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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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Predicting Egg Weight, Shell Weight, Shell Thickness and Hatching Chick Weight of Japanese Quails Using Various Egg Traits as Regressors

Khurshid. A., M. Farooq, F. R. Durrani, K. Sarbiland and N. Chand
Department of Poultry Science, NWFP, Agricultural University, Peshawar, Pakistan
Email: durraniff@yahoo.com

Abstract: The present study was conducted on eggs of Japanese quail maintained in cages at the research unit, NWFP, Agricultural University, Peshawar, Pakistan. Five hundred eggs selected at random were broken to record data on egg weight (g), egg length (cm), egg width (cm), shell weight (g) and shell thickness (mm). Another 500 eggs were put in the incubator after discarding undesirable eggs and recording data on egg weight, egg length and egg width. Egg weight was better predictable from egg width and length. Following equations were developed to predict egg weight from egg length and width; (Equation 1) $\hat{Y} = -3.3133600 + 1.835144(X_1) + 2.655127(X_2)$, (Equation 2) $\hat{Y} = 1.970096 + 2.252730(X_3)$ and (Equation 3) $\hat{Y} = -1.0109318 + 3.616882(X_4)$. Where; "$\hat{Y}$" was predicted egg weight, X_1 and X_3 the egg length and X_2 and X_4 the egg width for every equation separately. Following equations were developed for predicting eggshell weight from egg weight, length and width; (Equation 4) $\hat{Y} = -0.521102 + 0.310761(X_5) + 0.4074\ (X_6)$, (Equation 5) $\hat{Y} = 0.138189 + 0.062933(X_7) + 0.233078(X_8)$ and (Equation 6) $\hat{Y} = -0.001150 + 0.071568(X_9) + 0.311496(X_{10})$. Where $\hat{Y}$ was predicted eggshell weight, X_5 and X_8 were egg length, X_6 and X_{10} are egg width and X_7 and X_9 were egg weight (g), respectively. Shell thickness was predictable with sufficient accuracy from egg weight, width and length and following equations were developed to predict it; (Equation 7) $\hat{Y} = 0.154646 + 0.076448(X_{11})$ and (Equation 8) $\hat{Y} = 0.154721 + 0.000694(X_{12}) + 0.073939(X_{13})$. Where "$\hat{Y}$" was predicted eggshell thickness, X_{11} and X_{13} the egg width and X_{12} the egg weight for each equation separately. Weight of egg albumin was predictable from the following equations; (Equation 9) $\hat{Y} = -0.685557 + 0.460613(X_{14}) + 0.079842(X_{15}) + 0.412241(X_{16})$, (Equation 10) $\hat{Y} = -0.553150 + 0.468198(X_{17}) + 0.426649(X_{18})$, (Equation 11) $\hat{Y} = 0.279557 + 0.468198(X_{19})$ and (Equation 12) $\hat{Y} = -2.128934 + 0.925133(X_{20}) + 1.63522(X_{21})$. Where "$\hat{Y}$" was the predicted weight of egg albumin, X_{14}, X_{17} and X_{19} the egg weight, X_{15} and X_{20} the egg length in cm and X_{16}, X_{18} and X_{21} the egg width in cm for each equation separately. Weight of egg yolk could be predicted from the following equations; (Equation 13) $\hat{Y} = -0.618041 + 0.339520(X_{22}) + 0.156591(X_{23})$, (Equation 14) $\hat{Y} = -0.303204 + 0.355813(X_{24})$, (Equation 15) $\hat{Y} = 0.003214 + 1.141682(X_{25})$ and (Equation 16) $\hat{Y} = 0.050845 + 0.921437(X_{26})$. Where, $\hat{Y}$ was predicted weight of egg yolk, X_{22} and X_{24} were the egg weight in grams, X_{23} and X_{25} the egg width in cm and X_{26} the egg length in cm for each equation separately. Weight of the newborn chick was better predictable from egg weight, width, length and egg shape index (equation 17). $\hat{Y} = -5.558612 + 0.629504(X_{27}) - 0.839306(X_{28}) + 1.246874(X_{29}) + 0.050482(X_{30})$. Where; "$\hat{Y}$" will be the predicted weight of the new born chick, "X_{27}" the egg weight, "X_{28}" the egg width, "X_{29}" the egg length and "X_{30}" the egg shape index. The equations developed for each trait are to be used in the order given to ensure better accuracy of the results.

Key words: Chick weight, egg weight, egg length and width, shell weight and shell thickness

Introduction

Egg weight, shell weight, shell thickness, weight of egg yolk and albumin are the important egg traits influencing egg quality, weight of the newly hatched chicks and hatching performance if other management conditions and fertility are not the limiting factors. Farooq *et al.* (2001) also reported significant effect of egg weight on hatch ability and weight of the newly hatched chick in Japanese quails. Hatching chick weight was reported to be 68.21% (Murad *et al.*, 2001) and 62-76% (Wilson, 1993) of the initial egg weight. Shell weight and thickness have also been reported to affect hatch ability of eggs (Murad *et al.*, 2001). Among the aforementioned traits, egg weight is the only parameters which could be determined before setting eggs for hatching, while information on rest parameters are not possible as these are usually determined after breaking egg. Broken eggs can't be used for hatching; thus, it is imperative to develop some prediction equations that could provide information on shell weight, shell thickness and weight of egg yolk and albumin without breaking eggs. Egg weight was easily predictable from egg length and width as positive association among these traits existed (Farooq *et al.*, 2001a). Information on egg weight along with egg width and length will further open the domain for trying out various prediction equations in order to predict eggshell weight and shell thickness. Positive correlations between egg weight, shell weight and shell

thickness has also been reported by Farooq *et al.* (2001). This provides an indication for better prediction of egg shell weight and thickness from egg weight, width and length.

Prediction of chick weight prior to incubation is the pre-requisite of breed improvement program. Narkhede *et al.* (1981) reported positive correlation (r=0.83) of egg weight with weight of the newborn chick. Positive association of hatching chick weight with egg weight has also been reported by Farooq *et al.* (2001b). Wilson (1993) reported chick weight to be 68% of the initial egg weight. However, wide variability could be found in loss in egg content during incubation if eggs are having variable length and width. Egg length and width would also influence weight of the newborn chick. Farooq *et al.* (2001a) reported a positive correlation of hatching chick weight with length (r=0.0.58) and width (r=0.78) of the egg in chickens maintained under backyard conditions. Thus, knowing weight of the new born chick well in advance will help the policy makers to make decisions at an earlier instance before the eggs are set in the incubator. Indicators for prediction of hatching chick weight will be egg weight, length and width. The present study would therefore, be an effort to predicting egg weight, shell weight, shell thickness, weight of egg yolk and albumin and hatching chick weight using various egg traits as independent variables.

Materials and Methods

The present study was conducted on eggs of Japanese quail maintained in cages at the research unit, NWFP, Agricultural University, Peshawar, Pakistan. Five hundred randomly selected eggs were broken to record data on egg weight (g), egg length (cm), egg width (cm), shell weight (g) and shell thickness (mm). Another 500 eggs were put in the incubator after discarding undesirable eggs and recording data on egg weight, egg length and egg width. Each egg was given a unique number prior to putting it in incubator and for each egg a separate compartment was available in the Hatcher to facilitate data on individual basis. Data on shell weight, hatching chick weight and shell thickness of the eggs used for incubation were recorded when hatching process was over. Egg shape index was calculated using the following definition given by Panda (1996).

$$\text{Egg shape index} = \frac{\text{Egg width}}{\text{Egg length}} \times 100$$

Following model was used for prediction of egg weight, shell weight and shell thickness, using egg length, width and egg weight as independent variables in different cases;

$$\hat{Y} = b_0 + b_1X_1 + e_i$$

Where, "$\hat{Y}$" was response variable, "b_0" the intercept, "b_i" the partial regression coefficients, "X_i" the regressors, and "e_i" the residual term (Wonnacott and Wonnacott, 1985).

A similar model was used for predicting weight of the newborn chick using egg weight, length, width and egg shape index as independent variables.

Results and Discussion

Prediction of egg weight from egg length and width: Egg weight was predictable with sufficient accuracy from egg width and length as association of both traits with weight of the egg was significant (P=0.0001). Coefficient of multiple determinations (Adjusted R^2) of the fitted model was 31.86%. Farooq *et al.* (2001a) also reported significant and positive association of egg weight with egg length and width of Fayumi eggs. Following equation was developed for predicting egg weight from egg length and width,

$$\hat{Y} = -3.3133600 + 1.835144(X_1) + 2.655127(X_2) \text{ ------(1)}$$

Where; "$\hat{Y}$" will be predicted egg weight, "X_1" the egg length and "X_2" the egg width.

Egg weight was also better predictable (P=0.0001) from egg length and width one by one. Adjusted R^2 of the fitted model was 23.13% for equation 2 and 17.81% for equation 3. Any one of the following two equations can be used for predicting egg weight from egg length (equation 2) or egg width (equation 3);

$$\hat{Y} = 1.970096 + 2.252730(X_3) \text{ --------(2)}$$

$$\hat{Y} = -1.0109318 + 3.616882(X_4) \text{ ---- (3)}$$

Where; "$\hat{Y}$" will be predicted egg weight, "X_3" the egg length (cm) equation 2 and "X_4" the egg width (cm) for equation 3.

Predicting shell weight from egg weight, length and width: Shell weight and thickness are the two important egg traits that can't be exactly predetermined until and unless eggs are broken. However, prediction equations can be developed to get information about these traits without breaking eggs. Egg shell weight was found significantly (P<0.01) and positively associated with egg length (b=0.310761±0.0985) and width (b=0.4074±0.1797) providing a good ground for predicting egg shell weight from the aforementioned traits. Adjusted R^2 of the fitted model was 7.01%. Following equation can be effectively used for predicting eggshell weight from egg length and width;

$$\hat{Y} = -0.521102 + 0.310761(X_5) + 0.4074\ (X_6) \text{ ----------(4)}$$

Where $\hat{Y}$ will be predicted eggshell weight and X_5 and X_6, the respective measurements of egg length and width in cm.

Eggshell weight was also predictable with sufficient accuracy from egg weight and length (equation 5; P<0.01 and Adjusted R^2 = 7.85%) and egg weight and width (equation 6; P<0.01; Adjusted R^2 = 7.10%). Any one of the given equations can be used for predicting eggshell weight from egg weight and length or egg weight and width.

$$\hat{Y} = 0.138189 + 0.062933\ (X_7) + 0.233078(X_8) \text{ --------(5)}$$

$\hat{Y}$ =-0.001150+0.071568(X_9) +0.311496(X_{10}) ----------(6)
Where $\hat{Y}$ will be predicted eggshell weight and X_7 and X_9, the egg weight (g) and X_8 and X_{10}, are respective values of egg length and width in cm for each equation separately.

Predicting eggshell thickness from egg weight, length and width: Shell thickness was predictable with sufficient accuracy (P=0.0006) from egg width (Equation 7). Adjusted R^2 of the fitted model was 4.20%. Farooq *et al*. (2001a) and GulNawaz (2002) also reported significant association of shell thickness with egg width. Following equation was developed for predicting shell thickness from egg width;

$\hat{Y}$ = 0.154646 + 0.076448(X_{11}) ----------(7)

Where "$\hat{Y}$" will be the predicted eggshell thickness, "X_{11}" the egg width in cm.
Eggshell thickness can also be predicted from egg weight and width (P<0.01). The adjusted R^2 of the fitted model was 3.840%. Following equation was developed for predicting shell thickness from egg weight and width;
$\hat{Y}$ = 0.154721 + 0.000694(X_{12}) + 0.073939(X_{13}) -------(8)
Where "$\hat{Y}$" will be predicted shell thickness, "X_{12}" the egg weight (g) and "X_{13}" the egg width in cm.

Predicting weight of egg albumin from egg weight, length and width: Weight of egg albumin was predictable with enough accuracy (P<0.01; Adjusted R^2 = 72.71%; equation 9) from egg weight, length and width. Following equation was developed to predict weight of egg albumin from egg weight, width and length.
$\hat{Y}$ = -0.685557 + 0.460613(X_{14}) + 0.079842(X_{15}) + 0.412241(X_{16}) ---------- (9)
Where "$\hat{Y}$" will be the predicted weight of egg albumin, "X_{14}" the egg weight in grams, "X_{15}" the egg length in cm and "X_{16}" the egg width in cm.
Weight of egg albumin can also be predicted from egg weight and width (p<0.01; Adjusted R^2 = 72.75%). Following equation was developed for predicting weight of egg albumin from egg weight and width;
$\hat{Y}$ = -0.553150 + 0.468198(X_{17}) + 0.426649(X_{18}) ------(10)
Where "$\hat{Y}$" will be predicted weight of egg albumin, "X_{17}" the egg weight in grams and "X_{18}" the egg width in cm.
Weight of egg albumin was also predictable from egg weight (P<0.01 and Adjusted R^2 = 72.24%; equation 11) and or egg length and width (P<0.01 and Adjusted R^2 = 29.19; equation 12). Following two equations were developed for predicting weight of egg albumin from egg weight or egg length and width.

$\hat{Y}$ = 0.279557 + 0.468198(X_{19}) ---------(11)

$\hat{Y}$ = -2.128934 + 0.925133(X_{20}) + 1.63522(X_{21}) --(12)

Where "$\hat{Y}$" will be predicted weight of egg albumin, "X_{19}" the egg weight in grams for equation 11 and "X_{20}" the egg length and "X_{21}" the egg width in cm for equation 12.

Predicting weight of egg yolk from egg weight, length and width: Weight of egg yolk was predictable with better accuracy (P<0.01; Adjusted R^2 = 60.80%; equation 13) from egg weight and width.
$\hat{Y}$ = -0.618041 + 0.339520(X_{22}) + 0.156591(X_{23}) -----(13)
Where "$\hat{Y}$" will be the predicted weight of egg yolk, "X_{22}" the egg weight in grams and "X_{23}" the egg width in cm.
Weight of egg yolk can also be predicted from egg weight (p<0.01 and Adjusted R^2 = 60.54%; equation 14).

$\hat{Y}$ = -0.303204 + 0.355813(X_{24}) -------(14)

Where "$\hat{Y}$" will be predicted weight of egg yolk and "X_{24}" the egg weight in grams.
Weight of egg yolk can also be predicted from egg width (P<0.01 and Adjusted R^2 = 8.3%; equation 15) and or egg length (P<0.01 and Adjusted R^2 = 18.48; equation 16). Following two equations were developed for predicting weight of egg yolk from egg width or egg length.

$\hat{Y}$ = 0.003214 + 1.141682(X_{25}) --------(15)

$\hat{Y}$ = 0.050845 + 0.921437(X_{26}) ---------(16)

Where "$\hat{Y}$" will be predicted weight of egg yolk, "X_{25}" the egg width in cm for equation 15 and "X_{26}" the egg length in cm for equation 16.

Predicting weight of the newborn chick from egg weight, length and width: Weight of the newborn chick is an important indicator of the delivered body weight at later stages of life. Its significance is more in meat type birds where an accelerated growth and higher delivered body weight is required. Similarly, study of body weight traits in a breeding program is also influenced by weight of the newborn chick. Thus, keeping in view the importance of the weight of the newborn chick its prediction before eggs are set was necessary. Weight of the newborn chick was better predictable (p<0.01; adjusted R^2= 52.54%) from egg weight, width, egg length and egg shape index (equation 17).
$\hat{Y}$ = -5.558612 + 0.629504(X_{27}) - 0.839306(X_{28}) + 1.246874(X_{29}) + 0.050482(X_{30}) -------(17)
Where; "$\hat{Y}$" will be the predicted weight of the new born chick, "X_{27}" the egg weight, "X_{28}" the egg width, "X_{29}" the egg length and "X_{30}" the egg shape index.

Conclusions and recommendations:

1 Egg weight was better predictable when egg length and width were used as regressors, however, egg length and width could individually be used for prediction of egg weight.
2. Weight of egg albumin and egg yolk one by one was predictable with enough accuracy from egg weight, length and width.
3. Egg shell weight was predictable with sufficient accuracy from egg length and width. Egg weight can also be used for prediction of egg shell weight.
4. Shell thickness was predictable with sufficient accuracy from egg width. It could also be predicted

from egg weight and width.

5. Weight of the newborn chick was better predictable from egg weight, width, egg length and egg shape index.

The equations developed for each trait are to be used in the order given for each trait individually.

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