Bio-prediction of Egg Weight and Egg Component Parts at Different Ages in Small-sized Japanese Quails using Pre-broken Egg Traits as Regressors

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Abstract

The present study was conducted on eggs of Japanese quail reared on deep litter at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti. Three hundred eggs were randomly selected for the measurement of egg weight (g), egg length (cm) and egg width (cm); and broken to collect data of shell weight (g), albumin weight (g) and yolk weight (g) at different ages. A number of equations were developed to predict the egg weight and post-broken traits from pre-broken traits at the different ages. The prediction equations of egg weight at different ages showed that the associations were significant ($P<0.01$) and positive with adjusted R^2 at 22.1-25.9, 17.1-19.5 and 31.6-36.6% for egg length, egg width and egg length + width respectively. Egg shell weight was predictable with sufficient accuracy ($P<0.01$) from egg weight + egg length (R^2 = 8.1-9.3%); egg weight + egg width (R^2 = 7.7-9.1%) and egg weight + egg length + egg width (R^2 = 8.8-10.1%) across the ages. Egg albumin was predictable ($P<0.01$) from egg weight + egg length (R^2 = 71.5-76.3%); egg weight + egg width (R^2 = 71.9-77.9%) and egg weight + egg length + egg width (R^2 = 73.1-79.3%). The weight of egg yolk was predictable ($P<0.01$) from egg weight, length and width (, R^2 = 69.9-78.2%); from egg weight and width (R^2 = 61.4-66.8%) and from egg weight and length (R^2 = 40.0 to 48.3%). This study showed that *in vivo* prediction based on single trait was not as reliable compared to the use of more than one trait.

Key words: Deep litter, Japanese quail, post-broken, prediction equations,

Introduction

One of the major products of laying birds is the egg which can be used for breeding, sold to augment the farmers' financial needs or eaten to supply cheap and readily available animal protein (Orji *et al.*, 1998; Khurshid *et al.*, 2003). The main components of an egg are shell, albumin and yolk (Abanikanda and Leigh, 2007) which exist in varying proportions among the different poultry species. However, the important traits that are measurable in avian eggs include the egg weight, width and length; shell weight, thickness and strength; albumin weight and height; and yolk weight and height. The egg weight, width and length are usually determined before breaking the eggs while information on the other traits can only be obtained after breaking the egg. Broken eggs are not useful, so it is imperative to develop some prediction equations that could provide information on shell weight, yolk weight and albumin weight without breaking eggs.

Information on egg weight along with egg width and length will further open the domain for trying out various prediction equations in order to determine the post-broken traits of eggs. Egg weight was easily predictable from egg length and width because of the positive association among these traits (Farooq *et al.*, 2001). The egg weight is an important trait which influences egg quality as well as grading (Farooq *et al.*, 2001) while the shell, though non-edible, serves as a protective medium for the edible internal components- the albumen and yolk. The yolk contains all the fat and most of the vitamins in the egg while the albumin contains all the protein. Egg length is the long border of an egg while the egg width is the short border because the length predominate the width.

The relationship existing among these egg component traits can be exploited for genetic improvement strategies. The *in vivo* prediction based on single trait has been challenged because of its unreliability compared to the use of more than one trait (Raji *et al.*, 2009). It is, therefore, the aim of this study to provide information on the relationships between egg weight, shell, albumin and yolk weights and how these traits can be used singly and jointly in accurate predictions.

Materials and Methods

This study was carried out at the Aviary Unit, Teaching and Research Farm, of Ekiti State University, Ado-Ekiti. The eggs were collected from one hundred layers of Japanese quails at 8.00 am and 5.00 pm daily at week 6, 10, 14, 18, 22, 26, 30, 34, 38, 42 and 46 of age. Three hundred eggs were randomly selected to measure the egg weight (g), egg length (cm), egg width (cm); and broken to determine the shell weight (g), albumin weight (g) and yolk weight (g) at the different ages. The egg weight was determined using a digital scale sensitive to 0.01 g by gently placing the whole egg on the flat surface of the scale. Measurements of the internal components were obtained by carefully making an opening around the sharp end of the egg, large enough to allow passage of both the albumin and the yolk through it without mixing their contents together. The yolk was carefully separated from the albumen and the weights determined on wet basis. Regression analysis of the traits was carried out at different ages using SPSS version 18, 25 statistical packages.

The following model was used for prediction of egg weight, shell weight, albumin and yolk weights using egg length, width and egg weight as independent variables in different cases:

$$\hat{Y} = ß_0 + ß_1SW + ß_2AW + ß_3YW + e$$

where, $\hat{Y}$ is the response variable,
ß is the intercept,
$ß_1$, $ß_2$, $ß_3$ are the partial regression coefficients,
SW, AW and YW are shell weight, albumen weight and yolk weight, respectively
e is the residual term.

Results and Discussion

Prediction of egg weight from egg length and width

The prediction equations of egg weight from egg length, egg width and egg length + egg width at different ages in small-sized Japanese quails are presented in Table 1. The association of egg length and width singly and jointly with egg weight was significant ($P<0.01$) and positive similar to results obtained by Farooq *et al.* (2001) such that egg weight was predictable with sufficient accuracy. The ranges of adjusted R^2 values for egg length, egg width and egg length + width as predictors of egg weight are 22.1-25.9%, 17.1-19.5% and 31.6-36.6% of the fitted models across the ages, respectively. The range of values obtained in this study agrees with the 23.13%, 17.81% and 31.86% reported by

Khurshid *et al*. (2003) for egg length, egg width and egg length + egg width, respectively and the R^2 of 21.10% for egg length and 16.82% for egg width reported by Fajemilehin (2008). Comparing the R^2 values of the predictors, it is clear that using the two traits jointly gave higher accuracy than using the traits singly as reported by Raji *et al*. (2009) that *in vivo* prediction based on single trait is not as reliable compared to the use of more than one trait. However, any one of the equations in the table can be used for predicting egg weight from egg length at the equivalent age.

Predicting shell weight from egg weight, length and width

The shell weight cannot be accurately known until the egg is broken and the internal contents which include the thin membrane, albumin and yolk are removed. Nevertheless, prediction equations can be developed to obtain information about this trait pre-broken. Table 2 shows the prediction equations of egg shell weight from egg weight, egg length and egg width at different ages in small-sized Japanese quails.

Table 1: Prediction equations of egg weight (µ) from egg length (y_1) and egg width (y_2) at different ages in small-sized Japanese quails

	Egg length (y_1)	R^2 (%)	Egg width (y_2)	R^2 (%)	Egg length + Egg width	R^2 (%)
Wk 6	= 7.447 + 0.986(y_1)	23.2	= 4.940 + 0.774(y_2)	16.5	= 8.027 + 1.104(y_1) - 0.143(y_2)	34.6
Wk 10	= 4.172 + 0.935 (y_1)	23.3	= 5.688 + 0. 830 (y_2)	18.6	= 4.122 + 0.726(y_1) + 0.273 (y_2)	31.6
Wk 14	= 3.424 + 0.923 (y_1)	25.4	= 3.891 + 0.577(y_2)	17.1	= 6.290 + 1.484 (y_1) - 0. 668 (y_2)	36.6
Wk 18	= 6.117 + 0. 614(y_1)	25.9	= 8.228 + 0. 204(y_2)	17.8	= 9.334 + 2.170(y_1) - 1.738(y_2)	35.5
Wk 22	= 7.169 + 0. 322(y_1)	23.5	= 4.687 + 0.525(y_2)	19.5	= 4.172 - 0.744(y_1) + 1.191(y_2)	32.8
Wk 26	= 5.372 + 0.989(y_1)	22.1	= 4.717 + 0.593(y_2)	18.6	= 5.537 + 1.007(y_1) - 0.029(y_2)	35.7
Wk 30	= -14.797 + 0.564(y_1)	23.0	= -44.084 + 0.565(y_2)	19.3	= -31.528 + 0.282(y_1) + 0.304(y_2)	33.8
Wk 34	= 0.585 + 0.569(y_1)	25.8	= 9.209 + 0.062(y_2)	17.8	= -0.061 + 1.491(y_1) - 1.142(y_2)	35.3
Wk 38	= -85.500 + 0.967(y_1)	22.4	= 75.938 - 7.022(y_2)	18.1	= -73.232 + 0.898(y_1) - 0.075(y_2)	34.2
Wk 42	= -3.259 + 0.961(y_1)	23.9	= 1.683 + 0.692(y_2)	18.5	= -4.164 + 0.840(y_1) + 0.212(y_2)	32.9
Wk 46	= -17.266 + 0.855(y_1)	24.2	= -8.583 + 0.666(y_2)	18.8	= -19.852 + 0.705(y_1) + 0.263(y_2)	32.6

Eggshell weight was predictable with sufficient accuracy from egg weight + egg length ($P<0.01$, R^2 = 8.1-9.3%); egg weight + egg width ($P<0.01$, R^2 = 7.7-9.1%) and egg weight + egg length + egg width ($P<0.01$, R^2 = 8.8-10.1%) across the ages. The result agrees with the findings of Fajemilehin (2008) who obtained negative association between egg weight and shell weight and positive associations with egg length and width with R^2 of 8.8% when the three traits were used as regressors and 7.4%, 8.2% and 8.4% respectively when egg length, egg width and egg weight were used singly as a regressor in helmeted guinea fowl. However, the R^2 values obtained in this study are higher than the R^2 of 7.1-7.85% reported by Khurshid *et al*. (2003) in Japanese quails.

Predicting weight of egg albumin from egg weight, egg length and egg width

Table 3 shows the prediction equations of egg albumin weight from egg weight, egg length and egg width at different ages in small-sized Japanese quails. The weight of egg albumin was predictable from egg weight + egg length ($p<0.01$, R^2 = 71.5-76.3%); egg weight + egg width ($P<0.01$, R^2 = 71.9-77.9%) and egg weight + egg length + egg width ($P<0.01$, R^2 = 73.1-79.3%) with enough accuracy. The result agrees with the findings of Khurshid *et al*. (2003) who noted that weight of egg albumin was predicted from egg weight + egg width ($p<0.01$, $R^2 = 72.75\%$); egg weight + egg length ($P<0.01$, $R^2 = 72.24\%$) and egg weight + egg length + egg width ($P<0.01$, $R^2 = 72.71\%$).

Table 2: Prediction equations of egg shell weight (μ_1) from egg weight (y_3), egg length (y_1) and egg width (y_2) at different ages in small-sized Japanese quails

	Egg weight (y_3)+length	R^2 (%)	Egg weight (y_3)+width (y_2)	R^2 (%)	Egg weight (y_3) + length (y_3) + width (y_3)	R^2 (%)
Wk 6	$_1$ = 37.211- 4.779(y_3) + 4.458(y_1)	8.8	$_1$ = 6.92 - 1.458(y_3) + 1.386(y_2)	8.7	$_1$ = 20.642 - 3.129(y_3) + 1.945(y_1) + 1.058(y_2)	9.5
Wk 10	$_1$ = 4.482-0. 984(y_3) + 0. 624 (y_1)	8.1	$_1$ = 5.997 -1.557(y_3) + 1.393(y_2)	7.7	$_1$ = 7.377--2.258(y_3) + 0. 730(y_1) + 1.415(y_2)	9.0
Wk 14	$_1$ = 5.489 - 0.429(y_3) - 1.114(y_1)	8.6	$_1$ = 10.407 - 0.400(y_3) -0.346(y_2)	8.0	$_1$ = -33.787 + 5.170 (y_3) - 8.461(y_1) + 3.538 (y_2)	8.8
Wk 18	$_1$ = 1.802 - 0.408(y_3) + .572(y_1)	8.6	$_1$ = -0.088 -0.139(y_3) + 0.405(y_2)	8.0	$_1$ = 35.644 - 4.447(y_3) + 9.575(y_1) -7.287(y_2)	9.2
Wk 22	$_1$ = 8917.644 -0.403(y_3) - 0.747(y_1)	8.9	$_1$ = 9142.523 -0.198(y_3) - 0.848(y_2)	7.1	$_1$ = 9218.540 - 0.263(y_3) -0.317(y_1) - 0.530(y_2)	9.1
Wk 26	$_1$ = 9.684 -4.750(y_3) + 4.032(y_1)	8.4	$_1$ = 3.312 - 0.914(y_3) + 0.253(y_2)	7.9	$_1$ = 9.498 - 4.699(y_3) + 3.943(y_1) + 0.063(y_2)	9.8
Wk 30	$_1$ = 1.128 - 0.819(y_3) + 0.229(y_1)	7.3	$_1$ = 2.202 - 0.666(y_3) - 0.042(y_2)	7.6	$_1$ = 6.810 - 0.743(y_3) + 1.284(y_1) - 1.187(y_2)	10.1
Wk 34	$_1$ = 12.328 - 0.142(y_3) - 0.898(y_1)	8.4	$_1$ = 11.581 -0.609(y_3) - 0.711(y_2)	8.9	$_1$ = 12.309 - 0.216(y_3) - 0.754(y_1) -0.126(y_2)	9.5
Wk 38	$_1$ = 2.499 + 1.238(y_3) - 0.258(y_1)	9.3	$_1$ = -2.159 + 1.299(y_3) + 0.344(y_2)	9.1	$_1$ = -2.159 + 1.299(y_3) + 0.344(y_2)	9.2
Wk 42	$_1$ = -6.151 - 2.402(y_3) + 2.309(y_1)	8.5	$_1$ = 2.633 -0.235(y_3) + 0.077(y_2)	7.8	$_1$ = -12.379 - 3.591(y_3) + 3.090(y_1) + 0.632(y_2)	9.2
Wk 46	$_1$ = 7.378 - 0.431(y_3) -0.602(y_1)	8.2	$_1$ = 4.407 - 0.869(y_3) -0.115(y_2)	8.5	$_1$ = 7.986 - 0.357(y_3) - 0.601(y_1) -0.112(y_2)	9.2

Table 3: Prediction equations of albumin weight (µ) from pre-broken traits singly and jointly at different ages in small-sized Japanese quails

	Egg weight (y_3) + length (y_1)	R^2 (%)	Egg weight (y_3) + width (y_2)	R^2 (%)	Egg weight (y_3) + length (y_3) + width (y_3)	R^2 (%)
Wk 6	$_3$ = 69.89 - 4.839(y_3) + 4.602(y_1)	73	$_3$ = 14.357 - 1.411(y_3) + 1.431(y_2)	72.6	$_3$ = 39.513 - 3.137(y_3) + 2.017(y_1) + 1.092(y_2)	73.1
Wk 10	$_3$ = 10.411- 0. 680(y_3) + 0.680(y_1)	73	$_3$ = 15.900 - 1.304(y_3) + 1.519(y_2)	73.8	$_3$ = 20.906 - 2.069 (y_3) + 0. 796 (y_1) + 1.543(y_2)	79.1
Wk 14	$_3$ = 12.211 - 1.594(y_3) + 0. 709(y_1)	71.5	$_3$ = 10.440 - 1.304(y_3) + 0. 283(y_2)	77.3	$_3$ = 17.415 - 2.825(y_3) + 2.615(y_1) - 0.918(y_2)	73.5
Wk 18	$_3$ = -5.450 - 0.167(y_3) + 1.022(y_1)	72.4	$_3$ = -16.853 + 0.286(y_3) + 0. 853(y_2)	71.9	$_3$ = -63.504 + 2.239(y_3) - 4.339(y_1) + 4.339(y_2)	79.1
Wk 22	$_3$ = 15.450 - 0.196(y_3) + 0.884(y_1)	76.3	$_3$ = 15.040 - 0.031(y_3) - 0. 856(y_2)	72.5	$_3$ = 15.340 - 0.238(y_3) - 1.011(y_1) + 0.157(y_2)	73.9
Wk 26	$_3$ = 8.258 - 1.157(y_3) + 1.497(y_1)	73.2	$_3$ = 4.839 + 0.763(y_3) - 0. 741(y_2)	77.9	$_3$ = 13.419 - 1.862(y_3) + 2.734(y_1) - 0.873(y_2)	74.3
Wk 30	$_3$ = 3.224 + 0.550(y_3) + 0.471(y_1)	73.3	$_3$ = -0.248 + 0.458(Y_3) + 0.633(y_2)	77.5	$_3$ = -1.907 + 0.485(y_3) -0.443(Y_1) + 1.028(y_2)	76.2
Wk 34	$_3$ = 10.793 + 0.912(y_3) - 0.776(y_1)	75.8	$_3$ = 12.678 + 0.520(y_3) - 0.806(y_2)	73.8	$_3$ = 10.257 - 0.129(Y_3) + 1.249(Y_1) - 1.775(Y_2)	76.3
Wk 38	$_3$ = -20.548 -1.486(y_3) + 1.776(y_1)	74.5	$_3$ = 34.248 - 1.701(y_3) - 2.143(y_2)	72.1	$_3$ = 30.478 - 1.854(y_3) + 0.208(y_1) - 2.088(y_2)	75.1
Wk 42	$_3$ = 11.696 - 2.162(y_3) + 1.421(y_1)	75.4	$_3$ = 27.150 - 0.829(y_3) + 0.047(y_2)	77.0	$_3$ = 0.739 -2.894(Y_3) + 1.902(Y_1) + 0.389(Y_2)	79.3
Wk 46	$_3$ = -1.161 - 1.356(y_3) + 0.690(y_1)	72.9	$_3$ = 8.023 - 0.930(y_3) + 0.246(y_2)	74.0	$_3$ = -5.516 - 1.516(Y_3) + 0.688(y_1) + 0.243(y_2)	71

Table 4: Prediction equations of yolk weight (μ_4) from pre-broken traits at different ages in small-sized Japanese quails

	Egg weight (y_3) + length (y_1)	R^2 (%)	Egg weight (y_3) + width (y_2)	R^2 (%)	Egg weight (y_3) + length (y_3) + width (y_3)	R^2 (%)
Wk 6	$_4 = 53.060 - 4.822(y_3) + 4.554(y_1)$	40.30	$_4 = 10.149 -1.429(y_3) + 1.416(y_2)$	62.9	$_4 = 29.588 - 3.137(y_3) + 1.996(y_1) + 1.080(y_2)$	73.2
Wk 10	$_4 = -1.720 + 0.901(y_3) - 0.938(y_1)$	47.90	$_4 = -3.869 + 1.162(y_3) - 1.370(y_2)$	66.80	$_4 = -8.608+2.163(y_3) - 1.043(y_1) - 1.402(y_2)$	72.3
Wk 14	$_4 = 11.456 - 1.621(y_3) + 1.177(y_1)$	42.1	$_4 = 6.785 - 0.745(y_3) + 0.366(y_2)$	65.1	$_4 = 48.769 - 6.632 (y_3) + 8.942(y_1) - 3.739(y_2)$	69.9
Wk 18	$_4 = 6.254 - 0.917(y_3) - 0.119 (y_1)$	47.8	$_4 = 6.422 - 0.972(y_3) -0.090(y_2)$	67.6	$_4 = 4.879 - 0.505(y_3) - 1.037(y_1) + 0.742(y_2)$	77.1
Wk 22	$_4 = 0.831 + 0.966(y_3) - 0.487(y_1)$	43.3	$_4 = 0.485 + 0.969(y_3) - 0.305(y_2)$	64.3	$_4 = 0.608 + 0.709(y_3) -1.275(y_1) + 0.974(y_2)$	78.2
Wk 26	$_4 = 21.605 - 6.103(y_3) - 6.231(y_1)$	42.3	$_4 = 1.909 -0.174(y_3) + 0.392(y_2)$	62.4	$_4 = 21.030 - 6.024(y_3) + 6.093(y_1) + 0.097(y_2)$	77
Wk 30	$_4 = -0.138 -0.381(y_3) + 1.013(y_1)$	47.3	$_4 = -3.011- 0.295(y_3) + 0.858(y_2)$	64.4	$_4 = 0.780 - 0.367(y_3) + 1.208(y_1) - 0.219(y_2)$	72.6
Wk 34	$_4 = -1.574 + 0.222(y_3) + 0.845(y_1)$	45.1	$_4 = -1.227 + 0.661(y_3) + 0.652(y_2)$	63.3	$_4 = -1.57 + 0.209(Y_3)+0.871(Y_1) -0.023(Y_2)$	70.3
Wk 38	$_4 = 0.783 - 1.522(y_3) + 0.606(y_1)$	40	$_4 = 6.711 - 1.664(y_3) - 0.808(y_2)$	62.6	$_4 = 6.711 - 1.664(y_3) - 0.808(y_2)$	73.2
Wk 42	$_4 = -39.842 -0.022(y_3) + 0.881(y_1)$	47.8	$_4 = -17.572 + 1.166(y_3) - 0.493(y_2)$	61.4	$_4 = -23.925 + 0.788(y_3) + 0.348(y_1) - 0.431(y_2)$	75.7
Wk 46	$_4 = -6.252 -0.514(y_3) + 1.289(y_1)$	48.3	$_4 = -0.154 + 0.392(y_3) + 0.294(y_2)$	61.4	$_4 = -7.815 - 0.705(y_3) + 1.286(y_1) + 0.288(y_2)$	75.2

Predicting weight of egg yolk from egg weight, length and width

Table 4 shows that the weight of egg yolk was predictable with from egg weight, length and width (P<0.01, R^2 = 69.9-78.2%); from egg weight and width (P<0.01, R^2 = 61.4-66.8%); and from egg weight and length (P<0.01, R^2 = 40.0 to 48.3%). This result is similar to the report by Khurshid *et al*. (2003) using egg weight and width to predict the weight of egg yolk.

Conclusion

1. Egg length and width can individually be used for prediction of egg weight but the prediction was better when egg length and width were used as regressors.
2. Each of albumin and yolk weight was predictable with enough accuracy from egg weight, length and width.
3. Also, egg shell weight was predictable with enough accuracy from egg weight, length and width.
4. Using the predictors jointly was more accurate in predictions compared to using them individually

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