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Full Length Research Paper

Evaluation of economic traits in progenies of Nigerian heavy ecotype chicken as genetic material for development of rural poultry production

Agu, C. I., Ndofor-Foleng, H. M.* and Nwosu, C. C.

Department of Animal Science, University of Nigeria, Nsukka, Enugu State, Nigeria.

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Genetic evaluation of egg production and biometrical traits of the first filial generation of the Nigerian heavy ecotype chicken was carried out. Heritability and genetic correlations between the traits were estimated using the mixed model least squares and maximum likelihood computer programme of Harvey. Results show an average hen day production of 58.91% on the first month and 52.69% on the fourth month of lay. Age at first egg (AFE), weight of first egg (WFE), mean egg weight (EW), egg number (EN) and egg mass (EM) were 162.33 ± 1.22 days; 34.29 ± 0.67; 41.47 ± 0.57 g; 71.50 ± 3.77 eggs and 11790 ± 4.50 g, respectively. Heritability for EN, EW and EM were 0.16 ± 0.13, 0.31 ± 0.30 and 0.28 ± 0.24, respectively and thigh length, back-width and neck length range between 0.13 to 0.52, 0.23 to 0.40 and 0.10 to 0.52 between 4 to 20 weeks, respectively. Genetic correlations estimates between all the traits studied were positive, high and highly significant (P < 0.001). The egg production traits and biometric traits of heavy ecotype of Nigerian local chicken may respond to selection considering the medium heritability and the positive correlations between the traits studied.

Key words: Genetic evaluation, egg production traits, heavy ecotype, local chicken.

INTRODUCTION

Nigeria is endowed with many poultry species. These species have lived and produced for several years in the Nigerian environment. Their productivity is poor, owing to stressful environmental factors, problems of diseases, poor housing, and inadequate feeds and feeding. The factor responsible for low productivity of the local poultry resources is the neglect of the local chickens by animal research scientists in preference for exotic breeds (Ndofor-Foleng et al., 2010). These local chickens constitute 80% of the 120 million poultry type raised in the rural areas in Nigeria (Ajayi, 2010). They are self reliant, hardy, and known to possess qualities such as the ability to hatch on their own, brood and scavenge for their food. Recent works (Momoh et al., 2004, 2010; Udeh and Omeje, 2011; Oleforuh-Okoleh, 2011) revealed that there are different ecotypes of Nigerian local chicken, which could be grouped into two major categories based on body size and body weight as heavy ecotype and light ecotype. The heavy ecotype weighs about 0.9 to 2.5 kg at maturity while the light ecotype weighs between 0.68 to 1.50 kg (Momoh et al., 2004). Malago and Baitilwake (2009) reported that they are distinct and vary in performance with none meeting the attribute of good egg traits.

The study of egg production and its related traits such as age and body weight at sexual maturity attracted the attention of several investigators who found that there were wide variations in these traits between different breeds and/or strains of chickens (Iraqi et al., 2007). This genetic diversification could be exploited to improve their productivity. It is a laudable proposition that more

*Corresponding author. E-mail: harriet.ndoforfoleng@unn.edu.ng.

Abbreviations: AFE, Age at first egg; **WFE,** weight of first egg; **EW,** mean egg weight; **EN,** egg number; **EM,** egg mass.

attention be given to the genetic importance and development of the local chicken, in order to improve on the present acute animal protein shortage in Nigeria (Wines, 2009). Some authors had reported estimates of heritabilities and genetic correlations between growth traits in the local chicken. Momoh and Nwosu (2008) reported that heritability for body weight in Nigerian heavy ecotype local chicken and its crosses with the light ecotype ranged from 0.04 to 0.36. Similarly, Adeleke et al. (2011) reported heritability estimates for body weight in pure and crossbred local chicken that ranged from 0.05 at a day old to 0.45 at 16 weeks of age. Some other authors namely Nwosu et al., (1985), Ogbu and Nwosu (2010) and Ohagenyi et al. (2011) reported heritability estimates for growth traits that were moderate to high in magnitude. However, few works have been done on egg production parameters in the heavy chicken ecotype. Oleforuh-Okoleh (2012) reported pooled heritability over three generations of selection of body weight at first egg, egg number and egg weight as 0.28, 0.56, and 0.44, respectively in the light ecotype local chicken. Momoh et al. (2010) reported that egg number in Nigerian heavy ecotype local chicken and its crosses with the light ecotype ranged from 48.60 to 52.94.

Genetic estimates of egg production traits in different breeds and/or strains have been cited by many investigators, who found that there were many variations in these estimates according to the differences of the genetic make-up (Khalil et al., 2004; Nurgiartiningsih et al., 2004). There is extensive literature on genetic parameters of egg number and some production traits in exotic birds. This is not the case for the Nigerian heavy chicken ecotype. A comprehensive estimation of heritabilities and genetic correlations among different egg production traits is needed for designing a sustainable selection program in heavy ecotype chicken in Nigeria.

This study was therefore designed to gather preliminary information on egg production and biometrical traits and further estimate heritability and genetic correlation among the traits so as to see the feasibility or ascertain whether the Nigerian heavy ecotype chicken can respond positively to genetic improvement.

MATERIALS AND METHODS

This research was carried out at the local chicken unit of the poultry farm of the Department of Animal Science, University of Nigeria, Nsukka. Nsukka is located on Latitude 05° 22^{l} North and Longitude 07° 24^{l} East, with annual rainfall ranging from 986 to 2098 mm (Inyang, 1978; Asuquo and Nwosu, 1987).

Management of experimental birds

A total of 55 mature females and males gathered from rural areas in Obudu, a montana region of South-Eastern Nigeria and the adjuring villages of Vandeikya, Kaztina-Ala and Wannune in Benue State (Guinea Savannah) formed the base population for the experiment. These birds were maintained on deep litter floor in breeding pens with a mating ratio of 1 sire to 10 dams. Eggs were collected, pedigreed and hatched naturally using the Basket system as described by Momoh et al. (2004, 2005). On the day of hatching, all chicks were pedigreed by sire. A total number of 298 chicks of both sexes were hatched from the mating of 5 wing banded cocks and 50 hens. The chicks were brooded for 8 weeks and reared until 18 weeks when they were moved to the battery cages for the egg production study. All birds were fed on the same standard ration of chick mash consisting of 18% crude protein and 2,800 kcal ME/kg. From 8 to 18 weeks, hens were fed a 15% crude protein and a 2,700 kcal ME/kg diet. During the laying period, hens consumed at leisure, a diet containing 16% crude protein and 2,700 kcal ME/kg. All chicks were vaccinated and were subjected to the same management, hygienic and climatic conditions. Pedigreed eggs from each individual hen were collected and recorded daily.

Parameters measured

The traits evaluated at the short-term included percent egg production expressed as hen-day rate of production, age at first egg (AFE), weight of first egg (WFE), egg number (EN), egg weight (EW), and total egg mass (TEM), and the biometric traits were thigh length (TL), neck length (NL), and back width (BW).

Percent egg production

This was expressed as:

$$Hen\ day\ percent = \frac{\text{Total Number of eggs laid}}{\text{Average. Number of birds x Number of hens days}} x \frac{100}{1}$$

Egg number

This was measured as the total number of egg per bird.

Egg weight

All eggs laid were weighed singly using a 250 g capacity weighing balance. The average of all the single weights was computed to form the average egg weight.

Egg mass

This was expressed as:

Egg mass = Total egg number × Average egg weight

Statistical analysis

All the data on AFE, WFE, egg weight, EN, EM, TL, NL and BW were analyzed using the General Linear Model (GLM) procedure of the statistical analysis system (SAS, 2002). Treatment means were separated using Duncan's new multiple range test (Duncan, 1955). The model used for the analysis of biometric traits and egg production parameters was:

Table 1. Means of short-term egg production characteristics of the Nigerian heavy chicken ecotypes progeny.

Parameter/Sire	1	2	3	4	5
Age at first egg	159.33[a]	169.11[c]	168.39[c]	152.11[b]	159.10[a]
Weight of first egg	32.16[b]	36.45[a]	34.26[b]	34.55[ab]	33.60[b]
Egg number	71.00[c]	71.10[c]	66.00[a]	68.10[b]	68.20[b]
Egg mass	9574[b]	15459[a]	10142[b]	9995[b]	12479[ab]
Mean egg weight	40.89[b]	43.77[a]	41.26[b]	39.49[b]	41.13[b]

Means having different superscripts in rows are significantly different (P < 0.05).

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

Where, Y_{ij} is the observation of the j^{th} off spring of the i^{th} sire; μ is the overall mean; a_i is the effect of the i^{th} sire and e_{ij} is the random error.

Genetic analysis

Mixed- model least squares and maximum likelihood computer programme (Harvey, 1990) was used to estimate the observable variance components due to sire ($\hat{\delta}_s^2$) and error ($\hat{\delta}_w^2$) by equating computed mean squares by their expectations and solving for the components. Estimates of genetic correlations were obtained using varcomp procedure of Harveys computer program (Harvey, 1990). The programme also computed the genetic correlations and the appropriate standard errors of the estimated heritabilities.

$$h^2 s = \frac{4\hat{\delta}_s^2}{\hat{\delta}_s^2 + \hat{\delta}_w^2}$$

Where, h^2_s is the sire heritability; $\hat{\delta}_s^2$ is the sire variance component and $\hat{\delta}_w^2$ is the error variance component.

$$rG = \frac{Cov\ (x\ y)}{\sqrt{\hat{\delta}_s^2\ (x) \quad \hat{\delta}_s^2\ \ (y)}}$$

Where, rG is the genetic correlation; Cov (x y) is the genetic covariance of x and y components; $\hat{\delta}_s^2$ (x) is the sire variance of × component and $\hat{\delta}_s^2\ (y)$ is the sire variance of y component.

RESULTS AND DISCUSSION

The hen day percentage production ranged from 51.69 to 61.74%. The purebred, heavy ecotype hens reached its “peak” hen day production of 61.74% at second month of lay. Omeje (1983) and Adedokun and Sonaiya (2001) reported peak production of the main crossed between gold link and local chicken of Nigeria and Nigerian indigenous chicken, respectively to occur at the second month of lay. The highest peak HDP% reported in this study is higher than 60.8% reported for hybrid hubbard layers (Asuquo and Ofobrukata, 1991) but less than 63% peak hen-day egg production of eight exotic breeds and strains of chickens commonly used for commercial egg production in Nigeria as reported by Akinokun (1974).

The purebred hens laid their first egg on an average of 162.23 ± 1.22 days, which was on the 23rd week of age. This result is different from the reports of Nwosu (1979) and Omeje and Nwosu (1984), who recorded 133 ± 1.11 days and 157.80 ± 3.21 days, respectively as the age of first lay for the Nigerian light ecotype local chicken. On the other hand, Akinokun (1990) and Oleforuh-Okoleh (2011) reported that age at sexual maturity ranged between 159.47 ± 1.97 to 168.47 ± 1.90 days for the light ecotype local hens in Nigeria. However, findings from all populations studied are still within the range of 153 to 206 days reported in literature for unimproved local chickens both in Nigeria (Akinokun, 1990; Adedokun and Sonaiya, 2001; Momoh, 2005). The current information on the local chicken justifies the new trend that scientists must begin to distinguish between the heavy and light ecotype of the local chicken and the genotype of the local chicken.

The average weight of the first egg of the heavy ecotype local chicken was 34.29 ± 0.67 g. The result of weight at first egg was higher than 25.97 g reported by Omeje and Nwosu (1984); and 30.62 g reported by Oleforuh-Okoleh (2011) but lower than 38.06 g reported by Momoh (2005) for the local chicken known and described now as light ecotype, 41.14 g (Gold link × Local chicken) and 40.10 g (Local chicken × Gold link crosses) (Omeje, 1983). Momoh (2005) also stated that the crossing of light ecotype with the heavy ecotype resulted in significant (P < 0.05) increase in the weight of first egg of the crossbred over the light ecotype. The performance of crossbred was intermediate to those of the two parents, thus implicating an additive mode of inheritance in weight of first egg. However, data (Table 1) reveal that weight of first egg was significantly (P < 0.05) different among the sire breeding groups. This could be

Table 2. Effect of Sire on average thigh length (cm) of the Nigerian heavy ecotypes at 4 weekly intervals.

Age (week)	Sire 1	Sire 2	Sire 3	Sire 4	Sire 5
4th	5.12	5.15	5.33	5.44	5.09
8th	7.20^{a}	9.16^{b}	9.54^{b}	7.37^{a}	7.60^{a}
12th	8.90	8.87	9.36	8.85	8.84
16th	11.42^{b}	12.01^{a}	11.82^{ab}	12.08^{a}	11.72^{ab}
20th	12.65	13.18	13.08	13.02	12.67

Means having different superscripts in rows are significantly different (P < 0.05).

Table 3. Effect of Sire on mean back width (cm) of heavy ecotype of Nigerian local chicken at 4 weekly intervals.

Age (week)	Sire 1	Sire 2	Sire 3	Sire 4	Sire 5
4th	3.27	3.36	3.37	3.41	3.29
8th	4.13^{c}	5.40^{ab}	5.75^{a}	4.37^{bc}	4.10^{c}
12th	5.43	5.77	5.88	5.87	5.45
16th	6.39^{ab}	6.62^{a}	6.07^{b}	6.39^{ab}	6.26^{ab}
20th	6.92^{ab}	7.18^{a}	6.77^{b}	7.07^{ab}	6.85^{b}

Means having different superscripts in rows are significantly different (P < 0.05).

useful in the development of the Nigerian heavy ecotype chicken, since the trait (egg weight) is highly heritable and therefore could be manipulated and improved easily through genetic selection.

The Mean Egg Weight of heavy ecotype of the Nigerian local chicken was 41.47 ± 0.57 g. The breeding groups represented by different cocks (Table 1) had significant effects (P < 0.05) on egg weight. The mean egg weight of local chicken in the present study was consistent to values reported by others. According to Msoffe et al. (2009) mean egg weights of Tanzanian local chicken ecotypes range from 37.65 to 45.61 g for medium and heavy breeds while Odula et al. (2009) reported mean egg weights of 45 and 48 g in local chickens differing in weights in two locations in Kenya. On the other hand, Oleforuh-Okoleh (2011) reported lower value of 36.51 ± 0.55, 38.06 ± 0.50, 38.64 ± 0.49 g for the light ecotype local chicken under three generations of selection. Mean egg number was 71.50 ± 3.77 eggs. The short-term egg number of 71.50 ± 3.77 eggs obtained in this study for the heavy ecotype of hens is an indication that heavy ecotype could be developed as a layer breed. This result is much higher than the value of 48.5 ± 4.1 eggs reported by Omeje (1983) for the Nigerian Local chicken, which retrospectively could be described as the light ecotype hen. The difference in short-term egg number between the present result and Omeje (1983) result is indicative of differences in the genetic make-ups of the light and heavy ecotype chickens. Egg number was significantly different (P < 0.05) among the sires (breeding groups) (Table 1). The significant differences between the breeding groups in egg number may lead to the cautious conclusion that the heavy ecotype breeding groups as segregated by the cocks and hens paired randomly with them and differed from one another. Calculated egg mass (11790.82 ± 544.50 g) was significantly different (P < 0.05) in the breeding groups. The total egg mass of 11.79 kg reported in this work is much higher than 5.6 kg reported by Nwosu (1990) for the light ecotype chicken in southeast Nigeria. From the results obtained in this study on egg number and egg weight of purebred heavy ecotype of the local chicken, it would appear that pure breeding and selective breeding of our local chicken could positively enhance the performance of Nigerian poultry genetic resources.

The result of this experiment (Tables 2, 3 and 4), showed a significant difference (P < 0.05) in most of the biometric traits studied especially at the 8th and 16th week for thigh length; 8th, 16th and 20th week for back length and 4th, 16th and 20th week for neck length. The thigh length of heavy ecotype of Nigerian local chicken varied from 5.12 cm in the 4th week to 13.18 cm in the 20th week while the neck length (Table 2) ranged between 4.34 cm to 12.06 cm from 4th to 20th week. The yield of a reasonably good meat from a compact body as observed by Hill (1954) could be attributable to the broad back of the native chicken. Good back width seems to be associated with vigor and carcass yield. With improvement in the back width of the heavy ecotype local chicken through selection and breeding, there is the probability of improving the meat-producing ability of heavy ecotype local chicken of Nigeria as a broiler breed.

Table 4. Effect of Sire on mean neck length (cm) of heavy ecotype of Nigerian local chicken at four weekly intervals.

Age (week)	Sire 1	Sire 2	Sire 3	Sire 4	Sire 5
4	5.20^a	4.23^b	4.30^b	4.29^b	4.27^b
8	6.30	6.29	6.22	6.35	6.32
12	10.70^b	11.26^a	10.65^b	10.71^b	10.45^b
16	10.71^b	11.26^a	10.63^b	10.72^b	10.51^b
20	11.58^b	12.30^a	12.06^a	12.14^a	12.08^a

Means having different superscripts in rows are significantly different ($P < 0.05$).

Table 5. Heritability estimates of short- term egg production from sire variance components of the heavy ecotype of Nigerian local chicken.

Parameter	h^2	Interpretation
Egg weight	0.31±0.30	Medium h^2
Egg number	0.16±0.13	Low h^2
Egg mass	0.28±0.24	Medium h^2

Table 6. Heritability estimates of some biometric traits of heavy ecotype of Nigerian local chicken.

Age (week)	TL (h^2)	BW (cm) (h^2)	NL (cm) (h^2)
4th	0.13±0.23	0.23±0.23	0.34±0.35
8th	0.38±0.38	0.31±0.54	0.33±0.23
12th	0.52±0.24	0.41±0.29	0.52±0.44
16th	0.29±0.32	0.40±0.38	0.10±0.18
20th	0.24±0.30	0.34±0.35	0.35±0.36

TL, Thigh length; BW, back width; NL, neck length.

From this result, one can say that Nigerian local chicken has a compact body.

Heritability estimates of egg and biometrical traits

Heritability estimates of egg number, egg weight and egg mass from sire variance components for the F_1 heavy ecotype are presented in Table 5. Results show that both egg weight and egg mass had moderate heritability of 0.31 ± 0.30 and 0.28 ± 0.24, respectively and egg number had a low heritability estimate of 0.16 ± 0.13. Egg number heritability estimate of 0.16 obtained in this study differ with the values of 0.25 and 0.21, reported by Kiani-Manesh et al. (2002) in two populations of Iranian native chickens. Francesh et al. (1997), Szwaczkowski (2003) and Nurgiartiningsih et al. (2004) reported estimates of heritability for egg number to vary between 0.11 to 0.53 and concluded that the estimates of heritability were relatively low at the beginning of the laying period, which could be attributed to the significant physiological changes for hens commencing egg production. On the other hand, Momoh (2005) recorded heritability estimates of egg number, egg weight and egg mass as 0.29 ± 0.43, 0.21 ± 0.38 and 0.24 ± 0.44, respectively. The low heritability estimate in this study compares well with the medium h^2 estimated for egg number by Momoh (2005). This is to be expected since heritability coefficient is a random variable and the population of heavy ecotype has not been selected and classified as compared to the exotic breeds of chicken which has been selected and classified, based on their growth and reproductive efficiency. Adebambo et al. (2006) reported that our indigenous chickens have gone through more of natural selection for resistance to the tropical climate rather than artificial selection for productivity.

The estimated heritability of the biometric traits measured at specific ages is shown in Table 6. The heritability of thigh length was 0.13 (low), 0.38, 0.52 (high) 0.29 and 0.24 (moderate) at 4, 8, 12, 16 and 20 weeks, respectively. This indicates that the body length of heavy ecotype can be improved through mass selection. The

Table 7. Genetic (rG) between biometrical traits.

Parameter	rG	Interpretation
Egg number × egg weight	0.83***	Highly significant
Egg number × egg mass	0.80***	Highly significant
Egg weight × egg mass	0.71***	Highly significant
THL × NL	0.82***	Highly significant
THL × BW	0.81***	Highly significant
NL × BW	0.86***	Highly significant

***p < 0.001.

heritability estimate of back-width of the heavy ecotype increased from 0.23 ± 0.23 at 4 weeks to 0.44 ± 0.12 at 8 weeks and thereafter declined to 0.34 ± 0.35 at the 20th week. Similarly, heritability estimate of the neck length increased gradually up to 12 weeks and thereafter declined gradually until the 20th week. The highest heritability obtained for the biometrical traits was at the age of 8 and 12 weeks. This implies that selection based on biometrical traits should be carried out at the age of 8 weeks or 12 weeks. On the average, the biometrical traits of the heavy ecotype could be described as being lowly to moderately heritable and indicate that response to selection at the 8th or 12th week could be rapid.

Genetic correlations of egg and biometrical traits

Estimated genetic correlations for egg number, egg weight and egg mass are shown in Table 7. The genetic correlation between the egg number and egg weight was high and positive (0.83). This was higher than rG between egg number and egg mass (0.80) and rG between egg weight and egg mass (0.71). This favorable trend indicates that selection for earlier age at first egg is likely to be associated with moderate gain in egg number. The high genetic correlation between EN and EW is analogous to correlations reported by Fairfull and Gowe (1990) in unselected control lines of white leghorns, and very similar to those estimated by Besbes et al. (1992), Mielenz et al. (1994), Wei and van der Werf (1995), Tixier-Boichard et al. (1995) and Jeyarubau and Gibson (1996). However, Oleforuh-Okoleh (2011) reported negative genetic correlations between egg number and egg weight, suggesting an increase in EN led to a decrease in EW. The heavy ecotype chickens exhibited a more consistent and less variable (between traits) estimates of genetic correlations in this study. Adebambo et al. (2006) reported that genetic improvement for one trait could result in improvement for the other trait as correlated response. Pleitropic action of gene can be implicated here.

The estimates between all the biometric characters studied (Table 7) were positive, high and highly significant (p < 0.001). The estimated genetic correlations measured all fall between the range of 0.81 and 0.86. They were all positively correlated, implying that an improvement in one will lead to an increase of the other trait. The variability of these progeny provides advantage for improvement of the Nigerian heavy ecotype chicken. An additional benefit is given to the heavy ecotype local chicken by a positive and significant genetic correlation that exist between thigh length and back length, thigh length and neck length and neck length and back length.

Conclusion

This study shows that Nigerian heavy ecotype local chicken has a good potential for egg production and biometric (growth) traits. From this study, it indicates that the egg production traits and biometric traits of heavy ecotype of Nigerian local chicken may respond to selection, considering the medium heritability and the positive correlations between the traits studied. Such potentials can be exploited so that selection could be carried out in the heavy ecotype chicken and thus improve poultry production. The low to moderate heritability estimates observed could be due dominance and epistasis (non-additive genetic effects). Changes in heritability estimates across different ages could indicate various expressions of different genes at different ages of the chickens' growth and the reduction of environmental effects. However, since chickens under rural production systems are kept both for meat and egg production, selection for genetic improvement of local chickens should seek to improve the two traits simultaneously. However, more studies are needed to explore other factors like production, in terms of carcass quality and disease resistance so that findings from such studies and the ones presented here could be a significant prelude to the improvement of the heavy local chicken ecotype.

REFERENCES

Adedokun SA, Sonaiya EB (2001). Comparism of the performance of Nigeria Indigenous chicken from three agro-ecological zones of

Nigeria. Livestock Res. Rural Dev. (13)2, 2001. http.www.cipar.org.co/lrrd 13/2/aded132htm.
Ajayi FO (2010). Nigerian Indigenous Chicken: A Valuable Genetic Resource for Meat and Egg Production. Asian J. Poult. Sci. 4: 164-172.
Akinokun O (1974). The problem of the improvement of poultry production in Nigeria. Nigeria Agricult. J. 11: 61-71.
Akinokun O (1990). An evaluation of exotic and indigenous chickens as genetic Materials for development of rural poultry production in Africa. In: Rural poultry production in Africa. Ed. Sonaiya EB. Proceeding of an International workshop on rural poultry in Africa. Ile-Ife Nigeria, (13-16 Nov 1989). pp. 56-61.
Asuquo BO, Ofobruketa O (1991). Short-time egg production and physical egg characteristics in a flock of Hubbard layers. Nig. J. Anim. Prod. 18: 93-97.
Asuquo BO, Nwosu CC (1987). Heritability and Correlation estimates of body weight in the local chicken and their crosses. E. Afr. Agric. For. J. 52(4): 267-271.
Besbes B, Ducrocq V, Foulley JL, Protais M, Tavernier A, Tixier BM, Beaumont C (1992). Estimation of genetic parameters of egg production traits of laying hens by restricted maximum likelyhood applied to a multiple-trait reduced animal model. Genet. Selection Evol. USA. 24(6): 539-552.
Duncan DB (1955). New Multiple Range Test. Biometrics, 11: p. 1.
Fairfull RW, Gowe RS (1990). Genetics of egg production in chickens. In: Poultry Breeding and Genetics. Chapter 29. Crawford RD ed. Elsevier, Amsterdam, The Netherlands, pp. 705-759
Francesh A, Estany J, Alfonso L, Iglesias M (1997). Genetic parameter for egg number, egg weight and egg shell colour in three Catalan breed. Poult. Sci. 76: 1627-1631.
Harvey WR (1990). Mixed Model Least-squres and Maximum Likelihood Computer programme. Ohio State University Columbus (Mimeo).
Hill DH (1954). Poultry production in Nigeria. Sectional paper 67. 10th World poultry Congress Edinburgh, pp. 318-321.
Inyang PE (1978). The climate of Nsukka environs. In: The Nsukka Environment Ed. p. 152.
Iraqi MM, Afifi EA, El-Labban AM, Afram M (2007). Heterotic and genetic components in 4x4 diallel mating experiment for egg production traits in chickens. 4th World's Poultry Conference, 27-30 March 2007, Sharm EL-Sheikh, Egypt.
Jeyarubau MG, Gibson JP (1996). Estimation of additive genetic variance in commercial layer poultry and simulated populations under selection. Theor. Appl. Genet. 92: 483-491.
Khalil MK, AL-Homidan AH, Hermes IH (2004). Crossbreeding components in age at first egg and egg production for crossing Saudi chickens with white Leghorn livestock Res. Rural Dev. 16(1).
Kiani-Manesh A, Nejati–Javaremi A, Saneei D (2002). Estimation of variance component of economically important traits in Tranian native fowls. Proc. 7th World Congress on Genetics Applied to Livestock Production, Montpellier France, August 19–23 Abstract.
Malago JJ, Baitilwake MA (2009). Egg traits, fertility, hatchability and chick survivability of Rhode Island Red, local and crossbred chickens. Tanzania Vet. J. 26(1): 24-34
Mielenz N, Groeneveld E, Muller J, Spilke J (1994). Simultaneous estimation of variances and covariance's using REML and Henderson 3 in a selected population of White Leghorns. Br. Poult. Sci. 35: 669-676.
Momoh OM, Ani AO, Ugwuowo LC (2010). Part-period Egg Production and Egg Quality Characteristics of Two Ecotypes of Nigerian Local Chickens and Their F1 Crosses. Int. J. Poult. Sci. 9(8): 744-748, 2010 ISSN 1682-8356.
Momoh OM, Tule JJ, Nwosu CC (2004). Backward integration in natural incubation of local chickens using the basket system. Proceedings of the 29th annual conference of the Nigerian society for Animal production. 21st – 25th March 2004. Usman Danfodio University Sokoto. 29: 36-39.
Momoh OM, Nwosu CC (2008). Genetic evaluation of growth traits in crosses between two ecotypes of Nigeria Local Chicken. Livest. Res.Rural Dev., 20(10).
Momoh OM (2005). Genetic and phenotypic evaluation of the Nigerian heavy chicken ecotype and its crossbreds with the light ecotype. Ph. D Thesis University of Agriculture, Makurdi. p. 164.
Msoffe PL, Minga UM, Olsen JE, Yongolo MG, Juul-Madsen HR, Gwakisa PS, Mtambo MM (2009). Phenotypes including immunocompetence in scavenging local chicken ecotypes in Egg traits, fertility, hatchability and chick survivability of chickens Tanzania Veterinary Journal Vol. 26, No. 1 2009 36 Tanzania. Trop. Anim. Health Prod. 33: 341-354,
Ndofor-Foleng HM, Ngongeh LA, Uberu CPN, Nwosu CC (2010). Evaluation of the performance of two local chicken and the main cross ecotypes reared in Nsukka, Enugu State. Nigeria. I.J.S.N., 1(2): 179-182.
Nurgiartiningsih VM, Mielenz N, Preisinger R, Schmutz M, Schueler L (2004). Estimation of genetic parameters based on individual and group mean records in laying hens. Br. Poult. Sci. 5: 604-610.
Nwosu CC (1990). Review of indigenous poultry research. In: Sonaiya EB (Ed). Rural Poultry in Africa: Proceedings of an International Workshop held in Ile-Ife, Nigeria, (November 13 - 16, 1989). Thelia house, Ile-Ife. pp 62-71.
Nwosu CC (1979). Characterization of the local chicken of Nigeria and its potential for egg and meat production. In: poultry production in Nigeria. Proc. 1st National Seminar on poultry production. Zaria, pp. 187-210.
Nwosu CC, Ikeme AI, Omeje SSI (1985). Meat evaluation of the Nigerian local chicken and their crosses. Nig. Food J. 4(1): 121-124.
Odula OP, Ogara WO, Okuthe SO, Muchemi G, Okoth E, Odindo MO, Adhiambo RF (2009). Assessing the productivity of indigenous chickens in an extensive management system in Southern Nyanza, Kenya. Trop. Anim. Health Prod. 41: (ahead of print) 2009.
Oleforuh-Okoleh VU (2011). Estimation of genetic parameters and selection for egg production traits in a Nigerian local chicken ecotype. ARPN J. Agric. Biol. Sci. 6: 12, December 2011 ISSN 1990-6145. www.arpnjournals.com
Omeje SSI (1983). Heterosis of body weight and short – term egg production in crosses between parent stock of gold – link and local chickens of Nigeria. MSc. Thesis. Department of Animal Science. University of Nigeria, Nsukka, Nigeria, p. 208.
Omeje SSI, Nwosu CC (1984). Heterosis and superiority in body weight and feed efficiency Evaluation of Exotic parent stock by local chicken F_1 crosses. Nig. J. Genet. 5(1): 11-26.
SAS (2002). Statistical Analysis Systems Institute, (2002) SAS/STAT guide for personal computers, vers. 8. Cary, NC, USA, SAS Institute.
Szwaczkowski T (2003). Use of mixed model methodology in poultry breeding: Estimation of genetic parameters. In Poultry Genetics Breeding and Biotechnology. Muir WM and Aggrey SE ed. CAB Int., Wallingford, Oxon, UK. pp. 165-202
Tixier-Boixard MD, Boixard E, Groeneveld E, Bordas A (1995). Restricted maximum likelihood estimates of genetic parameters of adult male and female Rhode Island Red Chickens divergently selected for residual feed consumption. Poult. Sci. 74: 1245-1252.
Udeh I, Omeje SI (2011). Heritabilities and genetic correlations between body weight and pecking behaviour in Nigerian local chicken Research Opinions In Animal & Veterinary Sciences. PRINT ISSN 2221-1896, ONLINE ISSN 2223-0343. www.roavs.com
Wei M, van der Werf JH (1995). Genetic correlation and heritabilities for purebred and crossbred performance in poultry egg production traits. J. Anim. Sci. 73: 2220-2226. http://jas.fass.org/cgi/reprint/73/8/2220.
Wines M (2009). Malnutrition is cheating its survivors and Africa's future. The new Work Times. http://query.nytimes.com/gst/fullpage.html. Published: March 28, 2009. pp. 1-5.