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Research Article

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Phenotypic Correlations and Regression among some External and Internal Egg Quality Parameters of Nigerian Guinea fowl (*Numida meleagris*) Genotypes

***Ebegbulem, Victoria N., Ayuba Dauda**

Department of Animal Science, University of Calabar, Calabar- Nigeria

Abstract The research was done to estimate phenotypic correlations as well as regression among external and internal egg quality parameters of three genotypes of Nigerian guinea fowls. A total of 120 eggs (40 per genotype group) collected from 105 guinea hens at 28 weeks of age, were used for the study. The genotypes were first filial generation crosses of the pearl and black varieties in the mating scheme of Pearl male X Pearl female (P X P), Black male X Black female (B X B), and Black male X Pearl female (B X P). The external parameters were egg weight, egg length, egg width, shell weight, shell thickness and egg shape index, while internal parameters included yolk weight, yolk height, yolk width, yolk index, albumen height and albumen weight. Results of the linear correlations indicated high and positive associations between egg weight and egg length, egg width, shell weight, yolk weight and albumen weight, with figures ranging from 0.701- 0.935 in the P X P homozygous genotype. Very high and positive coefficients of correlation were recorded between yolk height and yolk index (0.915), albumen weight and egg weight (0.895), as well as between egg width and egg shape index (0.773) in the B X B homozygous genotype. Similarly, very high and positive correlation coefficients (ranging from 0.774 to 0.938) were recorded between egg weight and shell weight, shell thickness, yolk weight, as well as with albumen weight in the cross bred genotype. The results of the simple linear regression of egg weight on other egg parameters showed significantly high relationships with albumen weight in the three genotypes (R^2= 0.858, 0.802, and 0.880 for PXP, BXB and BXP groups respectively).The stepwise regression analysis however indicated significant relationship between egg weight and egg width (R^2 = 0.864) for birds of the PXP genotype, egg weight and shell thickness (R^2 = 0.749) for birds of the BXP genotype, and moderate relationship between egg weight and yolk weight, as well as, between yolk width and albumen height (R^2 = 0.300 and 0.497 respectively) in the B X P cross bred genotype. It was concluded from the findings of this research that selection and improvement of egg weight in the three genotypes would lead to a consequent improvement in egg length, egg width, shell weight, yolk weight, albumen weight, shell thickness and yolk width given the high correlation coefficients between them.

Keywords Egg parameters, correlations, prediction, guinea fowl, genotypes

Introduction

Sub-saharan Africa is faced with the challenge of inadequate protein intake. The fact that guinea fowl is adaptable to various climatic conditions therefore is reared even in temperate countries [1]. In most parts of Africa, the guinea fowl are reared in the traditional free-range system [2-5]. The indigenous guinea fowl breeds do not require elaborate, expensive housing. They feed on a wide range of plants and animals, and consume a large range of non-conventional feed not used in feeding chicken. This makes it the poultry of choice to the poor and is also ideal in an integrated crop-livestock farming system [4]. The guinea fowl egg and meat are good sources of protein and income. Ikani and Dafwang (2004) [6] reported that in Nigeria guinea fowl eggs and meat command premium prices because of their gamey flavor. Their eggs have better storage qualities than chicken eggs as a result of their thicker shells therefore they do not crack easily.

Eggs are not only important as cheap and readily available sources of animal protein, but are also important raw materials in confectionary and food industries. Their relevance in the cosmetics manufacturing, vaccine production and cryopreservation of frozen semen are worthy of mention. These extra demands on egg, apart from its basic role as food source for man and growing chicks necessitates the production of eggs to meet various specialized needs. Fajemilehin *et al.* (2009) [7] identified egg quality as the most important price contributing factor in table and hatching eggs. The nutrient content of an egg imparts on the development of the embryo and its post hatch performance [8]. Composition of poultry eggs vary among species [9].

Knowledge of the phenotypic and genetic relationships among egg quality traits will inform the choice of breeding programmes to be embarked upon for their improvement. This corroborates the opinion of Fajemilehin *et al.* (2009) [7] that establishing the relationship between egg quality traits is necessary for the assessment of the quality of the product without necessarily breaking it. The objective of this research therefore, was to investigate the phenotypic correlations as well as predictions of internal and external egg quality parameters of three genotypes Nigerian indigenous guinea fowl.

Materials and Methods

Location of the Study

The study was carried out at the poultry unit of the Teaching and Research Farm of Animal Science Department, University of Calabar, Nigeria. Calabar is located at 4.9517 latitude North and 8.322 longitude East (decimal degrees) with an average altitude of 42 meters. The annual rainfall range from 3000-3500 mm and the average daily temperature is 25^{O}C, while the wind speed/direction is 8.1km/hour west [10].

Acquisition of experimental eggs

A total of 120 eggs (40 per genotype group) collected from 105 guinea hens at 28 weeks of age, were used for the study. The guinea hens were F1 progeny of an unselected parent population consisting of 15 pearl males, 56 pearl females, 14 black males and 30 black females.

The mating ratio was 1:4 in the mating scheme of:

a. Pearl male X pearl female (P X P) Homozygous pearl thorough bred genotype.
b. Black male X black female (B X B) Homozygous black thorough bred genotype.
c. Black male X pearl female (B X P) Heterozygous crossbred genotype.

Egg quality parameters:

The external parameters include: Egg weight (EWT), Egg length (EL), Egg width (EWDT), Shell weight (SW), Shell thickness (ST) and Egg shape index (ESI) = egg width / egg length. The internal parameters include: Yolk weight (YW), Yolk height (YH), Yolk width (YWDT), Yolk index (YI) = yolk height/ yolk width, Albumen height (AH) and Albumen weight (AW).

Data collected were subjected to Pearson Correlation Analysis and simple linear as well as stepwise regression analysis using SPSS (2015) version to determine the phenotypic correlation and regression of values among the egg parameters. Regression equations were derived to establish predictive relationships between egg quality parameters. The regression equation was thus: Y = A + bX + e.

Where,

Y = dependent variable

a = intercept

b = regression coefficient

X = independent variable (egg weight)

Results

Correlations among egg quality parameters:

The results of the pair wise phenotypic correlations among egg quality parameters of the PXP genotype are presented in Table1. High and positive correlation coefficients were recorded between EWT and EL, EWDT, SW, YW and AW, with figures ranging from 0.701- 0.935. Medium and positive associations were recorded between EWT and shell thickness (ST) (0.557) as well as between EWT and YWDT (0.547). Negative correlation coefficients were recorded between EWT and yolk index (YI) (-0.368), as well as between EWT and AW (-0.408). EL was averagely and positively correlated with EWDT, SW, YW and AW, with figures ranging from 0.590- 0.675. There were however, negative associations between EL and YI, as well as between EL and

AW. High and positive correlation coefficients were recorded between EWDT and SW (0.814), SW and YW (0.767), as well as between SW and AW (0.843).

Table 1: Phenotypic correlation of egg quality parameters of P X P guinea fowl genotype

	EWT	EL	EWDT	SW	ST	ESI	YW	YH	YWDT	YI	AH	AW
EWT	1											
EL	0.701**	1										
EWDT	0.814**	0.569**	1									
SW	0.935**	0.675**	0.814**	1								
ST	0.557*	0.397	0.387	0.483*	1							
ESI	0.179	-0.404	0.519*	0.218	0.027	1						
YW	0.863**	0.620**	0.772**	0.767**	0.559*	0.219	1					
YH	0.024	0.124	0.047	0.029	0.109	-0.092	0.119	1				
YWDT	0.547*	0.284	0.539*	0.451*	0.558*	0.314	0.590**	-0.126	1			
YI	-0.368	-0.112	-0.292	-0.330	0.316	-0.230	-0.310	0.731**	-0.740	1		
AH	-0.408	-0.411	-0.385	-0.501	-0.059	0.011	-0.370	0.058	0.064	0.023	1	
AW	0.926**	0.630**	0.679**	0.843**	0.475*	0.096	0.625**	-0.055	0.444*	-0.353	-0.310	1

** Correlation is significant at 0.01 level (2 - tailed) EWT = egg weight, EL=egg length, EWDT= egg width, SW =shell weight, ST= shell thickness, ESI= egg shape index, YW= yolk weight, YH= yolk height, YWDT= yolk width, YI=yolk index, AH=albumen height, AW=albumen weight

Table 2 shows the results of the pair wise phenotypic correlations between egg quality parameters in the BXB genotype. Very high and positive coefficients of correlation were recorded between yolk height (YH) and YI (0.915), AW and EWT (0.895), as well as between EWDT and egg shape index (ESI) (0.773). Medium and negative correlation coefficient was recorded between YI and YWDT (yolk width) (-0.669).

Table 2: Phenotypic correlations of egg quality parameters in BXB guinea fowl genotype

Traits	EWT	EL	EWDT	SW	ST	ESI	YW	YH	YWDT	YI	AH	AW
EWT	1											
EL	0.436	1										
EWDT	0.141	0.450*	1									
SW	0.388	-0.190	-0.282	1								
ST	0.530*	0.098	0.162	0.509*	1							
ESI	-0.128	-0.214	0.773**	-0.164	0.108	1						
YW	0.540*	0.456*	0.303	-0.279	0.137	0.032	1					
YH	0.031	0.171	0.108	0.013	0.076	-0.033	-0.102	1				
YWDT	-0.095	-0.088	0.166	-0.210	-0.076	0.254	0.199	-0.319	1			
YI	0.045	0.150	0.007	0.097	0.079	-0.128	-0.189	0.915**	-0.669	1		
AH	0.020	0.354	0.006	-0.047	0.221	-0.261	0.058	-0.126	0.236	0.21000	1	
AW	0.895**	0.491*	0.231	0.102	0.358	-0.072	0.411	0.058	-0.043	0.050	-0.005	1

** Correlation is significant at 0.01 level (2-tailed); * Correlation is significant at 0.05 level (2-tailed).
EWT = egg weight, EL=egg length, EWDT= egg width, SW =shell weight, ST= shell thickness, ESI= egg shape index, YW= yolk weight, YH= yolk height, YWDT= yolk width, YI=yolk index, AH=albumen height, AW=albumen weight

Table 3 shows the results of the pair-wise correlations between egg quality parameters in the BXP genotype of guinea fowls. The result shows that very high and positive correlation coefficients (ranging from 0.774 to 0.938) were recorded between EWT and SW, EWT and ST, EWT and YW, as well as, EWT and AW. Similarly, high and positive correlation coefficients were obtained between EWDT and ESI (0.952), YH and YI (0.880) and between AW and ST (0.784). Negative correlation coefficients were obtained between ESI and YH (-0.112), ESI and YWDT (-0.073), ESI and YI (-0.042) and between ESI and albumen AH (-0.241).

Table 3: Phenotypic Correlations of egg quality parameters in BXP guinea fowl crossbred group

Traits	EWT	EL	EWDT	SW	ST	ESI	YW	YH	YWDT	YI	AH	AW
EWT	1											
EL	0.28	1										
EWDT	0.447*	0.475*	1									
SW	0.828**	0.263	0.519*	1								
ST	0.866**	0.115	0.401	0.756**	1							
ESI	0.411	0.186	0.952**	0.491*	0.414	1						
YW	0.774**	0.136	0.290	0.486*	0.670**	0.281	1					
YH	0.503*	0.091	-0.067	0.419	0.474*	-0.112	0.420	1				
YWDT	0.212	-0.235	-0.147	0.029	0.074	-0.073	0.435	0.068	1			
YI	0.380	0.230	0.043	0.397	0.417	-0.042	0.176	0.880**	-0.404	1		
AH	-0.096	0.302	-0.120	-0.238	-0.002	-0.241	0.055	0.129	-0.11	0.184	1	
AW	0.938**	0.291	0.361	0.680**	0.784**	0.316	0.604**	0.460*	0.144	0.374	-0.071	1

** Correlation is significant at 0.01 level (2-tailed); * Correlation is significant at 0.05 level (2-tailed).

EWT = egg weight, EL=egg length, EWDT= egg width, SW =shell weight, ST= shell thickness, ESI= egg shape index, YW= yolk weight,
YH= yolk height, YWDT= yolk width, YI=yolk index, AH=albumen height, AW=albumen weight

Simple linear regression of egg weight on egg quality parameters

The results of the simple linear regression of EWT on other egg quality parameters are presented in Table 4. EWT showed significantly high linear relationships with AW in the three genotypes (R^2= 0.858, 0.802, and 0.880 for PXP, BXB and BXP groups respectively). The PXP group showed high prediction between EWT and SW (R^2 =0.875), as well as, YW (R^2 =0.745). These values were however moderate in the BXP group (R^2 =0.685 and 0.599, for EWT and SW; EWT and YW respectively).

Table 4: Linear Regression of Egg weight on other egg quality parameters

Genotype	Prediction Equation	R^2	SE	LOS
PxP	EW=-25.086+13.017EL	0.492	3.64	***
	EW=-31.374+18.113EWD	0.663	2.964	***
	EW=6.124+4.257SW	0.875	1.803	***
	EW=21.562+32.707ST	0.311	4.236	**
	EW=21.404+21.013ESI	0.032	5.020	NS
	EW=11.596+2.271YW	0.745	2.574	***
	EW=36.361+0.763YH	0.001	5.101	NS
	EW=10.208+7.468YWD	0.300	4.270	**
	EW=50.415-24.738YI	0.135	4.745	NS
	EW=49.586-14.335AH	0.166	4.658	NS
	EW=3.277+1.840AW	0.858	1.924	***
BxB	EW=16.845+3.516EL	0.190	1.668	*
	EW=30.494+0.927EWD	0.020	1.834	NS
	EW=27.823+0.980SW	0.150	1.708	NS
	EW=27.741+11.588ST	0.281	1.571	**
	EW=37.681-4.617ESI	0.016	1.838	NS
	EW=17.493+1.593YW	0.291	1.560	**
	EW=33.688+0.208YH	0.001	1.852	NS

	EW=36.516-0.675YWD	0.009	1.845	NS
	EW=33.611+0.907YI	0.002	1.851	NS
	EW=33.909+0.170AH	0.000	1.853	NS
	EW=12.438+1.255AW	0.802	0.825	***
B×P	EW=-4.596+8.104EL	0.079	4.481	NS
	EW=17.269+5.099EWD	0.199	4.177	*
	EW=18.017+2.654SW	0.685	2.619	***
	EW=12.300+48.644ST	0.749	2.337	***
	EW=16.120+27.804ESI	0.169	4.256	NS
	EW=5.689+2.814YW	0.599	2.957	***
	EW=24.812+6.926YH	0.253	4.034	*
	EW=27.356+2.456YWD	0.045	4.563	NS
	EW=28.974+18.237YI	0.144	4.319	NS
	EW=39.797-2.973AH	0.009	4.647	NS
	EW=5.972+1.663AW	0.880	1.621	***

EW=Egg weight; EL= Egg length; EWD= Egg width; SW= Shell weight; ST= Shell thickness; ESI=Egg shape index; YW= Yolk weight; YH= Yolk height; YWD=Yolk width; YI= Yolk index; AH= Albumen height; AW= Albumen weight; SE= Standard error; LOS=Level of significance; NS= Not significant

Step wise regression of egg weight on egg quality parameters

The results of the step wise regression of egg weight on external and internal egg quality parameters of guinea fowl are presented in Table 4. There was a significant relationship between egg weight and egg width (R^2 = 0.864) for birds of the PXP genotype. There was a similar high significant coefficient of determination between egg weight and shell thickness (R^2 = 0.749) for birds of the BXP genotype, but the relationship between egg weight and yolk weight, as well as, between yolk width and albumen height were moderate (R^2 = 0.300 and 0.497 respectively).

Table 5: Stepwise regression of egg weight on external and internal egg parameters in three genotypes of guinea fowl

Genotype	Parameter	Prediction Equation	R^2	SE	LOS
	External parameters				
PxP		EW=-31.374+18.113EWD	0.814	2.964	***
		EW=-46.011+13.656EWD+6.540EL	0.864	2.643	***
BxB		EW=27.741+11.588ST	0.281	1.571	**
B×P		EW=12.300+48.644ST	0.749	2.337	***
	Internal parameters				
PxP		EW=10.208+7.468YW	0.300	4.270	**
BxB		EW=21.344+7.855YWD-15.623AH	0.497	3.725	***
B×P		EW=24.812+6.926YH	0.253	4.034	*
	External and Internal parameters				
PxP		EW=-31.374+18.113EWD	0.663	2.964	***
		EW=-46.011+13.656EWD+6.540EL	0.747	2.643	***

BxB	EW=27.741+11.588ST	0.281	1.571	**
B×P	EW=12.300+48.644ST	0.749	2.337	***

EW= Egg weight; EWD= Egg width; EL= Egg length; ST= Shell thickness; YW= Yolk weight; YWD= Yolk width; AH= Albumen height; YH= Yolk height;

*** Equation significant at $P<0.001$; ** Equation significant at $P<0.01$; * Equation significant at $P<0.05$

Discussion

The high, positive and significant ($P < 0.001$) correlations between EWT and EL, EWDT, SW, YW, AW, ST and YWDT in the present study were in tandem with the report of Nowaczewski *et al.* (2008) who recorded significant($P > 0.001$) high and positive relationships between EWT and YW ($r = 0.904$), AW ($r = 0.975$), and SW ($r = 0.811$) in guinea fowls. In the black variety of guinea fowl, Okoro (2012) [11] recorded positive significant correlations between EWT and EL ($r = 0.828$), EWDT ($r = 0.809$), and SW($r = 0.595$). In the pearl variety however, the author recorded positive associations between EWT and EL ($r = 0.825$), EWDT ($r = 0.723$) and SW ($r = 0.732$). Positive significant ($p < 0.01$) associations were reported by Obike and Azu (2012) [12] between EWT and EL ($r = 0.72$), EWDT ($r = 0.89$) for the black variety and EWT and EL ($r = 0.62$) EWDT ($r = 0.94$) and ESI ($r = 0.67$) in the pearl variety. These results were consistent with values recorded for the PXP and BXB genotypes in the present study. It can therefore be said that the associations recorded in the present study were due to genetic factors rather than non-genetic. The selection and improvement of EWT in the three genotypes would lead to a consequent improvement of the above traits, and vice versa.

Negative non-significant ($P > 0.01$) correlation coefficients were however, recorded between EWT and YI ($r = -0.368$), as well as, AH ($r = -0.408$) in the PXP genotype; EWT and ESI ($r = -0.128$), as well as, with YWDT ($r = -0.095$) in the BXB genotype; whereas EWT and AH ($r = -0.096$) were negatively correlated in the BXP genotype. The negative associations between EWT and ESI was corroborated by Okoro (2012) [11], ($r = -0.395$)in the black variety of guinea fowl. The varying positive and negative correlations recorded in this study were in consonance with the reports [12-15]. The implication of the negative association is that the larger the EWT, the smaller the ESI. On the other hand, Kuzniacka *et al.* (2004) [16] reported significant positive correlations between EWT and ESI. This implies that the selection and improvement of the PXP and BXP genotypes of guinea fowls will produce heavy eggs that can fit more easily into crates to minimize breakage during packing and transportation. The shape of the egg is characteristic for specific lines and individuals. This was in line with the results of the present study.

EL was significantly and positively correlated with EWT ($r = 0.701$), EWDT ($r = 0.569$), SW ($r = 0.630$) in the PXP genotype. In the BXB genotype, the significant positive associations with EL were with EWT ($r = 0.450$), YW ($r = 0.456$) and AW ($r = 0.491$). The BXP genotype had significant positive association between EL and EWDT ($r = 0.475$). These results were consistent with the report of Okoro (2012) [11] who gave correlation coefficients between EL and EWDT ($r = 0.469$ and 0.478), EL and SW ($r = 0.497$ and 0.546), EL and AW($r = 0.662$ and 0.512) and EL and YW ($r = 0.643$ and 0.567) in the black and pearl varieties of guinea fowl respectively. Alkan *et al.* (2013) [8] obtained significant and positive correlations between EL and EWT ($r = 0.569$), EWDT ($r = 0.859$), YW ($r = 0.236$), SW ($r = 0.236$) and non-significantly with AW ($r = 0.086$) in guinea fowls. Similarly, Obike and Azu (2012) [12] and Abanikannda *et al.* (2007) [17] found highly significant correlations between EL and EWT, and with EWDT. The findings of the present research suggest that the higher the EL, the greater the EWT, YW and AW.

Significant positive correlations were recorded in the present study, between EWDT and SW ($r = 0.814$), ESI ($r = 0.519$), YW ($r = 0.712$), YWDT (0.539) and with AW($r = 0.679$) in the PXP genotype. Okoro (2012) reported positive, but non-significant correlations between EWDT and SW ($r = 0.581$), ST ($r = 0.287$), as well as significant positive associations with AW ($r = 0.679$), AH ($r = 0.353$), YW (0.649) in the pearl variety of guinea fowl. In the BXB genotype, significant positive relationships were obtained between EWDT and ESI ($r = 0.773$), and with EL($r = 0.450$). The association between EWDT and other egg parameters were positive, except

SW. In another study, Okoro (2012) [11] obtained significant correlation coefficients of 0.634, 0.379, 0.651, 0.456, 0.463, 0.809, and 0.469 between EWDT and AW, AH, YW, YH, SW, EWT and EL respectively in the black variety of guinea fowl. In the BXP genotype, very strong significant and positive correlations were recorded between EWDT and ESI (r = 0.952) and with SW (r = 0.519). The associations were not significant with ST, YW, YI and AW in this genotype. Negative associations were obtained between EWDT and YH, YWDT and AH in this genotype.

The strong positive correlations between EWDT and ESI obtained in this study were not surprising as EWDT and El determined the ESI. The results indicate that the selection of birds that lay eggs with larger width, would lead to a better shape index. The importance of better shape index in poultry cannot be over emphasized. The selection of PXP individuals on the basis of their EWDT would lead to a concurrent improvement in the SW, YW, YWDT and AW. Oke *et al.* (2004) [18] equally reported a significant positive correlation between EWDT and YW. The negative association obtained between EWDT and YH in the BXP genotype was in agreement with the finding of Oke *et al.* (2004) [18], but contradict the report of Okoro (2012) [11] in pearl guinea fowl. The significance of the negative associations is that YH, YWDT and AH decreases with an increase in EWDT, and vice versa, in the BXP genotype.

Positive correlation coefficients were obtained between SW and EWT in the three genotype groups of the present study. The values were high and significant ($P<0.01$) in the PXP (r = 0.828) but low in the BXB genotype (r = 0.388). The result for the PXP was in agreement with the report of Okoro (2012) [11] in the pearl variety of guinea fowl (r = 0.732).The result recorded for the BXB genotype was however, lower than 0.595reported in the black variety of guinea fowl by the same author. The author also reported a correlation coefficient of 0.667 between SW and EW in the lavender variety of guinea fowl. Fajemilehin *et al.* (2009) [7], on the other hand, reported a negative, non-significant association between SW and EWT (r = -0.62). Going by the findings of the present research, a fast improvement can be achieved in SW when birds that lay heavier eggs are selected for breeding, especially in the PXP and BXP genotypes.

Medium to high, positive and significant ($P<0.05$) correlation coefficients were recorded between SW and ST among the three genotype groups in the present study (r = 0.483 - 0.756). The average correlation coefficients between the two traits recorded in the PXP and BXB genotypes of the study were close to the values reported by Nowaczewski *et al* (2008) [15] (r = 0.448), Okoro (2012) [11] : r = 0.445 and 0.424 for the pearl and lavender varieties respectively. The high correlation coefficient recorded between SW and ST in the BXP genotype in the present study, was in agreement the report of Alkan *et al.* (2013) [8] r = 0.867. On the contrary, Fajemilehin *et al* (2009) [15] reported a very low non-significant association between SW and ST (r = 0.04).The results of the present research suggest that SW increases simultaneously with ST, therefore, selection for one would lead to a concurrent improvement of the other.

The negative, non-significant association between SW and YW (r = -0.279) and positive but low association between SW and AW (r = 0.102) in the BXP genotype of the present study were in tandem with the report of Okoro (2012) [11]. The author obtained 0.502 and 0.793 correlation coefficients between SW and YW in the black and pearl varieties respectively, -0.025 between SW and YW in the lavender variety. Alkan *et al.* (2013) [8] reported a 0.568 correlation coefficient between SW and YW, 0.078 between SW and AW. Okoro (2012) [11] reported correlation coefficients between SW and AW: r = 0.641 and 0.430 in the lavender and pearl varieties respectively, which were lower than the results of the present study in the PXP and BXP genotypes. A low but positive association (r = 0.289) was obtained by the author in the black variety, which contradicted the r = 0.102 obtained for the BXB genotype of the present study.

Negative associations obtained between SW and AH in the three genotype groups differed slightly from the report of Okoro (2012) [11], who recorded a negative association between the two traits in the lavender variety only. The author however, reported low, positive association between the traits in the black and pearl varieties (r = 0.274 and 0.185 respectively).

The positively low correlation or negative association between and most of the traits, across the genotype groups in this research corroborated the reports of Alkan *et al.* (2013) [8] and Okoro (2012) [11]. ESI can be improved in guinea fowl by selection for greater EWDT, given the significant positive association recorded between the two characters. Okoro (2012) [11] and Alkan *et al.* (2013) [8] similarly reported positive associations between

YW and other egg traits. The association between YW and YH were positive, but non-significant in the PXP and BXP genotypes (r = 0.119 and 0.420 respectively), but negative in the BXB genotype (r = -0.102). These results differed with the reports of Obike and Azu (2012) [12], who recorded a positive non-significant correlation between YW and YH (r = 0. 06) in the black variety and a negative association (r = -0.14) in the pearl variety of guinea fowl. Alkan *et al.* (2013) [8] obtained a positive and significant ($P < 0.05$) association (r = 0.223) between YW and YH. Okoro (2012) [11] however, reported r = 0.182, 0.106 and 0.411 in the black, lavender and pearl varieties of guinea fowl respectively.

Very high, positive and significant ($P < 0.01$) correlations were obtained between YH and YI across the genotype groups in this study (r = 0.915, 0.731 and 0.880 in BXB, PXP and BXP groups respectively). Similar trend of result had been obtained by other authors: Obike and Azu (2012) [12] reported that r = 0.94 and 0.92 in the pearl and black varieties of guinea fowl respectively; while Alkan *et al.* (2013) [8] reported the association as 0.889. Likewise, Okoro (2012) [11] reported correlation values of 0.840, 0.882 and 0.859 in the black, lavender and pearl varieties of guinea fowl. There is a direct relationship between YH and YI, hence the high and positive association observed. Improvement of the YI can therefore be a direct selection of birds with greater YH. The freshness of eggs is to a large extent determined by the YI.

YH had negative non-significant associations with YWDT in the PXP and BXB groups (r = -0.126 and -0.319 respectively), but a positive and low, non-significant association (r = 0.068) in the BXP genotype. The results were expected as YW is the denominating factor in the determination of YI. The negative associations recorded in the PXP and BXB groups were in line with the report of Alkan *et al*. (2013) [8]: r = -0.255; Obike and Azu (2012) [12]: r = -0.56, and -0.43 in the pearl and black varieties respectively; Okoro (2012) [11]: r = -0.248, -0.207 and -0.665 in the black, lavender and pearl varieties respectively.

Prediction of egg parameters:

The significantly ($P < 0.01$) high linear relationship obtained between EWT and AW in the present study corroborated the report of Onunkwo and Okoro (2015) [19] in the black, lavender and pearl varieties. The authors however, gave slightly lower range of linear regression coefficients (0.210 - 0.546) among the three varieties. Similarly, the very high and significant prediction relationships obtained between EWT and SW were in agreement with the report of Onunkwo and Okoro (2015) [19]. Going by the results of the present research it can be concluded that EWT is a very good predictor of AW in the three genotype groups. In the PXP genotype, EWT can highly predict EWDT (R^2 = 0.663), SW (R^2 = 0.875), YW (R^2 = 0.745) and moderately predict EL (R^2= 0.492), as well as, YWDT (R^2 = 0.30). Onunkwo and Okoro (2015) [19] reported a non-significant relationship between EWT and YWDT but a significant relationship between EWT and YW for the pearl variety of guinea fowl.

The BXB genotype showed significant ($P < 0.01$) but low regression coefficient between EWT and EL (R^2 = 0.190) and with YW (R^2 = 0.291). This agreed with the report of Onunkwo and Okoro (2015) [19] in the black variety. The level of significance and magnitude of relationship suggest that EWT can highly predict SW (R^2 = 0.685), ST (R^2 = 0.749) and YW (R^2 = 0.599) and lowly predict EWDT (R^2 = 0.199) and YH (R^2 = 0.253) in the BXP genotype.

The results of the stepwise regression analysis in the present study suggest that the best predictors of EWT in the PXP genotype were EWDT and EL (R^2 = 864). ST was a very good predictor of EWT (R^2 = 0.749) in the BXP genotype and can lowly predict EWT in the BXB group (R^2 = 0.281). The knowledge of the relationship existing between egg weight and internal and external quality traits of the guinea fowl egg will go a long way in providing necessary information which will guide the animal breeder in his egg improvement programmes in the guinea fowl.

Conclusion

The selection and improvement of EWT in the three genotypes would lead to a consequent improvement in EL, EWDT, SW, YW, AW, ST and YWDT given the high correlation coefficients between them. SW increased simultaneously with ST, therefore selection for one would lead to a concurrent improvement of the other.

The result of the linear regression analysis indicated that EWT was a very good predictor of AW in the three genotype groups while the stepwise regression analysis results suggest that the best predictors of EWT in the PXP genotype were EWDT and EL (R^2 = 864). ST was a very good predictor of EWT (R^2 = 0.749) in the BXP genotype and can lowly predict EWT in the BXB group (R^2 = 0.281). The knowledge of the association between egg weight and quality traits of the guinea fowl egg will go a long way in providing necessary information which will guide the animal breeder in his egg improvement programmes in the guinea fowl.

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