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Evaluation of Growth and Genetic Parameters of Second Filial Generation (F2) Offspring of Crossbreed Exotic and Local Birds

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Abstract

This experiment evaluatedgrowth traits and estimated genetic parameters of offspring (F2)crossbreed of exotic and local birds in University of Nigeria Nsukka farm. A total of 240 F2 hatched chicks from the genotype groups of F1 (offspring of first filial generation)were used for this experiment. The chicks were brooded in groups according to their genotypes for six weeks. Parameters measured include; body weight, body length, thigh length, and shank length from which heritability were estimated. The result shows that *Amo* cock x *Isa* brown hen genotype (AC x IBH f2) was significantly ($p<0.05$) higher in body weight than other genotypes in all the weeks considered with a mean weight of 46.67±0.33 at 1st week and 1365.00±56.75at 12thweeks of age, followed by *Amo* cock x heavy ecotype hen genotype (AC x HEH f2) with a mean weight of 41.00±1.00 and 1253.00±69.51 at 1stand 12thweeks respectively. Heritability in week one were found to be low in all the traits observed except in body weight and body length of AC x IBH f2 with h^2s of 0.941 and 0.360 for body weight and body length respectively. It could be concluded therefore that crossbreeding of Nigeria local birds with a proven exotic birds increases production performance. Also additive gene effect was stronger than the non-additive gene effect, epitasis or even environmental factors.

Keywords: Growth, Traits, Genetic, Parameters, Birds, Crossbreeds, Generations, Heritability

Introduction

The Nigerian population is increasing at an alarming rate, with a projected population growth of 400,000 million people by 2030 (Bot et al., 2021). The continued expansion in urbanization, from 34.8 percent in 2000 to 49.5 percent by 2017, has implications for food availability and affordability (Owoo, 2021). Mubarak *et al*. (2016) noted that protein intake in Nigeria is still far below the suggested dietary allowance 36g per adult per day rather Nigerians' protein intake could be as low as nine g per day for an adult. This lamentable level of protein intake is execrable and may be implicated for high infant mortality, short life expectancy and stunted growth.There istherefore great need for animal scientists to begin to think inwards on how to avertmalnutrition, especially in children, through livestock intensification.

Throughout human history, approximately 40 livestock species have been domesticated, most of which still contribute to agriculture and food production as domestic animals today (Food and Agricultural Organisation, 2007; Hata*et al.,* 2021).Chicken is one of the most ubiquitous domesticated animals. It is bred for both its egg and meat, and is thought to have originally been domesticated from the red jungle fowl (*Gallus gallus*) native to multiple regions from Southeast Asia to Southwest China (Liu *et al.,* 2006; Miao *et al.,* 2013).Commercial chicken breeds, including layers and broilers, have been bred over the last 100 years through selective mating of various indigenous breeds (Rubin *et al.,* 2010; Elferink*et al.,* 2012; Núñez-León *et al.,* 2019).Over the years, indigenous chickens have acquired diverse genetic characteristics that have aided their adaptation to different challenging conditions in diverse locations such as heat, stress, humidity and disease (Hata*et al.,* 2021). Though local/indegenous chickens are slow growers and poor layers of small sized eggs, they are, however, ideal mothers and good sitters, excellent foragers, and hardy and possess natural immunity against common diseases such that the crossbred could form breed complimentarity.

Cross breeding of the local stock with an exotic commercial stock could take advantage of artificial selection for productivity in the exotic birds and natural selection for hardiness in the indigenous birds(Adebambo*et al*., 2009; Ndofor-Foleng*et al.,* 2014).Fulla (2022) reported that the main purpose of crossing the exotic and local chicken is to introduce new genes, to advance fitness and productiveness traits and to produce breeds adapted to local environment. Crossbreeding of indigenous birds with a proven exotic breed could therefore be advantageous and it is getting popularity in Nigeria (Dogara*et al,* 2021, Momoh&Nwosu, 2008). A good breeder must take into cognizance the genetic progress over a period of time while working with first, second or third or any filial generation (f1, f2, f3….fx) to help keep the track record of genetic improvement traits added achieved to the chosen animals.

Knowledge of genetic parameters is also necessary for designing an appropriate breeding plan for producing birds with the best genetic traits and performance. The purpose of animal breeding is not only to genetically improve individual animals, but also to improve animal populations. To improve populations, basic tools are required to identify and utilize genetic differences between animals for the traits of interest. Most of the economic characters in farm animals that are of concern to a breeder normally show continuous variation. Such characters are controlled by a large number of genes, each having a small, similar and supplementary effect on the character (John-Jaja *et al.,* 2016). Designing of effective selective breeding programs requires quantitative information concerning nature and scale of genetic and environmental sources of variation and correlation for components of performance. Nwosu (1990) stated that in making breeding plans, it is important to know the relative importance of the heritable and the environmental variation of the characters. Though the poultry industry has experienced tremendous growth in recent years, the growth has been with exotic chickens only. There is need to improve the productivity of Nigerian local chickens that are up till now, characterized by small body weight, small egg size and few number eggs (Ige, 2013).

Crossbreeding is a method of mating different breeds of animals in order to obtain desirable attributes and complement shortfalls in one breed with those of the other (Ngwogwugwu*et al.,* 2018).This degree of correspondence is measured by genetic parameters such as heritability, repeatability, and genetic correlation as prerequisite for making efficient selection strategies by the geneticists and breeders (Sajjad, 2012). Heritability estimates the degree of variation in a phenotypic trait in a population that is due to genetic variation between individuals in that population (Wray and Visscher, 2008). It measures how much of the variation of a trait that can be attributed to variation of genetic factors, as opposed to variation of environmental factors. Hermiz and Abdullah (2020), reported estimates of heritability for body weights of chicks at different ages to be; 0.42, 0.61, 0.76, 0.71, 0.43, 0.51, and 0.70 for body weight at one day;four;eight; nine;ten and sixteen weeks and at maturity respectively. Their findings indicated that the heritability of bodyweight traits ranged between 42-76 percent and that the rest could be controlled by environment.

This study therefore seeks to explore the growth traits in the local and exotic traits of birds as well as their crossbred within the university farm. The selected population of the animals (first filial generation, f1) were crossbred to generate second animal population (second filial generation, f2) from which data were collected. The finding could help for further strategies in increasing the farm animal population thereby increasing protein intake of the Nigerian populace.

Objectives of the study

This study focusedon growth traits and genetic parameters ofoffspring (f2) crossbreed of exotic and local birds in University of Nigeria Nsukka (UNN) farm: Specifically, it determined:

1. growth traits of f2 offspring of crossbred exotic and local birds in UNN agricultural farm.
2. heritability of F2 generation of crossbred exotic and local birds in UNN agricultural farm.

Hypotheses

The following null hypotheses weretested at 0.05 level of significance:

H_{01}: There is no significant difference in estimate of growth traits of f2 offspring of crossbred exotic and local birds in UNNagricultural farm. The growth traits (body weight and linear body measurements) were measured by sensitive electronic scale and measuring tape.

$H_{02:}$ There is low heritability estimate of heritability of F2 generation of the crossbred exotic and local birds in UNNagricultural farm.

Materials and Methods

***Design of Study*:** The study was an experimental research. The experiment lasted for twelve weeks from brooding to growing stages.

***Materials*:** The experiment was conducted at the Poultry Unit of the Department of Animal Science Teaching and Research Farm, UNN, located in the southern eastern part of Nigeria.

Experimental Animals included a total of 240 F2 hatched chicks from four genotype sire families of F1 chicken population from the UNN agricultural farm were randomly selected andused for this experiment.

Other materials include New castle disease virus (NDV) vaccine, Gumboro vaccine and fowl pox vaccine which were all purchased from Farmers Need shop Tectonics Road Nsukka. Feed used include chikun starter, hybrid layer and hybrid grower feeds. Kerosene lantern and charcoal stoves. Sensitive digital scale and measuring ribbon tapes which were sourced from Ogige market Nsukka.

Experimental Procedures: A total of the selected 240 F2 hatched chicks from four genotype sire families of F1 chicken population from the UNN agricultural farm was distributed to the 12 constructed pens. Each sire family was replicated four times with 20 birds per replicate/pen. The chicks were brooded in groups according to their sire families for six weeks, after which the black waterproof were removed to form a deep litter system for another six weeks. Colour markers and cloth ribbon were used to identify each birds in each pen.

Vaccination Schedule was as follows:

Age	Disease	Vaccine	Route
Day old	New castle	NDV- Lasota	Intraocular I/O
Week 2	Gumboro	IBVD	Drinking water
Week 3	New castle	NDV – Lasota	Intraocular I/O
Week 4	Gumboro	IBVD	Drinking water
Week 6	Fowl pox	Pox vaccine	Wing web

Commercial feeds (chikun starter, hybrid growers and hybrid layers as well as clean water were given ad libitum throughout the experiment.Charcoal stove and kerosene lantern were used as sources of heat during the brooding section.

***Instrument for Data Collection*:** Data on body weights and linear body measurements were collected every four weeks' interval from 4th week to 20th week with a sensitive scale (electronic kitchen digital) scale with 5000g x1g capacity. Linear body parameters evaluated were body length, shank length and thigh length. These were measured in cm using cloth tape.

***Data Collection Method*:** The body weight was measured by placing each live bird on the holding tray of the electronic scale and the body weight (bw) for that week was read and recorded from the screen. The body length (bl) of the bird was evaluated from the base of the neck to the base of the tail with a calibrated measuring tape in centimeter (cm).Likewise, the thigh length (tl) was measured from the hip joint to hocks joint while the shank length (sl) was taken as the distance between hocks joint to the tarsometatarus and recorded in centimeter for that week.

***Data analysis technique*:** The experimental design used was a completely randomized design (CRD) and the statistical model is as shown below

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

Where; Yij= observation/independent variable, μ =overall mean, Xii = Treatment/genotype effect and eij= residual/error

The data collected on growth traits were subjected to analysis of variance (ANOVA) in SPSS (2022) version 22 to access the significance of data and any significant means were separated using Duncan's new multiple range test (DNMRT) Duncan (1955)

***Genetic Parameters*:** Heritability was estimated using the standard formula below.

$$h^2 = \frac{4\sigma^2 s}{\sigma^2 s + \sigma^2 \omega}$$

Where: h^2 = heritability, σ^2 s = variance of sire and σ2ω = variance of error

Unbiased estimate of components of variance from the ANOVA and Restricted Maximum Likelihood (REML) in SAS software wereused to estimate the parameters above.

Results

Table 1: Mean±SEM of Monthly Body Weight of Four Sire Families of Experimental Birds.

Genotypes	Week 1	Week 4	Week 8	Week 12
AC x IBH f2	46.67±0.33[a]	302.33±4.48[a]	869.00±10.54[a]	1365.00±56.75[a]
AC x HEH f2	41.00±1.00[b]	293.33±12.99[a]	761.67±43.21[ab]	1253.00±69.51[ab]
HEC x IBH f2	37.33±1.86[c]	266.67±14.75[ab]	665.33±45.72[b]	1158.33±57.17[bc]
HEC x HEH f2	35.25±0.48[c]	235.50±19.35[b]	622.75±57.27[b]	969.75±52.24[c]

Means ± Standard Error on the same column with different superscripts are significantly different ($p < 0.05$) while those with the same superscripts are statistically the same or similar. AC x IBH f2 = f2 of Amo cocks and Isa brown crosses, AC x HEH f2 = f2 of Amo cocks and heavy ecotype crosses, HEC x IBH f2 = f2 of heavy ecotype cocks and Isa brown hen crosses and HEC x HEH f2 = f2 of heavy ecotype cocks and heavy ecotype hen crosses.

Table 1 presents the means and the standard errors of means of the body weight of f2 crossbred chicken at different ages. AC x IBH f2genotypewere significantly ($p<0.05$) higher than other genotypes in all the weeks considered with a mean weight of (46.67±0.33)at week 1 and (1365.00±56.75) at 12th week of age followed by AC x HEH f2 with a mean weight (41.00±1.00)and (1253.00±69.51) at first and twelfth week respectively. HEC x HEH genotype has the least weight (35.25±0.48g) and (969.75±52.24g) in first week and 12 weeks respectively.

Table 2: Heritability (h^2s) Estimates for Body Weights and Linear Measurements of F2 Birds.

Age	Traits	AC x IBHf2(h^2s)	ACx HEHf2(h^2s)	HEC x IBHf2(h^2s)	HEC xHEHf2(h^2s)
Week1	**Bw**	0.941	0.244	0.138	0.019
	Bl	0.360	0.186	0.046	0.269
	Tl	0.045	0.008	0.209	0.002
	Sl	0.001	0.001	0.006	0.040
Week4	**Bw**	0.175	0.175	0.000	0.086

Table 2 continued

	Bl	0.003	0.164	0.028	0.017
	Tl	0.032	0.263	0.108	0.003
	Sl	0.234	0.594	0.159	0.159
Week8	**Bw**	0.100	0.052	0.034	0.003
	Bl	0.198	0.074	0.046	0.585
	Tl	0.076	0.044	0.009	0.010
	Sl	0.270	0.245	0.636	0.294
Wek12	**Bw**	0.950	0.365	0.248	0.221
	Bl	0.380	0.296	0.266	0.286
	Tl	0.045	0.008	0.209	0.002
	Sl	0.001	0.001	0.006	0.040

Key: BW= Body weight, BL= Body length, TL=Thigh Length, SL=Shank Length, AC x IBHf2 = f2 of Amo cocks and Isa brown crosses, AC x HEHf2 = f2 of Amo cocks and heavy ecotype hen crosses, HEC x IBHf2 = f2 of heavy ecotype cocks and Isa brown hen crosses and HEC x HEHf2 = f2 of heavy ecotype cocks and heavy ecotype hen crosses, h^2s=heritability of sire/genetic heritability.

Table 2 shows the heritability estimates of body weight and linear body measurements at different weeks of age. The results generally show low to moderate and high heritabilities. Genetic heritabilities(**h^2s**) in week one were low in all the traits observed except in body weight and body length AC x IBHf2 which were high (0.941 and 0.360) in body weight and body length respectively. The heritabilities for other body linear measurements were generally low (<0.20), moderate (>0.20<0.40) except in 12th week for body weight and length.

Discussions

This mean body weights (Table 1) were within the range and agrees with Ilori et al. (2010) who observed 44.27±0.62, 48.57±1.07, and 44.32±0.58, mean body weights of local, exotic and crossbred turkey birds in the first week. The results also fall within the range observed by Chimenem-Amadi et al. (2021) who noted mean weights of 273.22, 689.30 and 1088.00 for 4 weeks, 8 weeks and 12 weeks age of mixed birds. The significant increase in the body weights of Amo cocks and Isa brown hen genotype (AC x IBHf2) than others shows that Amo Cocks which are foreign breeds and Noiler dual-purpose breed of chicken developed in Nigeria by Amo Farm Sieberer Hatchery (Afrimash, 2019) were good for genetic improvement for achieving such qualities of production performance. In the same way, 'Institute de SelectionAnimale'(ISA) Brown birds that were originally from France, and developed as layers in 1978 by ISA and Merck has become a breeding giant in genetic improvement (ISA Poultry, 2022).This confirms that these exotic chicken are dual purpose breeds which were bred to survive on low quality feedstuff to provide good quality meat and egg for small holders to address the challenges of food insecurity and financial dependency among rural populace, especially women (Amo farm, 2018; Dogara*et al.* 2021). The significant increase in AC x IBHf2 shows that this genotype could serve as food security in animal protein industry. This could also quell the tensionthat the constant increase in urbanization, from 34.8 percent in 2000 to 49.5 percent by 2017, has consequences for food availability and affordability (Owoo, 2021).

The presentresults also show that probably, people patronize exotic breeds of birds because of her quick growth rate compared to the local breed. However, the high and comparable values of 41.00±1.00, 293.33±12.99, 761.67±43.21 and 1253.00±69.51 for weeks 1, 4, 8 and 12 respectively show that when the local breed is sired with a proven exotic breed, the transferred genes continue to have effects on the second filial generation offspring. The high level of improvement recorded in body weight in 8th and 12th weeks by AC x HEH f2 genotype shows that this approach could reduce over dependence of farmers on exotic breeds of chicks.According to Fulla (2022), crossing local and exotic chickens primarily aims to introduce new genes, improve fitness and productivity attributes, and create breeds that are environment-adapted. The amo cocks have definitely introduced new genes that improved fitness and productivity in the heavy ecotype local hens in the f2 offspring. Therefore, it may be beneficial to crossbreed native birds with a recognized exotic breed; this practice is becoming more and more common in Nigeria (Dogara et al., 2021; Momoh & Nwosu, 2008). This improvement when sustained could ameliorate deficient protein intake in the local environment.

The findings in (Table 2) were indication that the parameters such as shank and thigh length were not heritable traits as a result of low heritability of 0.045 and 0.001 for thigh lenth and shank length both in week one and week 12 in this close relatives. According to Wray and Visscher (2008), heritability calculates the proportion of genetic diversity within a population that accounts for variation in a phenotypic characteristic. Therefore it quantifies the proportion of trait variation that can be traced back to genetic variation as opposed to variance caused by environmental influences.

This underscores the fact that heritability could be estimated by comparison of close relatives, parent-offspring regression; that is by comparing parent and offspring traits and by sibling comparison; that is by using full-Sib designs and comparing similarity between siblings who share both a biological mother and a father. Half-Sib designs compare phenotypic traits of siblings that share one parent with other sibling groups (Sajjad, 2012).

However, the heritability results fall within the range of values 0.10 reported by Udeh et al (2022), and Adeleke et al. (2011) for indigenous Nigerian Heavy ecotype at 4th week of age. Thesefindings also agrees with the report of Ugwumba (2020) who recorded 0.07±0.00 and 0.28±0.10 for Isa brown exotic cock and sire + dam cross between Isa brown and Frizzle feathered (IB X F) genotype at 20th week of age. Heritability estimates of body weight were also in agreement with the report of Rotimi et al. (2016) that observed inconsistent increase in the heritability estimates of body weight from sire variance components at different ages in the breeding groups of local chickens.

There was high to moderate heritability in the 12th week of age. The implication of high heritability is that the additive gene effect was stronger than the non- additive gene effect, epistasis or even environmental factors and could be used as selection index. This shows that before any method of genetic improvement is engaged, the animals in question should be allowed to be of age so as to allow full potentials to be expressed by their genes.

Conclusion

The findings in this work show that crossbreeding of local birds (Nigerian heavy ecotype local hens) with proven exotic cocks (Amo cocks) increased and improved growth traits like body weight and body length even in second filial generation f2. This shows that crossbreeding exercise could be employed to reduce over dependence of local farmers on exotic breeds of birds with better growth performance. This is because such quality growth traits could be transferred to local breeds in a proper designed crossbreeding plans.

The findings also indicated that the genetic heritability estimates of the additive gene effect was stronger than the non- additive gene effect, epitasis or even environmental factors in 12th week life of the genotype chickens. This means that the traits responsible for body weights and body linear measurements become pronounced at that age and shows that before any method of genetic improvement is engaged. It follows that animals in question should be allowed to be of age so as to allow full potentials to be expressed by the genes.

Recommendations

Based on the findings, it is recommended that;

1. farmers could improve the performance of their local chickens by crossbreeding them with a proven exotic chicken (*Amo* cocks) for a good transmission of better genes for production performance.
2. farmers who wish to engage a crossbreeding method should allow their growing birds to be of age at least 12 weeks for full expression of their heritable potentials before any selection is made.
3. thigh and shank length appear not be good selection indices for growth traits and therefore may not be used as such as they exhibit low heritabilities.

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