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Research Article

Phenotypic Correlations Between Body Weight and Egg Production Traits of Local Chicken Genotypes in Humid Tropical Rain Forest of Umudike

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ABSTRACT

Phenotypic correlations were established between body weight and some egg production and egg quality traits of F_1 local chicken hens. The hens consisted of 5 homozygous naked neck x naked neck (Na/Na), 6 naked neck x frizzle (Na/F), 7 naked neck x normal (Na/na), 6 homozygous frizzle x frizzle (F/F), 4 frizzle x naked neck (F/Na), 8 frizzle x normal (F/na) and 7 homozygous normal x normal (na/na) genotypes. They laid a total of about 151 eggs between 24 and 32 weeks of age. Correlated traits were body weight at first egg (BWTFE), body weight of laying hens (BWT), age at sexual maturity (ASM), egg number to 56 days (EN_{56}), hen day production (HDP), egg weight (EWT), egg index (EI), egg length (EL), sell thickness (ST), yolk weight (YWT), yolk height (YH), yolk width (YW), yolk index (YI), albumen weight (AWT), albumen height (AH) and Haugh unit (HU). Correlation coefficients of these traits were obtained by Pearson's Product Moment correlation method. Results indicated that the correlation coefficients between BWTFE and each of ASM, EN_{56} and HDP ranged from -0.77 in Na/F to 0.75 in na/na, -0.93 in F/na to 0.86 in Na/F and -0.89 in F/Na to 0.71 in Na/F, respectively. Large, positive and highly significant ($P<0.01$) correlation coefficients were observed between BWT of the laying hens and each of EWT (r =0.80, 0.85 and 0.74) and EW (r= 0.67, 0.75 and 0.62) in Na/F, Na/na and F/F, respectively. Egg length also correlated highly significantly ($P<0.05$) with BWT of F/na laying hens (r = 0.55). Yolk weight, YW, AH and AWT of most of the genotypes had positive and significant ($P<0.05$, $P<0.01$) correlation coefficients with BWT of the laying hens. All egg quality traits correlated positively among themselves in Na/na while only one negative coefficient (r =-0.022) was recorded between EWT and HU in F/Na. In conclusion, genetic improvement of body weight of laying hens will result in corresponding improvement of egg production and egg quality traits of the local chickens, especially those of naked neck and frizzle paternal origin. Indirect selection for any one of the positively correlated egg quality traits could result in genetic improvement in the others.

Key words: Phenotypic correlation, body weight, egg traits, genotype, local chicken

INTRODUCTION

Animal products such as egg and meat supply animal protein and essential amino acids required for the normal functioning of human body. There is insufficient animal protein consumption by Nigerians leading to malnutrition and susceptibility to many diseases. A more remote study (Ojo, 2003) revealed that the level of animal protein consumption in Nigeria is put at 5 g/caput/day, which is far below the Food and Agriculture Organisation recommended level of 35 g/caput/day. Recent report of FAO (2009) revealed that an average Nigerian consumes 20 % less than the recommended level of animal protein, giving about 7 g of animal protein/caput/day. Thus, Nigerians are still far from the required level of animal protein consumption for their normal healthy life. This calls for more production of animals and animal products. Local chickens have great potential in contributing to the total animal protein requirement of Nigerians. They are reported to account for 68.9 % of the total poultry meat and 12.4 % of the eggs produced in Nigeria (Sonaiya and Olori, 1990). They are abundant in number, constituting 80% of the 120 million poultry birds in Nigeria excluding guinea fowl (11.20%), duck (5.70%), turkey (2.00%) and others (1.10%) (Adedokun and Sonaiya, 2001). These chickens are hardy, resistant to many local diseases and require less maintenance and production costs than their exotic counterparts.

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However, it is generally known that the egg production performance of the local chickens is far less than that of the improved exotic layers. Nwaogwugwu *et al.* (2009) reported a range of 35.33 g - 40.02 g egg weights of local chicken genotypes, which are comparably less than the minimum egg weight of 49.99 g among three egg weight groups of Isa Brown layers studied by Ukwu *et al*. (2017). Assefa *et al*. (2019) also reported that the egg number (44.6±12.5 eggs) per year of the lowland local chicken was less than that of the lowland exotic Bovans Brown layer (144±20 eggs). There is need, therefore, to improve the egg production performance of the local chickens which constitute the greatest proportion of poultry in the nation in order to meet the animal protein requirements of Nigerians. One method of achieving this is by determination of the phenotypic correlation between body weight and egg production and egg quality traits of the local chicken genotypes consisting of frizzle (F) and naked neck (Na) and normal feather genes. The inclusion of frizzle (F) and naked neck (Na) strains in the improvement programme of local chickens is partly to prevent their extinction from the population as they are reported to be the smallest (F = 5.2 %, Na=3.0 %) compared to their normal feathered mate (91.8 %) (Ajayi and Agaviezor, 2009). Secondly, they are utilized in research because of their thermoregulatory efficiency exhibited mostly during egg production phase (Ibe, 1993). Body weight of laying birds has been shown to influence their total egg production (Ayorinde, 1988) while many egg production and egg quality traits affect one another (Ali *et al*., 2003; Udoh *et al*., 2012; Kwatala *et al.*, 2016). These findings have informed the choice of phenotypic correlation as improvement method for egg traits of these local chicken genotypes studied. With such correlation, selection of one trait will indirectly result in the improvement of other traits as correlated responses (Ebangi and Ibe, 1994). The objective of this study was to determine the phenotypic correlation between body weight during egg production and the various egg production and egg quality traits of different genotypes of the local chicken.

MATERIALS AND METHODS

Study location

The study was carried out at the Teaching and Research Poultry Farm of the College of Animal Science and Animal Production, Michael Okpara University of Agriculture, Umudike. The University is located within the tropical rain forest of Nigeria. It is geographical bounded at Latitude 05º 29′ North of Equator and Longitude 07º 33′ on Altitude 122 m. It is characterised by maximum and minimum daily temperatures of 27ºC - 36º C and 20º C, respectively, relative humidity of 57- 91 % and average annual rainfall of 2177 mm. It has a binomial rainfall pattern of between April-July and August-October.

Experimental birds and their management

The experimental birds consisted of three strains of local chicken used as parent stock to generate offspring. The population of the parents was made up of 4 naked neck males, 7 naked neck females, 3 frizzle males, six frizzle females, five normal males and ten normal females. These were acquired partly from the on-going research in the poultry farm and from the local markets within Abia State, Nigeria. The parents were mated by artificial insemination aided by natural mating. Eggs laid by the hens were set in incubator at weekly intervals and hatched for five consecutive times. One hundred and eighty-one (181) F_1 unsexed chicks were produced at day-old, out of which forty-three (43) females survived till laying age and were used to generate eggs for the study. The females were composed of 5 homozygous naked neck (Na/Na), 6 naked neck x frizzle (Na/F), 7 naked neck x normal (Na/na), 6 homozygous frizzle (F/F), 4 frizzle x naked neck (F/Na), 8 frizzle x normal (F/na) and 7 homozygous normal (na/na) genotypes. Three phases of management were administered to the birds namely starting phase (0-6 weeks), growing phase (6-24 weeks) and laying phase (24-32 weeks). At starting phase, intraocular Newcastle vaccine was given, one drop on each eye of a chick and its Lasota form given through drinking water at 21 days, to prevent Newcastle disease. The chicks were brooded in small cages of 0.25 m x 0.37 m per genotype. Brooding lasted for four weeks for each hatch. They were fed commercial chick mash containing 2650 kcal/kg metabolizable energy (ME) and 19 % crude protein (CP). The males were sexed at the beginning of the growing phase and culled. Thereafter the remaining pullets were transferred to open-sided deep litter pens measuring 2.49 m x 1.67 m and fed commercial grower mash containing 2700 kcal/kg ME and 16 % CP. They were vaccinated against Newcastle and Fowl Pox diseases using Kamorov and Fowl Pox vaccines, respectively. The pullets remained on the deep litter pens during the laying phase and were fed layer mash containing 2500 kcal/kg ME and 18.5 % CP, which was introduced at 24 weeks of age. Feed and water were supplied to the chickens *ad libitum* in all stages of management. A minimum of eighteen hours of light was given to the hens to assist in oviposition. An average of 151 eggs were laid by all the F_1 hens and used in the study. The period of the egg production lasted for 56 days.

Parameters Measured

Egg production parameters

Body weight at first egg (BWTFE) was measured in grammes (g) as the average body weight of all hens of a particular genotype attained when their first eggs were laid using a 20 kg Top Loading Camry Scale with sensitivity of 10 g. Subsequent body weight during laying period was measured on weekly basis for 56 days.

Age at sexual maturity (ASM) was counted in days from day-old to the day the first pullet of a genotype laid its first egg.

Egg number to 56 days (EN_{56}) was counted as the number of eggs laid by all hens of a particular genotype for a period of 56 days.

Hen day production (HDP) was computed in percentage as **HDP (%)** = [number of eggs laid by hens per genotype/(number of days in lay x number of hens alive)] according to Gopalakrishnan and Mohan Lal (1985) and Singh and Kumar (1994).

External egg quality parameters

Egg weight (EWT) was measured in g by weighing the eggs laid by hens of the same genotype on weekly basis using a beam balance (Ohaus cent-o-gram, model 311, sensitivity, 0.01 g).

Egg index (EI) was determined as the ratio of average **egg width (EW)** to average **egg length (EL).** The EW and EL were each measured in millimeters (mm) as average of three readings taken on the widest and longest egg parts, respectively using vernier calipers.

Shell thickness (ST) was measured in mm as the average of three readings taken on the peripheral, center and narrow or broad end of the shell containing membrane on wet basis using a micrometer screw gauge (DIN-863/11, sensitivity of 0.01 mm).

Internal egg quality parameters

Yolk weight (YWT) and Albumen weight (AWT). Each egg laid was neatly cracked with a table knife along its equatorial circumference. Then, using two Petri dishes, the first was weighed on a beam balance and the weight recorded as A (g). The yolk and albumen were carefully poured into the second dish and weighed to obtain the weight of the yolk, albumen and dish as B (g). The yolk was scooped and transferred to the second Petri dish with a table spoon. The weight of the albumen plus the second Petri dish was determined as C (g). The YWT and the AWT were then determined as **B-C and C-A,** respectively.

Yolk height (YH). With the yolk on the second Petri dish, the rod of the vernier calipers was inserted through the top to the base of the yolk, touching the dish and the height read in mm. **Yolk width (YW)** was measured as the distance from one end of the chalazae to the other using vernier calipers. **Yolk index (YI)** was determined in mm as the ratio of YH to YW.

Albumen height (AH) was measured by dipping the rod of the vernier calipers into the Petri dish containing the yolk and the albumen and reading from both the main and the vernier scale in mm. **Haugh unit (HU)** was computed using Haugh's (1937) method as **HU = 100 log (H+7.57-1.7W$^{0.37}$), w**here H was the observed AH and W, the observed weight of egg.

Statistical analysis

Phenotypic correlation between any two traits was established using Pearson's Product Moment correlation and analysed with SPSS (2006) software. The phenotypic correlation coefficient formula is given below.

$$r_P = \frac{COV(P_X P_Y)}{\sqrt{[\sigma^2_{(X)} \sigma^2_{(Y)}]}} = \frac{[\Sigma xy-(\Sigma x_i)(\Sigma y_i)/n]}{\left[\Sigma x_i^2-(\Sigma x_i)^2/n\right]\left[\Sigma y_i^2-(\Sigma y_i)^2/n\right]}$$

Where r_P is phenotypic correlation coefficient, Cov is shortened for covariance, which is the simultaneous variation between any two traits studied, x_i and y_i are any two correlated traits while n was the number of observation ie number of eggs laid per genotype. Average of 38.02, 12.59, 32.04, 12.62, 20.64, 21.40 and 12.91 eggs were laid by Na/Na, Na/F, Na/na, F/F, F/Na, F/na and na/na genotypes, respectively (Nwaogwugwu *et al*., 2009).

RESULTS

Correlation coefficients between body weight at first egg (BWTFE) and egg production traits of local chicken genotypes are presented in Table1. The BWTFE correlated negatively with age at sexual maturity in most of the genotypes and only positively in Na/Na and na/na. Body weight at first egg had both positive and negative correlations with egg number at 56 days (EN_{56}) and hen day production (HDP). Genotypes where positive correlation coefficients existed with EN_{56} had larger body weight at first egg, resulting in increased egg number. Na/F had the highest positive correlation coefficient (r =0.71) between BWTFE and HDP. In Table 2, the external egg quality traits had both positive and negative correlations with body weight of the laying hens in the different genotypes. More significant positive correlation coefficients were observed for egg weight, egg length and egg width and these occurred in Na/F, Na/na, F/F and na/na. Egg index and shell thickness were negatively correlated with body weight in most of the genotypes.

Table 3 presents the correlation between body weight of laying hens and internal egg quality traits of local chicken genotypes. The correlation coefficients between body weight and each of yolk weight, yolk height, yolk width, albumen weight and albumen height were positive and significant while those between body weight and each of yolk index and Haugh unit were negative in most of the genotypes studied.

Table 4 presents the correlations among egg quality traits of local chicken genotypes. Egg weight correlated positively with yolk width in all genotypes except in F/F, albumen weight in all genotypes, and albumen height in all genotype except in F/F and na/na. It correlated positively with Haugh unit in Na/Na, Na/na and na/na and negatively in Na/F, F/F and F/Na. Yolk weight had positive correlations with albumen weight, albumen height and Haugh unit in most of the genotypes except in in Na/Na where all correlation coefficients were negative. Other negative correlation coefficients were observed between yolk weight and albumen height in na/na and between yolk weight and Haugh unit in each of Na/F, F/na and na/na.

Albumen weight had positive correlations with albumen height in all genotypes except in na/na. It correlated positively with Haugh unit in the genotypes other than Na/F and F/na. Albumen weight correlated positively with each of albumen height and Haugh unit in Na/Na with coefficients being large but non-significant (P>0.05). The correlation coefficients between albumen weight and each of albumen height (r = 0.09) in F/Na and Haugh unit (r = 0.04) in na/na were very small. Correlation between albumen height and Haugh unit was large, positive and highly significant (P<0.01) in all the genotypes except in F/na where they did not correlate.

DISCUSSION

The negative correlation coefficients obtained between BWTFE and ASM in Table 1 implies that the bigger the body weight at first egg, the earlier the hen attains sexual maturity. However, the research conducted by Nwaogwugwu (2008) with these hens indicated that Na/F, F/F and F/Na which had the biggest BWTFE delayed most in reaching sexual maturity and laid fewer eggs, whereas Na/Na whose body weight at first egg was smaller than the afore mentioned had the smallest age at sexual maturity and laid the greatest number of eggs. This indicates that genotype, in addition to body weight, contributes to total egg production. The positive correlation observed between BWTFE suggests in part that egg production can be predicted using body weight at first egg and that total egg

Table 1: Correlation between body weight at first egg and egg production traits of local chicken genotypes

Parameter	Correlation coefficients of genotypes						
	Na/Na	Na/F	Na/na	F/F	F/Na	F/na	na/na
ASM (days)	0.31	-0.77	-0.35	-0.34	-0.31	-0.23	0.75
EN_{56}	-0.17	0.86	0.41	0.67	-0.93*	-0.59	-0.85
HDP (%)	-0.23	0.71	-0.17	-0.01	-0.89*	0.59	0.14

Significant correlation (P<0.05)

Table 2: Correlation between body weight of laying hens and external egg quality traits of local chicken genotypes

Correlated traits: BWT with	Correlation coefficients of genotypes						
	Na/Na	Na/F	Na/na	F/F	F/Na	F/na	na/na
Egg weight (g)	-0.33*	0.80**	0.85**	0.74**	-0.28	0.44**	0.41**
Egg length (mm)	0.32*	0.07	0.17	-0.06	-0.40	0.55**	-0.11
Egg width (mm)	-0.04	0.67**	0.75**	0.62**	0.20	-0.02	0.30
Egg index	-0.30*	0.06	-0.26*	-0.10	-0.54	0.11	0.05
Egg shell thickness (mm)	-0.03	-0.00	0.03	-0.02	0.21	-0.11	-0.09

*Correlation was significant (P<0.05) (2tailed): **Correlation was highly significant (P<0.01) (2tailed)

Table 3: Correlation between body weight of laying hens and internal egg quality traits of local chicken genotypes.

Correlated traits: BWT with	Correlation coefficients of genotypes						
	Na/Na	Na/F	Na/na	F/F	F/Na	F/na	na/na
Yolk weight (g)	0.12	0.63**	0.81**	0.62*	-0.20	0.46**	0.10
Yolk height (mm)	-0.34*	0.34**	0.11	0.15	-0.09	0.03	0.14
Yolk width (mm)	0.55**	0.50**	0.78**	0.69**	-0.47*	0.46**	0.22
Yolk index	-0.50**	-0.10	-0.48**	-0.34**	0.20	0.06	-0.02
Albumen weight (g)	-0.19	-0.06	0.74**	0.60**	-0.43*	0.32*	0.60**
Albumen height (mm)	-0.04	0.28*	0.41**	0.33*	0.39	0.13	0.08
Haugh unit	0.02	-0.07	-0.07	0.08	0.46*	-0.20	-0.05

*Correlation was significant (P<0.05) (2tailed): **Correlation was highly significant (P<0.01) (2tailed)

Table 4: Correlations among egg quality traits of local chicken genotypes at week 32

Correlated traits		Correlation coefficients of genotypes						
		Na/Na	Na/F	Na/na	F/F	F/Na	F/na	na/na
EWT	YWT	0.31	0.92**	0.77	-0.28	0.44	0.76**	0.45
EWT	AWT	0.16	0.84	0.78	0.74*	0.05	0.75**	0.25
EWT	AH	0.18	0.29	0.92	-0.08	0.07	0.73**	-0.33
EWT	HU	0.08	-0.43	0.89	-0.22	-0.22	0.00	0.40
YWT	AWT	-0.86**	0.85**	0.40	-0.44	0.16	0.39	0.14
YWT	AH	-0.55	0.23	0.46	0.11	0.61	0.56	-0.80*
YWT	HU	-0.56**	-0.44	0.39	0.07	0.60	-0.16	-0.82*
AWT	AH	0.74**	0.49	0.89	0.15	0.09	0.71**	-0.08
AWT	HU	0.70**	-0.14	0.88	0.02	0.90	-0.06	0.04
AH	HU	0.99**	0.74**	0.99**	0.97**	0.99*	-0.00	0.99**

*Correlation was significant (P<0.05) (2tailed): **Correlation was highly significant (P<0.01) (2tailed)

produced in a flock depends mainly on the body weight attained at first egg. This agrees with the finding of Bish *et al*. (1985) that body weight influences egg production. The observed negative correlation between these two traits means that smaller body weight led to more eggs while the positive correlation indicates that heavy body weight led to increased egg number. Genotypes which produced more eggs with lesser body weight at first egg may therefore be considered economically better for improvement of egg production. This is because light hens are known to consume less feed and utilize them more efficiently for egg production (Yeasmin *et al*., 2003) while heavy hens consume more feed and have prolonged age at sexual maturity (Nwaogwugwu 2008), leading to less egg production. The highest correlation coefficient between BWTFE and HDP recorded in Na/F is an indication that combining the two major genes in breeding could result in increased body weight of hens, which in turn could lead to better egg quality. This supports the finding of Yunis and Cahanar (1999) who reported that chickens with combined naked neck and frizzle major genes had highest feed consumption, body weight and egg production.

The positive correlation observed between body weight and each of egg weight, egg length and egg width in most of the genotypes (Table 2) agrees with the findings of previous authors (Ayorinde *et al*., 1988; Chineke, 2001; Muir and Aggrey, 2003). Results of previous research confirmed a partial pleiotropic basis for genetic correlation between body weight and egg weight traits (Di Masso *et al*., 1998; Mohammadabadi *et al*., 2010; Moazeni *et al*., 2016, Mohammadifar et al 2018; Liu et al., 2019). Partial pleiotropism is the exertion of a single gene effect on several traits. The implication is that the improvement of a single trait could result in corresponding improvement of one or more traits controlled by the same pleiotropic gene. The negative correlation between egg weight and body weight of the laying hens observed in Na/Na and F/Na could be as a result of population size and other experimental factors. Summarily, the results of Table 2 showed that selection of hens with heavy body weight during laying will improve egg weight, egg length and egg width and reduce egg index and shell thickness qualities of local chicken genotypes containing naked neck, frizzle and normal feathered genes.

The result of Table 3 means that increase in body weight of hens resulted in increase in yolk weight, yolk height, yolk width, albumen weight and albumen height and decrease in yolk index and Haugh unit. This supports the finding of Kirikçi *et al.* (2004) who reported significant effect of live body weight on egg quality traits of pheasant. Thus, selection for heavy body weight of hens will result in improved yolk weight, yolk height, yolk width, albumen weight and albumen height and decreased yolk index and Haugh unit of most local chicken genotypes.

Previous research findings (Şekeroğlu *et al*., 2008; Chimezie *et al*., 2017) corroborate with the results of the positive correlations among the egg quality traits of the genotypes in Table 4. This indicates strong pleiotropic genes controlling the traits. Consequently, improving one trait will result in indirect improvement of the others. For instance improving egg weight will results in indirect improvement of albumen weight and albumen height in each of Na/Na, Na/na and F/na. The practical breeding implication is that naked neck and frizzle cocks should be used to cross normal father hens to obtain correlated responses in egg quality traits. Improving albumen height will result in significant improvement in Haugh unit and hence the quality of the albumen. The exception was in F/na which may be due to different gene combinations or unequal sample size with the other genotypes. Traits which correlated positively can be included in a selection index programme for improvement while traits which correlated negatively may be selected independently by tandem or other selection methods. The positive correlation between egg weight and albumen weight in all the genotypes indicate that the weight of an egg determines the weight of its albumen, hence improving egg weight will result in improved yolk weight.

Conclusion

Body weight at first egg and during laying correlated with many egg production and egg quality traits. Smaller body weight at first egg which correlated positively with egg number indicated that hens with small body weight should be considered economically better for egg production since they consume less feed. Egg quality traits in turn correlate with one another. The magnitude and direction of the correlation coefficients were highly dependent on the genotype of the hen. Hens of frizzle and naked neck cock origin had better improvement. Efforts should be made towards improving body weight of laying hens and egg weight which have interrelated effects on other egg production and egg quality traits using frizzle and naked neck chickens.

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