Research Article

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Egg quality traits, phenotypic correlations, egg and yolk weights prediction using external and internal egg quality traits of Japanese quails reared in Calabar, Nigeria

Abstract

Three hundred freshly laid eggs collected from 12 weeks old brown Japanese quails on deep litters fed 18% CP and 2700 kcal ME/kg ration and water *ad libitum*. External egg quality traits measured included egg (weight and width) and yolk (weight, height and width). Data collected were used to estimate descriptive statistics, phenotypic correlations and to predict egg and yolk weights. Results of phenotypic correlation of external egg traits investigated expressed mostly non-significant (p>0.05) both positive and negative low values with the exceptions of two higher, negative significant (p<0.01) correlations observed between egg weight and egg length (r= – 0.721) and egg weight and shell thickness (r= – 0.616). Similarly, results of phenotypic correlations of internal egg traits expressed mostly non-significant (p>0.05) both positive and negative low values with the exceptions of very high negative correlation coefficient (r= – 0.802) between yolk weight and albumen width and moderate negative correlation coefficient (r= – 0.561) between albumen height and albumen width. The only moderate positive significant correlation (r=0.519) obtained in this study was between yolk weight and albumen height. The regression estimates of parameters and coefficient of determination for simple (one trait) and multiple (two traits and for predicting egg and yolk weight sh6wed very low non-significant associations/interrelationship. But with three to five traits fitted into the multiple linear regression equations, highly significant (p<0.001) associations/interrelationships were obtained for egg and yolk weights. Egg and yolk weights can be predicted using external and internal egg traits measurements with two external traits (egg length and egg width) and two internal traits (albumen height and albumen width) best predicted egg and yolk weights respectively.

Keywords: Japanese quail, egg quality traits, phenotypic correlation, prediction

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Description of problem

Quail belongs to the family *Phasianidae*, order *Galliform* and genus *Coturnix*. The bird share family with pheasants and partridges with over 40 species recognized worldwide. Japanese quail (*Coturnix coturnix japonica*) is one of the major five species of the *Coturnix*.[1,2] The Japanese quail, also known as *Coturnix* quail, Pharoah's quails, Stubble quail and Eastern quail,[3] is a small bodied bird of weight varying between 150g and 700g when fully matured from 5 to 6 weeks and usually in full egg production by 50 days of age.[4] It differs from the North American Bobwhite quail. The Bobwhite is larger than the Japanese quail; however, the *Coturnix* produces larger eggs.

Abdulraheem[2] opined that quail production is becoming an important business in the Nigerian poultry industry especially among small and medium scale poultry producers. This[5] noted could be associated with marked advantages the bird possess over others galliforms. The features among others include fast growth, early maturity, high rate of egg production, short gestation interval and short incubation period.[2] The Japanese female quail starts laying eggs as early as 6 weeks of age compared to 10 weeks for Bobwhite[6] and can lay over 300 eggs in the first year of production if properly maintained and cared for.[2,7] Though the small size of the egg is less than 15g compared to egg laying chicken of about 40 – 70g.[8] Quail eggs are high in nutritional value, are a hoarder of many nutrients, rich sources of protein, good cholesterol, vitamin B, vitamin B_2, vitamin A, Vitamin C and are unquestionably one of the most balanced foods with a safe option to include in man's diet. Between other protein-containing foods, quail eggs contain the highest variety and mixture of amino acids that are indispensable for healthy growth and development of children, adolescents and young adults. In addition, the high muscular degeneration, which is the leading cause of blindness in developed countries.

Egg quality, according to,[2] is the most important price-contributory factor in both table and hatching eggs, as it portrays the characteristic of an egg that affects its acceptability to the consumers. Thus, the authors opined that economic success of a laying flock depends solely on the number of quality eggs produced. External egg quality traits include size and shell qualities, while the internal egg quality traits include yolk and albumen qualities. In the egg producing industries,[9] pointed out that egg shell weight, albumen and the yolk that form the egg as well as their ratio affect the amount and price of the product. Egg weight is an important egg trait, which influences egg quality as well as grading.[10] The egg weight has a direct relation with egg quality which has a positive correlation with the shell thickness and shell weight.[11] Besides,[3] observed that positive phenotypic correlation exist between egg weight and other biometrical traits; egg length being weighty and significantly correlated with egg width. Positive correlations between egg weight, shell weight and shell thickness has been reported by.[10] Also better prediction of egg shell weight and thickness from egg weight, width and length.[12] In addition,[13] opined that egg shell weight, shell thickness, weight of egg yolk and albumen are the important egg traits influencing egg quality, weight of the newly hatched chicks and the hatching performance.

Consequently,[14] pointed out that apart from correlation procedure describing the interrelationship that exist among body traits, estimates of correlation coefficients are therefore very useful in animal breeding as a mean of predicting potential response to, or progress from selection. Since production traits are interrelated,[15] noted that considerations of such relationships are very relevant to selection for improvement. Genetic improvement of animal species can be achieved by quantitative measurement, correlation among performance traits and development of selection programme for effective planning.[16,17] The use of correlation coefficients to examine the relationships between measurements of body traits has been widely reported in chicken, whereas such information is less documented for quails.[14] There are limited number of reports on egg quality traits, correlations and egg and yolk weights prediction of Japanese quails in literature. To ensure the sustainability of the bird, there is need to improve on its productive capabilities. This study was undertaken to provide egg quality traits (external and internal), phenotypic correlations and prediction equations for predicting life egg and yolk weights using external and internal egg quality traits of Japanese quails.

Materials and methods

Location of experiment

The experiment was carried out at the Poultry Unit, Department of Animal Science Teaching and Research Farm, University of Calabar, Nigeria.

Experimental animals and data collection

A total of 300 freshly laid eggs were collected at 12 weeks of age from a foundation stock of brown Japanese quails. The quails were raised intensively under deep litter system and fed ration containing 18%CP and 2700 Kcal ME/Kg and water *ad libitum*. Constant and regular sanitation of the pen including the feeders were carried out.

Data measured on external egg quality traits included egg weight (EW), egg length (EL), egg width (EG), shell weight (SW) and shell thickness (ST). The egg weight (EW) was measured with an electronic balance, Scout™ pro-scale with 0.001g to 1000g sensitivity. Egg length and width were measured with a pair of Vernier caliper (mm). For shell weight and thickness, after the removal of the internal components (yolk and albumen), the egg shell was washed and sundried for 24 hours. Then, the shell was weighed using and electronic balance, scout™ pro-scale with 0.001g 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 measured on internal egg traits included 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 deviation, standard error and coefficient of variation). Phenotypic correlations among egg weight and egg linear traits were determined with Pearson's correlation coefficients (r) using.[18] The model for the Pearson's correlation used was

$$r = \frac{\sum x_1 y_1}{\sqrt{\sum x_1^2 \sum y_1^2}}$$

Where:

r = Regression's product moment correlation coefficient

X_1 = First random variable of the ith egg weight of egg trait

Y_1 = Second random variable of the ith egg linear trait

The data were analyzed using[18] for simple and multiple linear regression analysis.

$Y = a + b_1 X_1 + E$

Where:

Y = egg weight

a = constant

b_1 = regression coefficient of the ith 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 using 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 of Japanese quails in this study are shown in Table 1. The results of external egg quality traits revealed that mean egg weight, egg length, egg width, shell weight and shell thickness were 10.195 g, 32.199 mm, 22.536mm, 1.280mm and 0.228 mm respectively. The mean egg weight 10.195g obtained here was higher than 8.19±0.02g, 9.20±0.08g and 7.43 – 8.52g reported by[2,3,19] respectively for Japanese quails of the same age, but rather agreed with mean egg weight of 10.53g for brown variety of quails reported by.[20] Egg weight, one of the most uniform with regards to relationship with egg production is an important egg size quality traits. Abdulhareem[2] and according to[20] may be of advantage in quail breeding industry. Similarly, the values obtained for egg length, egg width, shell weight and thickness were higher than those of.[2,3,19,21] Information of these egg traits will further open the dogma for trying out various prediction equations in order to predict egg shell weight and shell thickness.[22]

The differences observed among reports for traits related to external egg quality could be expected because of differences in genetic structures, content of diets and management practices adopted[2] as well as plumage genotype,[22] agreeing with[22,23] reports that hens with coloured feathers lay bigger eggs than hens with white feathers. Kul and Seker[24,25] recorded lower value of 0.231 mm for shell thickness similar to the 0.228mm obtained in this study. However, the value obtained for egg shell thickness falls within the range of 0.20 – 0.30mm reported by[26–28] while[20] recorded higher and consistent value of 0.27mm from three varieties of quails studied. Altan[9] opined that the inability of an egg to resist fracture can be attributable to deficiencies in shell structure (e.g. thickness) and shape; while eggs of normal shape hatch more successfully than those with abnormal shape[29] and thickness. The coefficient of variation (CV%) for external egg quality

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traits were generally low, less than 10% (Table 1). These agreed with the report of[3] of very low (0.01 – 1.50%) coefficient of variation for egg quality traits. The CV% results indicated low individual variation present in the external egg traits measured.

Table 1 Descriptive statistics of egg quality traits of quails

Egg traits	Mean ± S.E	Standard deviation (SD)	Coefficient of variation (CV %)
External egg quality			
Egg weight (g)	10.195±0.175	0.781	7.664
Egg length (mm)	32.199±0.249	1.114	3.461
Egg width (mm)	22.536±0.279	1.247	5.533
Shell weight (g)	1.280±0.022	0.1	7.822
Shell thickness (mm)	0.228±0.018	0.086	0.277
Internal egg quality			
Albumen weight (g)	4.270±0.105	0.471	11.041
Albumen height (mm)	4.198±0.039	0.175	4.164
Albumen width (mm)	30.230± 0.136	0.136	2.011
Yolk weight (g)	4.441±0.118	0.529	11.911
Yolk height (mm)	10.268±0.098	0.438	4.267
Yolk width (mm)	22.931±0.120	0.538	2.348

The results of the internal egg quality traits were 4.270 g, 4.198mm, 30.230 mm, 4.441 g, 10.268mm and 22.931mm for albumen weight, albumen height, albumen width, yolk weight, yolk height and yolk width, respectively (Table 1). Again, these values obtained for internal egg quality traits were higher than those reported by[3] except for albumen weight (4.95g) and albumen height (4.96mm), but lower than those reported by[30] as well as albumen weight (5.16g) reported by.[20] 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,[2] effect of breed, direct influence of age and plumage genotype.[22,31]

The phenotypic correlation (r_p) coefficient obtained for external egg quality traits are shown in Table 2. Interestingly, most of correlation coefficients obtained from paired external egg quality traits were non-significant (p>0.05) either positively or negatively low. These results negate[20] high significant results. The reason being that the authors concentrated only on egg weight. But these low, non- significant associations obtained here agreed with the reports of[3] on external egg quality traits. However, higher negative significant (P<0.01) correlations were observed between egg weight and egg length (– 0.721) and egg weight with shell thickness (– 0.616). These negative correlation results negate the positive correlations between egg weight with shell weight and shell thickness reported by.[10] The higher, though negative and significant (P<0.01) correlation values obtained between egg weight and egg length as well as between egg weight and shell thickness agreed with[20] values of 0.823 and 0.456, respectively for brown variety of quails. The negative correlation signifies that both traits are controlled by different genes, meaning that an improvement in one trait will lead to decrease in the other trait. According to[32] the traits are controlled by more than one gene (pleiotrophy).

Phenotypic correlation (r_p) coefficients obtained for internal egg traits are shown on Table 3. Surprisingly again, most of the correlation coefficients obtained were non-significant (P>0.05) and either positively or negatively low. These results agreed with the low, non-significant (P>0.05) reports of[3] for internal egg quality traits. But very high, negative significant (P<0.01) correlation coefficient obtained (Table 3) between yolk weight (YW) and albumen width (AD) (– 0.802) and moderate, negative significant (P<0.05) correlation coefficient between albumen height (AH) and albumen width (AD) (– 0.561). The only moderate positive, significant (P<0.05) correlation obtained was between yolk weight (YW) and albumen height (AH) (0.519). This positive correlation signifies that the traits are controlled by same gene and shows an indication that any of these egg traits could serve as a predictor of egg weight. Thus,[15] opined that correlation coefficients indicate the strength of linear association between traits, thereby give useful information of traits involved for the purpose of breeding and improvement plan.

The results of regression equations, coefficients of determination and residual mean square (RMS) relating the egg weight with external egg traits and yolk weight with internal egg traits of quails are shown in Table 4. The regression estimates of parameters and coefficients of determination for simple (one trait) and multiple (two traits and above) linear functions for predicting egg weight and yolk weight showed very low non-significant associations/interrelationships (Table 4). However, when three and four external traits (egg length, egg width, shell length and shell thickness) for predicting egg weight and from three to five internal egg traits (albumen height, albumen width, albumen weight, yolk height and yolk width) for predicting yolk weight were fitted into multiple linear regression function, a highly significant (P<0.001) association was obtained for egg and yolk weights. The coefficient of determination (R^2) results varied from 0.089 to 0.0810 with external egg traits and varied from 0.009 and 0.602 with internal egg traits. Although, egg weight was predicted using either single or combine external egg traits of length, width, shell thickness and shell weight but egg weight was predictable with sufficient accuracy from egg length and width (Table 4). The results agreed with the reports of[12–13] Similarly, yolk weight was predicted using single or combine internal egg traits, but albumen height and albumen width predicted most accurately yolk weight (Table 4). The results of this study confirmed that egg and yolk weights of quails can be predicted with confidence from most external and internal egg trait measurements. The value 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. Topal[33] 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. The higher and significant ($P<0.001$) R^2 value and smaller RMS obtained in this study (Table 4) using single or multiple predictor variable indicated that all external traits (EL, ED, ST, SH) and internal egg traits (AH, AW, AD, YH, YD) as independent variables were good estimators of egg and yolk weights in quails.

Table 2 Phenotypic correlation coefficients of external egg traits of quails

Traits	EW	EL	ED	ST	SW
EW	1				
EL	– 0.921**	1			
ED	– 0.327ns	– 0.258ns	1		
ST	– 0.616**	0.258ns	0.123ns	1	
SW	– 0.360ns	– 0.043ns	0.011ns	0.224ns	1

**p<0.01 (high significant), *p<0.05 (low significant) ns(p>0.05) non-significant

EW, egg weight; EL, egg length; ED, egg width; ST, shell thickness; SW, shell weight

Table 3 Phenotypic correlation coefficients of internal egg traits of quails

Traits	YW	AH	AW	AD	YH	YD
YW	1					
AH	0.564*	1				
AW	-0.074ns	-0.231ns	1			
AD	-0.802**	-0.561*	-0.330ns	1		
YH	0.213ns	-0.136ns	0.468ns	-0.345ns	1	
YD	-0.296	-0.015ns	0.289ns	-0.196ns	-0.345ns	1

**p<0.001 (Highly significant), *p<0.01 (High significant), p<0.05 (Moderate significant), ns(p>0.05) non-significant. YW, yolk weight; AH, albumen height; AW, albumen weight; AD, albumen width; YH, yolk height; YD, yolk width

The results of actual and predicted/computed egg and yolk weights of quails are presented in Table 5. The actual and predicted egg and yolk weights were more or less similar, which confirmed the facts that egg and yolk weights can be predicted from both external and internal egg traits measurements with accuracy. Multiple regression models using multiple traits (EL and ED) from external egg traits and (AH and AW) from internal egg traits best predicted egg and yolk weights, respectively (Table 5). A comparison between actual; and predicted egg and yolk weights revealed that there was no significant difference. The predicted egg values of 10.195 ± 0.175 g and 4.441 ± 0.118g best matched with actual live weight (Table 5). This means that both the simple and multiple linear models with one, two to five external and internal egg traits, respectively best predicted egg and yolk weights of quails.

Table 4 Regression equations for predicting egg weight and yolk weight

Traits	Prediction equations	R^2	SEE	RMS
External Egg Traits				
EL	Y=16.93-0.209EL	0.089	0.766	0.587
EL, ED	Y=16.23-0.227EL+0.056ED	0.097	0.785	0.617
EL, ED, ST	Y=2.04-0.057EL+0.1223ED+7.835ST	0.751***	0.425	0.18
EL, ED, ST,SW	Y=-0.74-0.065EL+0.1239ED+8.36ST + 1.949SW	0.810***	0.384	0.147
Internal Egg Traits				
AH	Y=5.67-0.293AH	0.009	0.541	0.293
AH, AW	Y= 3.90-0.228AH +0.352AW	0.107	0.529	0.28
AH,AW,AD	Y=-15.67-0.216AH-0.130AW+0.714AD	0.595*	0.367	0.135
AH, AW, AD, YH	Y=-16.42-0.217AH-0.170AW+0.773AD-0.086YH	0.597*	0.378	0.143
AH,AW, AD, YH, YD	Y= -17.22 -0.174AH -0.141AW+0.722AD -0.144YH +0.116YD	0.602**	0.389	0.151

***p<0.001 (highly significant), **p<0.01 (High significant), *p<0.05 (Moderate significant), R^2=Coefficient of determination

EL, egg length; ED, egg width; ST, shell width; SEE, standard error estimate; AH, albumen height; AW, albumen weight; AD, albumen width; YH, yolk height; YD, yolk width; RMS, residual mean square

Table 5 Comparison between actual and predicted egg weight and yolk weight of quail eggs

Traits used	Actual egg weight (g)	Predicted weight (g)
External egg traits		
EL	10.195±0.175	10.195±0.171
EL,ED	10.195±0.175	10.195±0.175*
EL, ED,ST	10.195±0.175	10.195±0.09
EL,ED, ST, SW	10.195±0.175	10.195±0.086
Internal egg traits		
AH	4.441±0.118	4.441±0.121
AH, AW	4.441±0.118	4.441±0.118*
AH,AW,AD	4.441±0.118	4.441±0.082
AH,AW,AD,YH	4.441±0.118	4.441±0.085
AH,AW,AD,YH,YD	4.441±0.118	4.441±0.087

*values with asterisk predicted actual weight most accurately

EL, egg length; ED, egg width; SH, shell weight; ST, shell thickness; AH, albumen height; AW, albumen width; YH, yolk weight; YH, yolk height; YW, yolk width

Conclusion and application

The results of this study revealed that there are low variations as indicated by the results of coefficient of variation (CV%) within external and internal egg traits measured. Phenotypic correlations among egg traits showed low, non-significant relationship/association between egg weight and all other external egg traits as well as low, non-significant relationship/association between yolk weight and all other internal egg traits studied. Worthy of note were high, negative significant ($P<0.01$) correlations obtained between egg weight and egg length (– 0.721) and between egg weight and shell thickness (– 0.616); as well as higher, negative significant ($P<0.01$) correlation between yolk weight and albumen width (– 0.802). The only moderate, positive significant ($P<0.05$) correlation obtained was between yolk weight and albumen height (0.519). Prediction of egg and yolk weights using simple and multiple regression analyses has accurately predicted these traits using either external or internal egg traits or combination of two or more traits. Thus, suggesting that egg and yolk weights can be predicted from external or internal egg trait measurements with high accuracy to support improvement, husbandry practices and marketing of quail eggs. However, multiple regression model with two traits (EL and ED) from external egg traits and (AH and AW) from internal egg traits best predicted egg and yolk weights, respectively.

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Conflicts of interest

The author declares there are no conflicts of interest.

References

1. Harvard R, Moor A. A *computer checklist of birds of the world.* Revisededition. Macmillan, London. 1984.
2. Abdulraheem AO, Alade NK, Aliyu J, et al. Heritability estimates of external egg quality characteristics of Japanese quails raised under semi-arid environment of Borno State, Nigeria. *Nigerian Journal of Animal Science Technology.* 2018;1(1):60–66.
3. Ojedapo LO. Phenotypic correlation between the external and internal egg quality traits of Pharaoh quail reared in derived Savannah zone of Nigeria. *Journal of Biology, Agriculture and Healthcare.* 2013;3(10):80–83.
4. Akpa GN, Kaye J, Adeyinka IA, et al. Repeatability of body weight and egg quality traits of Japanese quail. *Savannah Journal of Agriculture.* 2006;1(2):119–120.
5. Raji AO, Abdulraheem AO, Medugu CI. Serum biochemical indices of young and adult Japanese quails raised in semi-arid Borno State. *Proceedings of the Annual Conference of Nigerian Society for Animal Production (*NSAP*),* 18th – 22nd March, 2018, FUT, Owerri, 2018; p. 192–194.
6. Sam KY. The japonica quaila.k.aConturnix, *published in the Fancier Newspaper, Canada's monthly Publication, Forest, Ontario Canada NONIJO.*1999.
7. Sezer M. Heritability of exterior egg quality traits in Japanese quails. *Journal of Applied Biological Sciences.* 2007;1:37–40.
8. Owosibo AO, Adeyemi OO, Omole AJ, et al. *Quails: A wonder bird. Back to Agric. Series*, Green choice Agric. Publications, Nigeria. 2013;56.
9. Altan OI, Oguz I, Akbas Y. Effects of selection of high body weight and egg of hen on egg characteristics in Japanese quail (*Corturnix japanica*). *TurkisJournal of Veterinary and Aanimal Science*. 1998;2:67–93.
10. Farooq M, Mian MA, Ali M, et al. Egg traits of Fayomi bird under sub-tropical conditions. *Sarad J Agric*. 2001;17:141–145.
11. Olawumi SO, Ogunlade JT. Phenotypic correlation between some external and internal egg quality traits in the exotic brown layer breeders. *Asian Journal of Poultry Science.* 2008;2:30–35.
12. Alkan S, Karabag K, Galic A, et al. Predicting yolk height, yolk width, albumen length, eggs shell weight, egg shape index, egg shell thickness, egg surface area of Japanese quails using various egg traits as repressors. *International Journal of Poultry Science.* 2008;7(1):85–88.
13. Kurshid A, Farooq M, Durrani FA, et al. Predicting egg weight, shell weight, shell thickness and hatching chick weight of Japanese quails using various egg traits as regressors. *International Journal of Poultry Science.* 2003;2(2):164–167.
14. Obike OM, Nwachukwu EN, Onwuchekwa JU. Phenotypic correlations of body weight and linear body traits in Heavy, medium and low body weight lines of sigmond strain of Japanese quails in humid rain forest zone of Nigeria. *Nigerian Journal of Animal Production.* 2016;43(1):1–9.
15. Ige AO. Relationship between body weight and growth traits of crossbred Fulani ecotype chicken in derived Savannah zone of Nigeria. *International Journal of Agricultural and Apicultural Research.* 2013;9(1–2):157–166.
16. Okon B, Ibom LA. Phenotypic correlation and body weight prediction using morphometric traits of snails in Calabar. *Ethiopian Journal of Environmental Studies and Management.* 2011;4(3):7–11.
17. Fajemilehin SOK, Fagbuaro MKA, Sunday S. Relationships among body traits of African giant land snail (*Archachatina marginata*) at different age groups. *Global Journalof Science Frontier Research Agriculture and Veterinary.* 2003;13(14):1–6.
18. SPSS. *Statistical package for Social Sciences*, SPSS Inc. 2015.

19. Malik AA, Ijaiya AT, Tsado DN, et al. Growth performance and egg production of Japanese quail (*Coturnixcoturnix* Japonica) fed diets containing graded levels of sun-dried cassava (*manihot esculenta*) peel meal. *Nigerian Journal of Animal Science.* 2018;20(2):232–240.

20. Chimezie VO, Fayeye TR, Ayorinde KL, et al. Phenotypic correlations between egg weight and some egg traits in three varieties of Japanese quail (*Cortunixcorturnixjaponica*). *Agric-search.* 2017;17(1):44–53.

21. Ingram DR, Wilson HR, Nesbeth WG, et al. Repeatabilies, heritabilies and phenotypic and genetic correlations of egg characteristics of the Bob white quail (*Coturnixvirginianus*). *Brazil Journal of Genetics.* 1989;12(2):227–233.

22. Sari M, Serpil I, Onk K, et al. Effects of layer age and different plumage colors on external and internal egg quality characteristics in Japanese quails (*Coturnixcoturnixjaponica*). *Arch*. *Geflugelk*. 2012;78(4):254–258.

23. Halaj M, Grofik R. *Table eggs characteristics*. Nitra: Garmond, Pp. 37-62. In: Slovak. 2012.

24. Kul S, Seker I. Phenotypic correlations between one external and internal egg quality traits in the Japanese quail (Coturnixcoturnix *japonica*). *International Journal of Poultry Science.* 2004;3(6):400–405.

25. Jubril AA. Egg quality traits of Japanese quails raised under semi-arid conditions. *Bachelor of Agriculture Degree Project:* Department of Animal Science, University of Maiduguri, Nigeria, 2008; Pp. 54.

26. Uluocak AN, Okan F, Efe E, et al. Bdlldridn yumurtalardnda bazd ic ve aas kalite Ozellikeri ile bunlardn yasa gore desgisimi. *Turkish Journal of Veterinary and Animal Science*. 1995;19:181–185.

27. Erensaymn C, Camcm O. Effects of the oviposition time on egg quality in quails. *Arch Geflugelk.* 2002;66:283–284.

28. Ojo V, Ayorinde KL, Fatoki HO. Relationship between body weight and some egg production traits in the Japanese quail (*Coturnixcoturnixjaponica*). *Nigerian Society of Experimental Biology (NISEB) Journal.* 2011;11(2):89–94.

29. Narnshin VG, Ramanov MN. Egg physical characteristics and hatchability. *World's Poultry Science Journal.* 2002;58:297–303.

30. Punya Kumuri BP, Gupta BR, Prakash MG, et al. A study of egg quality traits in Japanese quails (*Coturnixcoturnixjaponica*). *Tamil nadu Journal of Veterinary and Animal Science*. 2008;4(6):227–231.

31. Hanusova E, Hrnicar C, Hanus A, et al. Effect of breed on some parameters of egg quality in laying hens*. Acta fytotechn. Zootechno*., 2015;18(1):20–27.

32. Fayaye TR. *Genetic principles and animal breeding*. Happy printing enterprises, Ilorin, Nigeria. 2014.

33. Topal M, Yildiz N, Esenbuga N, et al. Determination of best fitted regression model for estimation of body weight in Awassi sheep. *Journal of Applied Animal Research*. 2003;23(2):201–208.