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Models of the Relationships between Egg Dimension and Egg Quality of Alabio Duck

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ABSTRACT

This research aimed to establish the relationship models between the length and width of Alabio duck (*Anas platyrhynchos Borneo*) eggs and the weight of eggshells, albumen, and yolk. Data were collected from 100 eggs and were further examined using Pearson's correlation and regression analysis. The results showed that egg length was positively correlated with eggshell, albumen, and yolk weights (r=0.28, 0.53, 0.52, respectively; P<0.05). These results were lower than the correlation between egg width and eggshell, albumen, and yolk weights (r=0.43, 0.66, 0.46, respectively; P<0.05). Egg length (x1) and egg width (x2) conjointly had a significant relationship with the weight of shell, albumen, and yolk, with a model of y = -2.59 + 0.34x1 + 0.15 x2 (R2=0.23; P<0.05); y = -51.98 + 0.49x1 + 2.06 x2 (R2=0.56; P<0.05); and y = -32.43 + 0.45x1 + 0.63x2 (R2=0.38; P<0.05), respectively. It was concluded that the length and width of Alabio duck eggs offer the potential to estimate albumen and yolk's weight.

Keywords: *Alabio duck egg, relationships, length and width, egg quality*

1. INTRODUCTION

Egg quality is primarily split up into internal and external qualities. A non-destructive method to assess internal egg quality can be undertaken using relationship models developed from the external egg quality data [1]. The length and the width of an egg are the external quality variables determining the egg dimension. It is affected by genetics, the hen's age and physiological traits [2], feed and season [3]. For instance, pullet's reproduction grooves on the oviduct are still narrow and have not fully developed so that the first laid eggs will have an oblong shape with a relatively low width [4].

Eggshell is the primary shield to protect the egg from damage during transportation and storage. The weight and thickness of the shell are the principal criteria determining eggshell quality [4]. The strength of the shell was associated with the supply of calcium obtained during the shell formation [5] and it was influenced by genetic, feed calcium, hormones, environment, and management [6].

An egg mainly consists of albumen (58-60%) with inner and outer viscous layers [7]. The difference in albumen weight in each poultry egg is contingent upon the duckling's ability to synthesize the albumen by the Goblet cells secreting thick and liquid albumen. The proportion of liquid and viscous albumen varies during the storage and depends on the egg weight. The egg freshness can be assessed by measuring the albumen thickness after spreading the liquid albumen into a flat surface [8]. However, this method is unfeasible as it requires the egg to be cracked.

The yolk is a fat emulsion that mainly consists of the vitelline membrane, germinal disc, latebrae and yolk layers [9], with the weight ranging from 30-33% of the total egg weight [10]. Because yolk is a constituent of the internal egg quality [8], it is difficult to determine

its quality without destructing the eggshell. Current methods to determine internal egg quality using advanced technologies such as digital imaging [11] are considered impractical in a commercial farm.

The correlation between the egg's length and width and internal quality has been done in other poultry eggs, including goose and chicken, but not ducks. Hence, this research aims at establishing the relationship models between the length and width of Alabio duck (*Anas platyrhynchos Borneo*) eggs and the weight of eggshells, albumen, and yolk.

2. MATERIALS AND METHODS

2.1 Materials

This study used 500 Alabio Duck eggs from the eight-months-old female ducklings. The measurements were performed using an analytical balance, a Vernier calliper, a spoon, a plastic jar, stationery, an oven, a Petri dish and glass.

2.2 Methods

A quantitative observation method was performed by measuring egg length and width sections for determining the association level to eggshell weight, albumen weight, and yolk weight in Alabio duck eggs. The parameters were based on the previously performed experiment [4].

2.2.1. Observed variables

The independent variables included the length and width of the egg whilst the dependent variables included the weight of eggshell, albumen, and yolk.

2.2.2. Statistical analysis

The correlation between the length and width of the egg with the weight of eggshell, albumen weight, and yolk weight in Alabio duck eggs was measured using Pearson's correlation coefficient [12].

$$\frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\left[\sum x^2 - \frac{(\sum x)^2}{n}\right]\left[\sum y^2 - \frac{(\sum y)^2}{n}\right]}}$$

Description:

r : correlation coefficient
y : eggshell, albumen, or yolk weight (g)
x : length and width of the eggs (mm)
n : number of data (500)

A simple linear regression analysis was performed to examine the correlation between the length and width of the eggs and the weight of the eggshell, albumen and yolk [12].

$$y_i = \beta_0 + \beta_1 x_1 + \varepsilon_i$$

Description:

y_i : Dependent variable (eggshell weight, albumen weight, and yolk weight)
x_i : Independent variable (egg length or egg width)
β_0 : Constant
β_1 : Regression coefficient
ε_i : Random error
n : 1 – 500 eggs

A multiple linear regression analysis was used to establish models between the two continuous independent variables (egg length and egg width) and dependent variables of internal egg quality [12].

$$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon_i$$

Description:

y_i : Dependent variable (egg shell weight, albumen weight, or yolk weight)
x_1 : Independent variable 1 (egg length)
x_2 : Independent variable 2 (egg width)
β_0 : Constant
β_1 : Regression coefficient 1
β_2 : Regression coefficient 2
ε_i : Random error
n : 1 – 500 eggs

The level diversity contribution of the independent variable (x) to the dependent variable (y) was assessed using the coefficient of determination (R^2).

3. RESULTS AND DISCUSSION

3.1. Summary statistics of the egg size and internal egg qualities

Descriptive statistics of the egg dimension and internal egg qualities are described in Table 1. On average, the length of Alabio duck eggs is 58 mm. This result is 2 mm lower than the length of Manila duck eggs [13] and 2 mm higher than Isa Brown chicken eggs [14]. The Alabio egg width ranges from 41 - 49 mm with an average of 45 mm. A study in Muscovy duck eggs reported a slightly higher result (45.5 mm) [13] but higher than study in Isa Brown chicken eggs (42.4 mm) [14]. In this study, the SD of the egg length is 1.05 mm higher than the egg width SD, indicating that egg length is more variable than egg width.

Table 1. Summary statistics of egg dimension and internal egg quality of Alabio duck eggs

	Egg Length (mm)	Egg Width (mm)	Eggshell Weight (g)	Albumen Weights (g)	Yolk Weights (g)
n	500	500	500	500	500
Minimum	48.90	41.50	4.19	27.57	14.13
Maximum	68.00	49.70	7.82	46.96	29.22
Mean	58.06	44.98	6.21	36.32	22.22
SD	2.33	1.28	0.48	3.09	2.44
CV	4.01	2.85	7.66	8.50	10.98

Description; n = Number of samples; SD= Standard deviation; CV= Coefficient of variance; mm = Millimeters; g = gram

3.2. Models of the association between egg length or egg width and eggshell, albumen and yolk weights of Alabio duck eggs

The association models and the correlation between egg length or egg width and shell weight, albumen weight or yolk weight of Alabio duck are shown in Table 2. From the regression equations, it appears that the longer the egg, the heavier the eggshell. An elongation of 1 mm in egg length would increase the weight of the eggshell by 0.6 g. A positive correlation is also reported in a study on the eggs of Muscovy ducks [13], Japanese quail [15] and indigenous chicken [16, 17]. This study's correlation coefficient between egg length and eggshell weight differs from indigenous chicken eggs [18] that have a negative correlation (r=-0.11). The R2 indicates that egg length influences egg weight variation by 8%. A positive correlation between egg length and albumen weight also occurs, so the longer the egg, the heavier the albumen. The correlation between egg length and albumen weight is lower than on indigenous chicken eggs [18], with the R2 indicating that 28% of albumen variation could be explained by egg length.

The regression equation between egg length and yolk weight shows that if the length of the egg increases by 1 mm, then the yolk weight will increase by 0.70 g. The correlation coefficient between the length of the egg and the yolk weight is considered as a quite strong significant correlation (r=0.52). This result is lower than the study on local Tswana chicken eggs (r=0.56) [6--19] and indigenous chicken eggs (r=0.68) [18] because chicken eggs are more uniform than duck eggs. Genetics and physiological condition of the hens are primarily responsible for egg size variation, with other factors such as diets and ambient temperature considered [20].

The regression equation between the egg width of the egg and the weight of the eggshell shows that if the egg's width increases by 1 mm, the weight of the eggshell will increase by 0.17 g with the contribution of egg width to the variability of eggshell weight being 21%. The correlation coefficient between the width of the egg and the weight of the eggshell has a significant positive relationship (r=0.46). These results are higher than the research found in Muscovy Duck eggs [13], 0.24 in indigenous chicken eggs [18].

The regression equation between egg width and albumen weight indicates that if the width of the egg increases by 1 mm, then the albumen weight will increase by 1.59 g, with the contribution of egg width to the variability of albumen weight being 43%. The correlation coefficient between egg width and albumen weight is similar to the study in indigenous chicken eggs [10] and better than the study in Muscovy duck eggs (r=0.40) [13].

The regression equation between the width of the egg and the yolk weight shows that if the width of the egg increases by 1 mm, then the yolk weight will increase by 0.87 g. The R2 shows that egg width contributes to the yolk weight variation by 21%. The correlation coefficient between egg width and yolk weight is lower than the study in Isa Brown's chicken layer (r=0.48) [14] but higher than the study on the indigenous chicken egg was (r=0.42) [18].

3.3. Models of the association between egg dimension (length and width) and the weight of eggshell, albumen and yolk of Alabio duck egg

Table 3 specifies the multiple regression equations between egg dimension (length and width) and eggshell, albumen, and yolk weights of Alabio duck eggs. Egg length and width contribute 56% to the variation of albumen weight. The change in yolk weight is likely to be affected by egg length and width by 38%. Egg length and width are responsible for only 23% of the eggshell weight variation. The increase in the length

Table 2. Simple linear regression equations between egg dimension (length and width) and eggshell, albumen, and yolk weights of Alabio duck eggs

x (mm)	y (g)	Regression Equation	RMSE (g)	R2	r
Egg Length	Egg shell weight	y = 2.87 + 0.60x	0.46	0.08*	0.28
	Albumen weight	y = - 4.33 + 0.70x	2.63	0.28*	0.53
	Yolk weight	y = - 9.70 + 0.55x	2.08	0.28*	0.52
Egg Width	Egg shell weight	y = - 1.43 + 0.17x	0.42	0.21*	0.46
	Albumen weight	y = - 34.99 + 1.59x	2.33	0.43*	0.66
	Yolk weight	y = - 16.84 + 0.87x	2.18	0.21*	0.46

* significance (P<0.05); R^2 : coefficient of determination; r: correlation coefficient; RMSE: Root Mean Square Error

Table 3. Models of the multiple regression equations between egg dimension (length and width) and eggshell, albumen and yolk weights of Alabio duck eggs

Dependent Variable (y)	Regression Equation	RMSE (g)	R2
Egg shell weight	$y = - 2.59 + 0.34x_1 + 0.15x_2$	4.17	0.23*
Albumen weight	$y = - 51.98 + 0.49x_1 + 2.06x_2$	2.06	0.56*
Yolk weight	$y = - 32.43 + 0.45x_1 + 0.63x_2$	1.92	0.38*

* significance (P<0.05); y: dependent variable; g: gram; x_1: egg length; x_2: egg width; RMSE: Root Mean Square Error; R^2: coefficient of determination

and width of the egg by 1 mm would enlarge the eggshell weight by 0.34 and 0.15 g, albumen weight by 0.49 and 2.06 g, and yolk weight by 0.45 and 0.63 g, respectively. A conjoint egg length and egg width model could predict albumen and yolk weight with a prediction error of 6% and 9%, respectively. However, the prediction error of a model to predict eggshell using egg length and egg width is substantial (67%).

4. CONCLUSION

A conjoint model of egg length and egg width of Alabio duck eggs is capable of estimating the weight of albumen and yolk weight. However, the egg length and width model could not predict the eggshell weight satisfactorily as the model's mean error is substantial.

AUTHORS' CONTRIBUTIONS

Lilis Hartati, Danang Biyatmoko, Muhammad Riyadi, Abrani Sulaiman, Gamaliel Simanungkalit and Nurul Muawanah contributed to the design, implementation of the research, the analysis of the data results and to the writing of the manuscript.

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