental than genetic factors.

CONCLUSION AND APPLICATIONS

The heritability estimates were highest at week 4 of age for both generations G7 and G8 bird populations. It was therefore concluded that selection for fast body weight improvement in the Nigerian heavy local chicken ecotype is better carried out at week 4 of age.

Funding Declaration

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Conflict of Interest

The authors hereby declare that there is no conflict of interest.

Author’s contribution

UFU: Design, methodology, original drafting of manuscript and statistical analysis, NHM: Supervision, writing of manuscript, review, editing and experimentation, CCN: Supervisory Assistant, Initial design of the experiment and review editing, OMO: Assisted in data collection, feeding and management of the experimental animals, UVC: Assisted in data collection, review and analysis.

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