CORRELATION AND PREDICTION EQUATIONS BETWEEN EXTERNAL AND INTERNAL EGG QUALITY TRAITS OF JAPANESE QUAILS (*Corturnix japonica*)

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ABSTRACT

The study evaluated the correlations and prediction equations between external and internal egg quality traits of Cinnamon Brown (CB) and Panda White (PW) strains of Japanese quails (Corturnix japonica). The study was conducted at the Teaching and Research Farm of the Department of Animal Science, University of Uyo. A total of120 Japanese quail eggs from both CB and PW strains were examined for both external and internal egg traits. External egg traits examined were Egg weight (EWT), Egg length (ELT), Egg width (EWD) weeks, Shell weight (SWT), and Shell thickness (STH). Internal egg traits examined were Yolk length (YKL), Yolk diameter, Albumen length, Albumen diameter, Yolk weight, and Haugh unit. EWT were predicted using both external and internal traits. The result showed that EWT had a strong positive association with ELT in week 10 (0.857) and this was highly significant (p<0.01). The phenotypic correlation coefficients obtained for EWT and YKL was positive and significant at week 10 (0.313). The coefficient of determination obtained for external egg traits ranged between 53.4 and 91.9 % for PW and 48.2 to 86.2% for CB. Selection for improvement using EWT will result in good performance and significant genetic gain.

Key words: Japanese Quails, Egg traits, Correlations, Prediction

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INTRODUCTION

The Japanese quail is an additional source of animal protein for human use. They are kept for both commercial and scientific purposes. Abdulraheem, *et al.* (2018) observed that quail production has the potential to become a feasible poultry business enterprise in the Nigerian poultry industry which could be particularly important among small and medium scale poultry producers due to remarkable advantages the bird possess over other poultry birds (Raji*, et al.* 2018). The meat and egg are delicious, noted for high dietary and medicinal values (Thomas *et al.* 2016, Troutman, 2017).

Egg is a biological structure intended by nature for reproduction. It protects and provides complete diets for the developing embryo and serves as the principal source of food for the first few days of the chick's life (Dudusola *et al.* 2019). Egg quality traits determine price directly in commercial flocks and it is usually described in connection with consumer's right requirements (Ukwu *et al.* (2017).Understanding how economic traits, such as egg quality in poultry perform is essential for formulating breeding programs that will further improve production traits based on the needs of the community and stakeholders (Ashenafi, 2023).In order to derive a model for predicting the internal traits of eggs using the external traits, it is necessary to take advantage of the association between the internal and external characteristics of eggs (Ashenafi, 2023).

Aimed at improving egg quality, measurements of the internal and the external egg traits are necessary to provide information on the selection of eggs with good egg shell structure and shape for use as breeding purposes. Hence, this study evaluates genetic parameters on the external and internal egg traits of Japanese quails.

MATERIALS AND METHODS

Experimental Site

The research was conducted at the poultry breeding unit, Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture, University of Uyo, Uyo. Akwa Ibom State, Nigeria. The area is geographically located on latitude 05º02' North and longitude 07º5` East, at an altitude of 38m above sea level. It is a humid environment with a mean annual rainfall ranging from 2000mm to 3000 mm. Uyo has a mean temperature range of between 21.3ºC and 34.5ºC and a relative humidity range of 78%. The relative humidity ranged from 78 to 93%. (NIMET, 2018).

Procurement and Management of experimental birds

One thousand two hundred (1200) freshly laid fertile Japanese quail eggs from two strains of Japanese quails (600 per strain) were procured from the Veterinary Research Institute, VOM, Plateau State, Nigeria.

Hatching: The eggs were incubated in Uyo with model 1520 Sportman digital thermostat–equipped incubator at a temperature of 37.78ºC and humidity range of between 45% and 55% and turning of eggs was at an angle of 45º for 4-6 times a day till the chicks were hatched after 18 days of incubation. The eggs were hatched artificially within 16 to 18 days. A total of 868 day old chicks (400 Panda white, 468 Cinnamon brown) were obtained.

Experimental Diets:

The experimental birds were fed with three types of feed: Chick starter mash with 22% crude protein and metabolizable energy of 3000 Kcal/kg (0 to 3 weeks), grower mash with 15% crude protein (CP) and metabolizable energy (ME) of 2500Kcal/Kg (3 to 6 weeks) and layer mash with 16.8% CP and ME of 2680Kcal/Kg (6 to 12 weeks) Udoh *et al*. (2020). The birds received *adlibitum* feed and water throughout the period of the experiment. The birds were reared in a wooden cage with wire nettings.

Data Collection

Data were obtained from the external and internal egg traits for a period of one month. 120 freshly laid eggs were collected weekly (60/genotype) from 8 weeks of age for four weeks. Altogether 480 eggs were assessed during week 8,9,10 and 11, respectively for laboratory analysis of the both external and internal egg characteristics.

External egg traits

(i) Egg weight (EWT): The eggs were numbered, labeled and weighed on an OH AUS digital electronic scale with sensitivity of 0.01 g.

(ii) Egg length: (ELT) Egg length was measured using a pair of vernier caliper to the nearest 0.01mm.

(iii) Egg width (EWD): The width of the egg was measured using a pair of vernier caliper to the nearest 0.01mm.

(iv) Shell weight (SWT): Eggs were carefully broken and the internal component (yolk and albumen) removed. The eggshells were washed and sun dried for 24 hours. Then the shells were weighed using an OHAUS digital electronic scale with sensitivity of 0.01 g

(v) Shell thickness (STH): The egg shells were collected and oven dried for 24 hours after which a micrometer screw gauge was used to measure the thickness of the shell to the nearest 0.01mm.

Internal egg traits

Yolk length (YKL), Yolk diameter (YKD) and Albumen length (ABL): were measured with vernier caliper to the nearest 0.01mm.

Yolk weight (YWT): The yolk were carefully separated from the albumen by spoon scooping it into a plate and then weighed with an

OHAUS digital electronic scale with a sensitivity of 0.01 g**.**

Albumen Diameter (ABD): was measured with vernier caliper to the nearest 0.01mm.

Haugh unit (HU): This was obtained using the formulae:

Haugh Unit (H.U) = 100log(H+7.57-1.7W0.37)

Where; H.U = Haugh Unit; H = Observed albumen height; W = Observed weight of egg in gram.

Statistical analysis:

Phenotypic correlations: Phenotypic correlations between egg weight and other egg parameters were ascertained with Pearson's product moment correlation coefficient (r) using General statistic software Computer programme.

The model for the correlation is shown as:

$$r = \frac{\sum X_1 Y_1}{\sqrt{\sum X_1^2 - \sum Y_1^2}}$$

Where: r = Pearson's correlation; X1 =First random variable of the ith egg weight or egg traits; Y1= Second random variable of the ith egg weight or egg parameters

Descriptive statistics: Data obtained were analyzed using SPSS Software Computer Programme and means were separated with T-test procedure. The model of the analysis was of the form:

$$Y_{ij} = U + P_i + i_j + e_{ij}$$

Where: Yij = record of the ith individual in the ith measurement period; U =overall mean; Pi = effect of the ithstrain (1, 2); Ij = effect of the ithage (8, 10); eij = random effect

RESULTS AND DISCUSSION

Phenotypic Correlation between the External and the Internal egg traits of Cinnamon brown and Panda White Japanese quails at week 8.

The correlation coefficient in Cinnamon Brown (CB) strain ranged between -0.01 and 0.32, and -0.01 and 0.55 in Panda White (PW) strain which showed very low to medium correlations between the external and the internal egg parameters at week 8 studied (Table 1). The relationship between EWT and ELT (0.11), EWT and EWD (0.10), EWT and YKL (0.15), and EWT and YWT (0.32) in CB, showed positive correlations, while all other traits were negatively correlated at week 8 of the study. ELT of CB eggs positively correlated with EWD (0.08), STH (0.11), SWT (0.06) ABL (0.15), YKL (0.25), and YWT (0.18), but negatively correlated with ABD (-0.12), and YKD (-0.04). EWD positively correlated with STH (0.07), SWT (0.10), ABL (0.08), YKD (0.11), and YWT (0.06), but negatively correlated with ABD (-0.15), and YKL (-0.03). STH correlated positively with SWT (0.14), ABD (0.11), and YKL (0.07), but correlated negatively with ABL (-0.12), YKD (-0.04), and YWT (-0.11). SWT positively correlated with ABL (0.15) YKL (0.05), YKD (0.10), and YWT (0.05), but negatively correlated with ABD (-0.08). ABL correlated positively with YKL (0.17), and YWT (0.27), but negatively correlated with YKD (-0.09). ABD negatively correlated with YKL (-0.19), YKD (-0.02), and YWT (-0.43). YKL positively correlated with YKD (0.02), and YWT (0.19). YKD had positive correlation with YWT (0.26) in CB strain of Japanese quails.

Table 1 shows that the correlation coefficient in PW strain of Japanese quails (above diagonal) ranged between -0.01 and 0.61 which showed very low to moderate correlation trend between the external and the internal egg parameters at week 8 studied. There was a positive correlation between EWT and (ELT (0.37), EWD (0.23), SWT (0.22), ABL (0.01), ABD (0.07) and YKL (0.29) while all other traits were negatively correlated at week 8 of the study. ELT of PW eggs positively correlated with (EWD (0.61), SWT (0.16), YKL (0.27), YKD (0.16) and YWT (0.04), but negatively correlated with STH (-0.10), ABL (-0.04), and ABD (-0.03). EWD positively correlated with SWT (0.08), ABL

(0.04), YKL (0.11), YKD (0.13) and YWT (0.03), but negatively correlated with STH (-0.04) ABD (-0.05). STH positively correlated with ABL (0.01), YKD (0.08), and YWT (0.55), but negatively correlated with SWT (-0.18), ABL (-0.01) and YKL (-0.06). SWT was positively correlated to ABD (0.04), and YKL (0.21) but negatively correlated with ABL (-0.11), YKD (-0.01) and YWT (-0.18). ABL correlated positively with YWT (0.21) but negatively correlated with YKL (-0.03) and YKD (-0.02). ABD positively correlated with YKL (0.14) and YKD (0.00). YKL positively correlated with YWT (0.04) but negatively correlated with YKD (-0.12). YKD showed positive correlation with YWT (0.12).

Table 1: Phenotypic Correlation between external and Internal Egg traits of two strains: Cinnamon Brown (below diagonal) and Panda White Quails (above diagonal) Japanese quail at week 8

	EWT	ELT	EWD	STH	SWT	ABL	ABD	YKL	YKD	YWT
EWT		0.37	0.23	-0.13	0.22	0.01	0.07	0.30	-0.14	-0.06
ELT	0.11		0.61	-0.10	0.16	-0.01	-0.03	0.27	0.16	0.04
EWD	0.10	0.08		-0.04	0.08	0.04	-0.05	0.11	0.13	0.03
STH	-0.01	0.11	0.07		-0.18	0.01	-0.11	-0.06	0.08	0.55
SWT	-0.05	0.06	0.10	0.14		-0.11	0.04	0.21	-0.01	-0.18
ABL	-0.07	0.15	0.08	-0.12	0.15		-0.38	-0.03	-0.02	0.21
ABD	-0.12	-0.24	-0.12	0.11	-0.08	-0.48		0.14	0.00	-0.47
YKL	0.15	0.25	-0.03	0.07	0.05	0.17	-0.19		-0.12	0.04
YKD	-0.02	-0.04	0.11	-0.04	0.10	-0.09	-0.02	0.02		0.12
YWT	0.32^*	0.18	0.06	-0.11	0.05	0.27	-0.43	0.20	0.26	

EWT = egg weight (g), ELT = egg length (mm), EWD = egg width (mm), STH = shell thickness (mm), SWT = Shell Weight (g)

ABL = Albumen length (mm), ABD = Albumen diameter (mm), YKL = Yolk length (mm), YKD = yolk diameter (mm), YWT = yolk weight (g)

The correlation coefficient between egg weight and external egg parameters of panda white strains ranged between -0.11 and 0.61. However, negative relationships were recorded for egg weight (shell thickness, yolk diameter, yolk weight). The relationship between egg weight and egg width was positive (0.23) and weak. Similarly, for other external traits, correlation between egg length and egg width (0.61), egg length and shell weight (0.16), egg width and shell weight (0.08) were all positive in PW strain. While that of CB (below diagonal) as presented in Table 1, showed a correlation coefficient between egg weight and external parameters to range between -0.01 and 0.14. The highest value (0.14) was recorded for shell thickness and shell weight, while the least was -0.01 was recorded for egg weight and shell thickness. On comparing the two strains, panda white strain had the highest correlation coefficient values of -0.11 and 0.61, while cinnamon brown had -0.01 and 0.32 at week 8 studied.

Positive significant correlations were observed between egg weight and egg length (0.37) for panda white in this study at week 8 agrees with the positive correlation (0.823) recorded by Chimezie *et al.* (2017) for brown variety of quails but contradicts with the higher negative significant value of -0.92 reported by Okon *et al.* (2020) for the same traits in quails. However, the relationship between egg weight and shell thickness was negative and non-significant in panda white (-0.13) and in cinnamon brown quails (-0.01). This agrees with the value (-0.616) obtained by

Okon *et al.* (2020) in quails for the same traits though was higher in magnitude, but contradicts the positive values of 0.19 and 0.56 obtained by (Chimezie *et al*. 2017) for the same traits in black and brown quails.

Most of the correlation coefficient obtained for internal egg traits were non-significant (p>0.05) and either positively or negatively low. Egg weight significantly correlated with yolk length (0.30) in panda white strain (Table 1) and this agrees with the value (0.15) reported by Chimezie *et al.* (2017). A moderately negative significant (p<0.05) correlation was obtained between albumen diameter and albumen length (-0.48) at week 8, and this disagrees with the positive significant correlation (0.48) obtained by Chimezie *et al*. (2017) for egg weight and albumen length in quails.

Most of the correlations between egg weight and other egg traits were found to be weak and non-significant at week 8 for egg from both cinnamon brown and panda white strains. Similarly, Olawumi and Christiana (2017) has reported that phenotypic correlations between egg weight and egg length was statistically non-significant (*P*>0.05).

Table 2: Phenotypic Correlation between the external and Internal Egg traits of two strains of Japanese quail: Cinnamon Brow (below diagonal) and Panda White Quails (above diagonal) at week 10

	EWT	ELT	EWD	STH	SWT	ABL	ABD	YKL	YKD	YWT
EWT		0.42	0.31	-0.03	0.43	0.21	-0.13	-0.18	0.26	0.30
ELT	0.85		0.34	-0.15	0.08	-0.11	0.05	0.21	0.22	0.06
EWD	0.26	0.19		-0.15	-0.09	0.04	0.11	0.61	0.09	0.21
STH	0.01	0.14	-0.04		0.31	0.09	0.09	-0.23	0.04	-0.02
SWT	0.32	0.30	0.08	0.02		0.19	-0.12	-0.32	-0.10	-0.29
ABL	0.17	0.17	0.21	-0.47	0.25		-0.37	-0.13	0.05	0.31
ABD	0.21	0.13	0.28	-0.07	-0.07	-0.09		0.10	0.02	-0.10
YKL	0.31	0.40	0.04	0.12	0.18	0.14	-0.12		0.13	-0.32
YKD	0.06	0.18	0.02	0.53	0.12	-0.51	0.09	0.07		0.11
YWT	0.49	0.54	0.15	0.14	0.35	0.05	0.26	0.33	0.24	

*= Correlation is significant at the 0.05 level (2-tailed), ** = Correlation is significant at the 0.01 level (2-tailed), EWT = egg weigh t (g), ELT = egg length (mm), EWD = egg width (mm), STH = shell thickness (mm), SWT = Shell Weight (g)**,** ABL = Albumen length (mm), ABD = Albumen diameter (mm), YKL = Yolk length (mm), YKD = yolk diameter (mm), YWT = yolk weight (g).

The correlation coefficient between egg weight and external parameters of cinnamon brown strain ranged between -0.04 to 0.85 as presented in table 2, whereby 0.85 was the highest value for the relationship between egg weight and egg length and was positive, while the least value was recorded between egg width and shell thickness (-0.04). The correlation between egg length and egg width (0.19), egg length and shell thickness (0.14), egg length and shell weight (0.30), egg width and shell weight (0.08) and shell thickness/shell weight (0.02) were all positive in CB strain. However, for the panda white strains (above diagonal) in Table 2showed a correlation coefficient between egg weight and external parameters to range between -0.02and 0.61. The highest value (0.61) was recorded for egg width and yolk length, while the least was -0.02 was recorded for shell thickness and yolk weight. On comparing the two strains, panda white had the higher correlation coefficient value of -0.02 and 0.61 while cinnamon brown had -0.04 to 0.85 for egg weight and external egg parameters studied at week 10.

The phenotypic correlation obtained for egg weight/egg length of Cinnamon Brown quails in this study for week 8 and 10 (0.11 and 0.85) contradicts the report of Okon *et al.* (2020) who reported a negative and strong relationship between egg weight and egg length (-0.92) in quails. However, the high relationship between egg weight and egg length at week 10 (0.85) which was highly significant was in agreement with the positive values reported by Chimezie *et al.* (2017),and (0.65) reported by Ciftsuren and Akkol (2018), for egg weight and egg length in quails. It was also similar to the positive values of (0.210) egg weight/egg length reported by Ojedapo (2013) but was stronger in magnitude.

The Phenotypic correlation coefficients obtained between yolk length and albumen length in this study was however found to be low and non-significance at week 8 and 10 (0.17 and 0.14), respectively. This contradicts the report of a moderately significant relationship (0.56) reported by Gwaza *et al.* (2017) in chicken eggs.

Prediction of egg weight from external and internal egg traits in Panda white Japanese quails

The result for the prediction of egg weight from external and internal egg traits of Panda white strain of Japanese quails is shown in Table 3. From the model obtained, it was observed that Egg weight was significantly predictable from external egg traits (ELT and EWD) of Panda white strain of Japanese quails. The coefficient of determination showed that the reliability of prediction models ranged between 53.4 % and 91.9%. For the single prediction models, egg length and egg width significantly ($P<0.05$) predicted egg weight as revealed in the model that a unit increase in Egg weight resulted in 4.98 units in egg length whereas egg width increased by 8.24 units for every unit increase in egg weight. EWD and egg length were both fitted into a prediction model with regression coefficients of 5.05 and 4.19, respectively while for the second multiple prediction model where R^2 was highest (91.9%), EWD and ELT recorded regression coefficients of 5.51 and 2.75 each. The intercept for all the prediction models were all negative and ranged between -4.94 and -11.60 (Table 3).

Yolk length, yolk weight and Albumen diameter were reported as single predictors for egg weight in three different models with a regression coefficient of 3.15, 1.27, and -5.47 respectively. However, these predictions equally recoded a low coefficient of determination, (R^2) which ranged between 26.6 and 38.5%. The intercept for all the prediction models were all positive and ranged between 2.67 and 12.36 (Table 3).

Table 3 Prediction of egg weight from external and internal egg traits of Panda white Japanese quails

Using External traits				**Using Internal traits**			
Prediction Equations	R^2 (%)	S.E	Sig.	Prediction Equations	R^2 (%)	S. E	Sig
EWT = -4.94 + 4.98 ELT	53.4	0.54	*	EW T= 2.67 + 3.15 YKL	26.6	0.68	*
EWT = -14.99 + 4.19ELT +5.05EWD	78.5	0.38	*	EWT = 6.06 + 1.27 YWT	38.5	0.65	*
EWT = -9.82 + 8.24 EWD	70.9	0.45	*	EWT = 12.36 - 5.47ABD	26.6	0.65	*
EWT = -11.60+ 5.51EWD+2.75ELT	91.9	0.25	*				

* significant at the 0.05 level ** significant at the 0.01level EWT = egg weight, ELT = egg length. EWD = Egg width, YKL = yolk length, YWT = yolk weight

Prediction of egg weight from external and internal egg traits of Cinnamon brown Japanese quails

The result for the prediction of egg weight from external and internal egg traits of Cinnamon brown of Japanese quail is shown in Table 4. From the model obtained, it was observed that Egg weight was significantly predictable from external and internal egg traits of CB Japanese quails. Shell weight, egg length and egg width were seen as single predictors for egg weight with a prediction equation that has a coefficient of determination that ranged between 48.2% and 86.2% (Table 4). The highest value for coefficient of determination (86.2%) was recorded when egg length was used as a single predictor with a regression coefficient of 8.07. Shell weight and egg width had regression coefficients of 8.82 and 13.93, respectively. The intercepts were all negative and ranged between -1.50 and -24.55.

Yolk weight and albumen length were reported as the internal egg trait predictors of Cinnamon brown egg weight. Yolk weight had a regression coefficient of 1.92 and R^2 of 62.6%; 1.66 and R^2 of 57.7% when fitted as single predictor for egg weight. Similarly, albumen length had a regression coefficient of 0.47 and R^2 of 28.8%. When both yolk weight and albumen length were fitted as predictors for Cinnamon brown egg weight, the multiple prediction models recorded the highest value for Coefficient of determination (71.9%) and it was observed that for every unit increase in egg weight, there was a partial contribution of 1.87 units by YWT and 0.44unit increase in ABL. The intercepts for all the prediction equation were mostly positive apart from when albumen length was used as a single predictor (-7.54) (Table 4).

Table 4 Prediction of egg weight from external and internal egg traits in Cinnamon brown strains of Japanese quails

Using External traits				Using Internal traits			
Prediction Equations	R^2 (%)	S.E	Sig.	Prediction Equations	R^2 (%)	S.E	Sig.
EWT = -1.50 + 8.82 SWT	76.5	0.56	*	EWT = 4.03 + 1.92 YWT	62.6	0.70	**
EWT = -14.57+8.07 ELT	86.2	0.59	**	EWT =1.72 + 1.87 YWT + 0.44 ABL	71.9	0.59	**
EWT = -24.55+13.93EW D	82.0	0.52	**	EWT= 4.32 + 1.66 YWT	57.7	0.54	**
EWT = -4.42+4.71ELT	48.2	0.45	**	EWT = -7.54 + 0.47 ABL	28.8	0.53	*

*.significant at the 0.05 level; **.significant at the 0.01 level; EWT = egg weight, ELT = egg length, EWD = egg weight, SWT = Shell Weight, ABL = Albumen length, YWT = yolk weight.

This study has revealed that prediction equations can be generated for egg weight using internal and external egg traits. External egg traits (such as egg length and egg width) and internal egg traits (such as yolk weight and albumen length) can be fitted into egg weight prediction models either singly or combined with a reasonable level of accuracy. The coefficient of determination obtained in this study for external traits (53.4% to 91.9%) for Panda white and for Cinnamon brown(48.2 to 86.2%) were found to be higher than the range of 8.9 to 81% obtained by Okon *et al.* (2020) when external egg traits were used to predict egg weight.

CONCLUSIONS

- Egg weight is a good determinant of egg shell quality in quails and changes that occurred in the internal egg quality traits of quail eggs.
- Panda White Japanese quail is superior in egg weight and in most egg quality traits measured. The result on correlations suggests that egg weight could be used as an index of egg quality in Japanese quails.
- Egg weights are better predicted using external egg traits than internal egg traits. Selection for improvement using egg weight will result in good performance and significant genetic gain.

RECOMMENDATION

- Due to the strong phenotypic correlations between egg weight and other egg traits, measurements of the internal and external egg traits should be included in a selection index in Japanese quail improvement.

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