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Egg morphometric analyses, phenotypic correlations and prediction of egg traits of domestic pigeon in Nigeria

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Abstract

Pigeon is a common domesticated bird in Nigeria, but is often times reared for shows and consumed only in rare occasions. The eggs of this bird are sizeable and proven to be nutritionally comparable with the eggs of chicken, duck, quail, etc, which are readily and widely consumed by Nigerians. This study was undertaken to evaluate the relationship (correlation and regression/prediction) between phenotypic traits of quail eggs. These could assist in the recommendation of strategies for improvement of pigeons and their subsequent inclusion in the menu of Nigerians. Two hundred freshly laid eggs of domestic pigeons were collected from 28 weeks old foundation stock raised intensively on cage system. The birds were fed 15% CP and 2700 KcalME/Kg ration and water was given ad libitum. The external egg quality traits measured were egg weight, shell length, shell thickness, yolk weight, yolk height and yolk width. Data collected were used to estimate descriptive statistics, phenotypic correlations and to predict egg and yolk weights. Results of correlation coefficients obtained for paired external egg quality traits were low, negatively significant ($p<0.05$) between egg weight and shell weight (– 0.609) and between shell weight and shell thickness (– 0.538). Whereas results of phenotypic correlations of internal egg quality traits expressed mostly non-significant ($p>0.05$) both positive and negative, low values with the exceptions of very high, negative significant ($p<0.001$) correlation coefficient between yolk width and yolk weight (– 0.806); high, negative significant ($p<0.01$) correlation coefficient between albumen weight and albumen height (– 0.627) and moderate, negative significant ($p<0.05$) correlation coefficients between yolk height and albumen height (– 0.506) and between yolk height and albumen width (– 0.523).The only positive, high significant ($p<0.01$) correlation expressed was between albumen height and yolk weight (0.632). The results on phenotypic correlations suggested that egg and yolk weights could be used as an index of egg quality in domestic pigeon. Egg and yolk weights were predictable with sufficient accuracy from both the external and internal egg quality traits.

Keywords: Morphometrics, correlation, prediction, egg trait, pigeon

Analyses morphométriques des œufs, corrélations phénotypiques et prédiction des caractéristiques des œufs de pigeon domestique au Nigéria

Résumé

Le pigeon est un oiseau domestique commun au Nigéria, mais il est souvent élevé pour des spectacles et consommé seulement en de rares occasions. Les œufs de cet oiseau sont de grande taille et se sont avérés nutritionnellement comparables aux œufs de poulet, de canard, de caille, etc., qui sont facilement et largement consommés par les Nigérians. Cette étude a été entreprise pour évaluer la relation (corrélation et régression/prédiction) entre les traits phénotypiques des œufs de caille. Ceux-ci pourraient aider à la recommandation de stratégies d'amélioration des pigeons et à leur inclusion ultérieure dans le menu des Nigérians. Deux cents œufs fraîchement pondus de pigeons domestiques ont été collectés à

partir d'un stock de base de 28 semaines élevé intensivement sur un système de cage. Les oiseaux ont été nourris avec 15% de CP et 2700 KcalME/Kg de ration et de l'eau a été donnée à volonté. Les caractères externes de qualité des œufs mesurés étaient le poids des œufs, la longueur de la coquille, l'épaisseur de la coquille, le poids du jaune, la hauteur du jaune et la largeur du jaune. Les données recueillies ont été utilisées pour estimer les statistiques descriptives, les corrélations phénotypiques et pour prédire le poids des œufs et des jaunes. Les résultats des coefficients de corrélation obtenus pour les caractères appariés de qualité externe des œufs étaient faibles, négativement significatifs (p<0,05) entre le poids de l'œuf et le poids de la coquille (– 0,609) et entre le poids de la coquille et l'épaisseur de la coquille (– 0,538). Alors que les résultats des corrélations phénotypiques des caractères internes de qualité des œufs s'exprimaient pour la plupart non significatifs (p>0,05) à la fois positifs et négatifs, des valeurs faibles à l'exception d'un coefficient de corrélation très élevé et négatif significatif (p<0,001) entre la largeur du jaune et le poids du jaune (– 0,806); coefficient de corrélation élevé, négatif significatif (p<0,01) entre le poids de l'albumen et la hauteur de l'albumen (– 0,627) et coefficients de corrélation modéré, négatif significatif (p<0,05) entre la hauteur du jaune et la hauteur de l'albumen (– 0,506) et entre la hauteur du jaune et la largeur de l'albumen (– 0,523). La seule corrélation positive hautement significative (p<0,01) exprimée était entre la hauteur de l'albumen et le poids du jaune (0,632). Les résultats sur les corrélations phénotypiques suggèrent que les poids des œufs et des jaunes pourraient être utilisés comme indice de la qualité des œufs chez le pigeon domestique. Les poids des œufs et des jaunes étaient prévisibles avec une précision suffisante à partir des caractéristiques de qualité externes et internes des œufs.

Mots-clés : Morphométrie, corrélation, prédiction, trait de l'œuf, pigeon

Introduction

Pigeon belongs to the class Aves, order Columbiformes, large family Columbidae and genus Columba. The bird share family with several hundred species consisting of the smaller forms usually called doves, while the large forms are pigeon. Pigeon land birds, cosmopolitan in temperate and tropical regions are characterized by stout bodies, short necks, small heads and thick, heavy plumage (Parvez *et al*., 2016). According to Marques *et al*. (2007) and Parvez *et al*. (2016), pigeons are ubiquitous birds and can be found in virtually every town and city around the globe. Although pigeons are one of the most intelligent of all bird species man has found limited uses for the bird other than for the purposes of sport, food and as a messenger carrier (Parvez *et al*., 2016). Daikwo *et al*. (2017) opined that domestic pigeon (*Clumbialivia domestica*) are durable birds that can be raised with little capital input and they are able to survive harsh climate. Besides, they are monogamous, couples are stable but prolificacy is low. Female pigeons can reach sexual maturity as early as 7 months of age and lay eggs 8 to 12 days after mating. Domestic pigeons lay 1 to 3 (usually 2) small sized, oval shaped, white eggs. The eggs measured about 3 cm long and have a smooth surface and porcelain-white shell. Pigeon farming is a promising enterprise as urban micro-livestock as it requires little space, grows at a rapid rate, its meat is finely textured, has an attractive flavor and there is no taboos against consumption of its meat or egg (NRC, 1991). In addition, Daikwo *et al*. (2017) noted that the domestic pigeon is a reservoir of valuable genetic resources that have traditionally been used as a source of animal protein in Nigeria. Despite all these numerous advantages, Adeyeye (2012) and Daikwo *et al*. (2017) lamented that Nigeria still lay more emphasis on the production of

poultry chicken to the neglect of other classes of poultry. Thus, Sun *et al*. (2019) pointed out that besides the usual poultry species, other classes such as duck, goose, turkey, quail and pigeon should also be paid attention to as their egg properties would be helpful in technological and functional application of egg albumen from different poultry species. Poultry eggs according to Cotterill *et al*. (1978) and Sun *et al*. (2019), as the whole nutrition reservoir for embryo development, have been recognized as one of the major nutrient for human. Egg is known as one of the most important component of human diet (Amao and Olugbemiga, 2016) and is one of the most nutritious and complete food to man (Scott and Silverside, 2001). Egg morphometric parameters such as egg weight, egg width, albumen and yolk weights according to Farooq *et al*. (2001), are very important in poultry because their factors influence egg quality and grading, reproductive fitness of the chickens and embryonic development (Onagbesan *et al*., 2007). Also, Spark (2006) opined that internal egg quality parameters such as albumen and yolk weights are very important from nutritional and cholesterol contents for human consumption. Egg weight according to Olawumi and Ogunlade (2008), has a direct relation with egg quality which has a positive correlation with shell thickness and shell weight. Again, Ojedapo (2013) observed that positive phenotypic correlation exist between egg weight and other biometrical traits; egg length being weighty and significantly correlated with egg width. Farooq *et al*. (2001) reported positive correlations between egg weight, shell weight and shell thickness. On the other hand, Alkan*et al*. (2008) noted better prediction of egg shell weight and thickness from egg weight, width and length. Consequently, Okon and Ibom (2011) and Fajemilehin *et al*. (2013) pointed out that genetic improvement of animal species can be achieved by quantitative measurement, correlation among performance traits and development of selected programme for effective planning. There are very limited number of reports on egg morphometric analyses, correlations and prediction of egg traits from domesticpigeon in literature. To ensure the sustainability of this bird, there is urgent need to improve on its production capabilities. This study was therefore undertaken to investigate the egg morphometric analyses, phenotypic correlations and prediction of egg traits in the domestic pigeon with a view to assist in designing a breeding programme for improvement and sustainable use of pigeon genetic resources in Cross River State, Nigeria.

Materials and methods

Location of experiment

The experiment was carried at a private farm in Calabar farm (BATONIA FARM) in Calabar, a farm approved by the Department of Animal Science, University of Calabar for students to undertake their studies. Calabar is located in South-South region of Nigeria at latitude 4°57'N of the equator and longitude 8°19'E of the Greenwich meridian with annual rainfall range from 1260 to 1280 mm, annual temperature ranging from 25° to 30°C with relative humidity of 70 – 90% and at an elevation above sea level of 98 meters (NMA, 2018).

Experimental animals and data collection

A total of 200 fresh laid eggs were collected from a foundation stock pigeons aged 28 weeks. The pigeons were raised intensively on cage system with ration containing 15% CP and 2700 KcalME/Kg and water *ad libitum*. Constant and regular sanitation of the cages and the feeders were carried out.

Data measured on external quality traits were egg weight (EW), shell length (SL)and shell thickness (ST). The egg weight was measured with an electronic scale, Scout™

pro-scale with 0.001 g to 1000 g sensitivity. For shell weight and shell thickness, after the removal of the internal components (yolk and albumen), the shell was washed and sundried for 24 hours. Then the shell was weighed using an electronic scale, Scout™ pro-scale with 0.001 g to 1000 g sensitivity, while average shell thickness was obtained from average values of the samples taken from sharp, blunt and pointed parts of the egg shell using micrometer screw gauge (mm). Data obtained on internal egg traits were albumen weight (AW), albumen height (AH), albumen width (AD), yolk weight (YW), yolk height (YH) and yolk width (YD). Yolk and albumen heights and widths were determined using a spherometer calibrated in millimeters (mm).

Statistical analysis

All data collected for external and internal egg traits were subjected to descriptive statistics (mean, standard error and coefficient of variation). Phenotypic correlations between weight and egg linear traits were determined with Pearson's correlation coefficient (r) using SPSS (2015). The model FOR Pearson's correlation used was:

$$r = \frac{\sum XiYj}{\sqrt{\sum Xi2 \sum Yj2}}$$

where:

r = Pearson's correlation.

X_i = First random variable of the i^{th} egg weight of egg trait.

Y_i = Second random variable of the i^{th} egg linear trait.

The data were analyzed using SPSS (2015) for simple and multiple linear regression analyses.

$$Y = a + b_1X_1 + E$$

where:

Y = egg weight

a = constant

b_1 = regression coefficient of the i^{th} independent variable

X_1 = the value of the independent variable

E = error term

The goodness of fit (R^2) was tested to determine that contribution of each of the independent variables measured to the prediction of the dependent variable, egg weight. The accuracy of the regression equations were estimated by residuals (absolute value of the difference between predicted weight by using the developed equations and actual weight measured with the scale).

Results and discussion

The descriptive statistics for external and internal egg quality traits results in this study are shown in Table 1. The results for external egg quality traits revealed that mean egg weight (EW), shell weight (SW) and shell thickness (ST) were 16.941 g, 1.875 g and 0.857 mm, respectively. The mean egg weight (EW) of 16.941 g obtained here was lower than 18.06 g and 22.57 g reported by Daikwo *et al*. (2017) and Sun *et al*. (2019), respectively. Also, the shell weight (SW) here was lower than 2.40 g reported by Kakir *et al*. (2012) for domestic pigeons of different ages. Conversely, the mean values obtained for shell thickness (ST) in this study was higher than 0.180 mm reported by Sun *et al*. (2019). Altan *et al*. (1998) opined that the inability of an egg to resist fracture can be attributed to deficiencies in shell structure [e.g. thickness and shape, while eggs of normal shape hatch more successfully than those with abnormal shape (Narushin and Ramanov, 2002). As shown in Table 1, the coefficient of variation (CV%) for external egg quality traits were generally low, less than 12%. This did not agree with the report of Ojedapo (2013) of very low (0.01 to 1.50%) coefficient of variation for egg quality traits. The low CV% results obtained might be attributed to the low individual variation present in the external and internal egg traits measured, as well as influence of age and breed. The values of

the internal egg quality traits were 7. 653 g, 25.463 mm, 41.379 mm, 8.510 g, 10.668 mm and 26.002 mm for albumen weight (AW), albumen height (AH), albumen width (AD), yolk weight (YW), yolk height (YH) and yolk width (WD), respectively (Table 1). Again, these values obtained for internal egg quality for domestic pigeon were higher than those reported by Kabir *et al*. (2012) and Sun *et al*. (2019); except for albumen weight (16.62 g) reported by Sun *et al*. (2019). The differences in the results might again be attributed to differential expression of genes by different birds under different management conditions and content of diets adopted (Abdulraheem *et al*., 2018), effect of breed, direct influence of age and plumage genotype (Sari *et al*., 2012 and Hanusova *et al*., 2015). The phenotypic correlation (r_p) coefficients obtained for external egg quality traits are shown in Table 2. Surprisingly, most of the correlation coefficients obtained for paired external egg quality traits were negatively significant ($p<0.05$); correlations between egg weight and shell weight (– 0.609) and between shell weight and shell thickness (– 0.538) (Table 2). The negative correlation signifies that both traits will lead to decrease in the other trait. Thus, Fayeye (2014) pointed out that the traits are controlled by more than one gene (pleiotropy).

Table 1: Descriptive statistics of egg quality traits of pigeon

Egg traits	Mean±SE	Coefficient of variation (CV%)
External egg quality		
Egg weight (g)	16.941±0.146	3.867
Shell weight (g)	1.873±0.036	8.633
Shell thickness (mm)	0.857±0.020	10.257
Internal egg quality		
Albumen weight (g)	7.653±0.166	9.721
Albumen height (mm)	25.463±0.282	4.952
Albumen width (mm)	41.379±0.148	1.598
Yolk weight (g)	8.510±0.501	26.327
Yolk height (mm)	10.668±0.079	3.313
Yolk width (mm)	26.002±0.054	0.929

Table 2:Phenotypic correlation coefficients of external egg traits of pigeon.

Traits	EW	ST	SW
EW	1		
ST	-0.338^{NS}	1	
SW	-0.609^{**}	-0.538^{*}	1

EW = Egg Weight, ST = Shell Thickness, SW = Shell Weight, * = $p<0.05$ (Moderately significant), ** = $p<0.01$ (Highly significant), NS= $p>0.05$ (Non- significant)

Phenotypic correlation (r_p) coefficients obtained for internal egg quality traits are shown in Table 3. Interestingly again, most of the correlation coefficients expressed were non-significant ($p>0.05$) and either positively or negatively low. But very high, negative significant ($p<0.001$) correlation coefficients were obtained (Table 3) between yolk width (YD) and yolk weight (YW) (– 0.816); high, negative significant ($p<0.01$) correlation coefficient between albumen weight (AW) and albumen height (AH) (– 0.627) and moderate, negative significant ($p<0.05$) correlation coefficients between yolk height (YH) and albumen height (AH) (– 0.506) and yolk height (YH) and albumen width (AD) (– 0.523). The only positive, high significant ($p<0.01$)

correlation expressed was between albumen height (AH) and yolk weight (YW) (0.632). The positive correlation signifies that they are controlled by same gene and shows an indication that any of these egg traits could serve as predictor of egg weight. Hence, Ige (2013) noted that correlation coefficients indicate the strength of linear association between two traits involved for the purpose of breeding and improvement plan.

Table 3: Phenotypic correlation coefficients of internal egg traits of pigeon.

Traits	YW	AH	AW	AD	YH	YD
YW	1					
AH	0.632^{**}	1				
AW	-0.320^{NS}	-0.627^{**}	1			
AD	-0.362^{NS}	-0.094^{NS}	-0.089^{NS}	1		
YH	-0.101^{NS}	-0.506^{*}	0.497^{NS}	-0.523^{*}	1	
YD	-0.816^{***}	-0.486^{NS}	0.158^{NS}	-0.146^{NS}	0.153^{NS}	1

YW = Yolk Weight, AH = AlbumenHeight, AW = Albumen Weight, AD = Albumen Width, YH = Yolk Height, YW = Yolk Width, ***= $p<0.001$ (Very highly significant), ** = $p<0.01$ (Highly significant), NS= $p>0.05$ (Non-significant)

The results of regression equations, coefficients of determination (R^2) and residual mean square (RMS) relating the egg weight with external traits and yolk weight with internal egg traits of domestic pigeons are shown in Table 4. The regression estimates of parameters and coefficients of determination for simple (one trait) and multiple (two or more traits) linear functions for predicting egg and yolk weights showed very low, non-significant associations (Table 4). The coefficient of determination (R^2) results varied from 0.3278 to 0.3349 for external egg traits and from 0.0124 to 0.1669 for internal egg traits. The values of R^2 increased as more independent variables were added to the regression equation (Table 4) showing that estimating egg weight using a single egg trait measurement is not the only suitable criterion for predicting egg and yolk weights (Okon *et al*., 2020). Hence, Topel *et al*. (2003) opined that anyone of R^2 or RMS may be confidently applied to investigate the fitting state of simple and multiple regression models to actual data for estimation of body weights in livestock. Egg and yolk weights were predicted with significant accuracy from both the external and internal egg quality traits for domestic pigeons reared in Calabar.

Table 4: Regression equation for predicting egg weight and yolk weight of pigeon.

Traits	Prediction equations	R^2	SEE	RMS
External egg quality				
ST	Y = 13.28 + 4.27ST	0.3278^{NS}	0.552	0.3046
ST, SW	Y = 12.87 + 3.86ST	0.3349^{NS}	0.565	0.3190
Internal egg qquality				
AH	Y = 3.5 + 0.198AH	0.0124^{NS}	2.29	5.233
AH, AW	Y = 3.6 + 0.196AH + – 0.015AW	0.0125^{NS}	2.35	5.540
AH, AW, AD	Y = – 32.7 + 0.211AH + – 0.171AW + 0.897AD	0.0796^{NS}	2.34	5.487
AH, AW, AD, YH	Y = – 49.8 + 0.500AH – 0.467AW + 1.91AD – 2.79YH	0.0334^{NS}	2.38	5.676
AH, AW, AD, YH, YD	Y= – 34.0 + 543AH – 0.413AW + 2.01AD – 2.75YH – 0.85YD	0.1669^{NS}	2.47	6.112

R^2= Coefficient of Determination, SEE = Standard Error of Estimates, RMS = Residual Mean Square

Conclusion

The study revealed low variations as indicated by coefficient of variation within the external egg traits and within the internal egg traits measured with the exception of yolk weight. The study on correlations suggests that egg weight and yolk weights could be used as an index of egg quality in domestic pigeon. Egg and yolk weights were predictable with sufficient accuracy from both external and internal egg quality traits.

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