The Estimate Heritability Value of Eggs Quality Traits from Tegal Male and Magelang Female Crossed Duck (Gallang)

Dattadewi Purwantini[1*], R. Singgih Sugeng Santosa[1], Setya Agus Santosa[1], Agus Susanto[1], Dewi Puspita Candrasari[1]

[1] *Animal Science Faculty. Jenderal Soedirman University*
[*]*Corresponding author. Email: dattadewi2002@yahoo.com*

ABSTRACT

This study aimed to estimate the heritability value of egg quality traits from Tegal male and Magelang female crossed duck, hereafter referred to as Gallang duck. One hundred female ducks consisted of 50 Magelang (F0), and 50 Gallang (F1) were used in this study. Heritability value (h^2) was estimated using the Parent Offspring Regression method. Egg quality data of the parent were obtained from Magelang female ducks (F0), and the offspring was from Gallang female ducks (F1). The observed egg quality traits were egg weight (EW), yolk weight (YW), albumen weight (AW), eggs index (EI), yolk color (YC), and shell thickness (ST). This research has successfully obtained the mean and standard deviation of eggs quality of Magelang female ducks (F0), namely, EW: 69.42 ± 4.97 g, YW: 24.20 ± 2.87 g, AW: 32.27 ± 4.36 g, EI: 79.28 ± 2.63 %, YC: 5.12 ± 1.14, and ST: 0.43 ± 0.04 mm, while that of Gallang female duck (F1) EW: 61.57 ± 2.30 g; YW: 18.96 ± 1.50 g; AW: 33.57 ± 1.67 g; EI: 81.17 ± 1.94 %, YC: 7.98 ± 0.39, ST: 0.34 ± 0.03 mm. Also, the h^2 and standard error of eggs quality traits of Gallang ducks was EW: 0.20 ± 0.07; YW: 0.09 ± 0.07; AW: 0.08 ± 0.05; EI: 0.03 ± 0.11; YC: 0.11 ± 0.05, and ST: 0.21 ± 0.11. Conclusively, the heritability value of egg quality traits of the Gallang duck is low. However, it carries the potential inheritability coefficient to determine genetic quality in the breeding program of Magelang ducks, particularly Gallang ducks.

Keywords: *Heritability value, Egg quality traits, Duck crossed, Magelang duck, Gallang duck.*

1. INTRODUCTION

Eggs are a source of inexpensive, easy-to-get animal protein for Indonesian people, with complete nutrition content from protein, fat, vitamin, and mineral. Nevertheless, egg quality may be compromised due to microbial contamination, physical damage, as well as the evaporated water and gas from the eggs, such as carbon dioxide, ammonia, nitrogen, and hydrogen sulfide [1]. The quality traits of eggs, including egg weight (EW), yolk weight (YW), albumen weight (AW), eggs index (EI), yolk color (YC), and shell thickness (ST) are the quantitative expressions dependent on genetic and environmental factors. The genetic factor is the abilities that an individual inherits from the parent to the offspring, that remain the same since the individual is formed until deceased or terminated [2].

1.1. Estimate Heritability Value

Heritability value (h^2) determines to what extent the genetic factor of a characteristic is heritable from the parent to the offspring [3]. The h^2 value of a characteristic in livestock breeding plays a crucial role because it is the genetic parameter that provides a guide to determine the steps of improving the genetic quality of the population [4]. The h^2 value ranges from 0.00 to 1.00 with several categories: $h^2 < 0.10$ is low, h^2 : 0.10 – 0.30 is medium, and $h^2 > 0.30$ is high. A characteristic with high h^2 means the phenotypes are dominantly affected by the additive genetic rather than the environment; therefore, it is likely to produce a high selection response. In contrast, when h^2 is relatively low, the selection program will not be effective, and crossbreeding is improved [5].

1.1.1. Eggs Quality Traits from Duck

Male Tegal duck and female Magelang duck crosses produce Gallang duck [6]. Tegal and Magelang ducks are native ducks in Central Java province with excellent egg production and quality. The superior quality of Tegal duck includes the relatively high egg weight (71.14 ± 6.08 g) and yolk color (7.20 ± 0.97), but it has low albumen weight (34.18 ± 4.27 g), yolk weight (27.02 ± 299 g), shell thickness (0.38 ± 0.02 mm), and HU (78.04 ± 6.08). Meanwhile, Magelang duck is superior for its relatively thick shell (0.38 ± 0.02 mm) and high haugh unit (HU) (78.35 ± 6.87) but a relatively low egg weight (69.19 ± 4.05 g), albumen weight (32.77 ± 3.42 g), yolk weight (24.47 ± 2,75 g), and yolk color (6.98 ± 0.65) [7].

The estimation of the h^2 value of egg quality traits in the Gallang duck has not been published, so the present study aims to investigate the heritability value (h^2) of egg quality traits using a Parent Offspring Regression. The h^2 value in this study was intended to provide 1) the proportional illustration of egg quality traits affected by the additive genetic effects; 2) the basic selection program, and 3) an important parameter to estimate the genetic improvement due to selection in Gallang duck. This research aimed to estimate the heritability value of egg quality traits, including the egg weight, yolk weight, albumen weight, egg index, yolk color, and shell thickness of Gallang duck.

2. MATERIALS AND METHODS

This study used 100 ducks, consisted of 50 Magelang female ducks (F0) and 50 female Gallang duck (F1). Three quality eggs were sampled from each female duck, hence 300 eggs in total. The duck feed on the production period consisted of rice bran, concentrate, and corn (50 kg: 20 kg: 30 kg), with 15.95% crude protein and 9.12% crude fat. The feed offered 150 g/duck/day two times a day and water was provided ad libitum. The equipment consisted of an analytic scale, knives, petri dish, Roche yolk color fan, Micrometer Calliper, and a micrometer mounted on a tripod.

The method to estimate the heritability value (h^2) was Parent Offspring Regression. The data of the parent's egg quality (P) were derived from Magelang female ducks (F0), and data of offspring's egg quality (O) were from the female Gallang duck (F1). The observed egg quality traits included egg weight (EW), yolk weight (YW), albumen weight (AW), eggs index (EI), yolk color (YC), and shell thickness (ST). The analytical scale was used to measure EW, while egg yolk and white egg were weighed to obtain YW and AW, respectively. The Roche yolk color fan measured YC and Micrometer Calliper measured the ST from three parts, namely the pointed end, the middle, and the blunt end of the eggshell. The egg shape (AI) is the comparison of the width and length circumference of eggs expressed in percentage.

The h^2 value of egg quality traits are estimated with a equation [8]: $h^2 = 2\ b_{OP}$

where b_{OP} is the parent offspring regression coeficient obtained from $b_{OP} = \frac{Cov_{OP}}{\sigma_P^2} = \frac{\frac{1}{2}\sigma_A^2}{\sigma_P^2} = \frac{1}{2}h^2$ and $Cov_{OP} = \frac{1}{2}\sigma_A^2$ where Cov_{OP} is the covariation between parent- offspring, σ^2_A is the additive genetic variance, σ^2_P is the total variance of a trait. The standard error for h^2 estimates shows the accuracy of h^2 estimates calculated with the following equation:

$S.E.(h^2) = 2 \times S.E.(b_{op})$ from $S.E.(b_{op}) = \sqrt{((Sb^2)/(Var_P))}$ where $Sb^2 = Var_O - ((Cov_{OP})^2)/(Var_P) / N - 2$.

N is the total livestock sample.

3. RESULTS AND DISCUSSION

3.1. Eggs Quality Traits.

The findings reported the mean and standard deviation of the egg quality traits of Magelang duck (F0) and Gallang duck (F1), presented in Table 1.

Based on Table 1, the egg quality traits of Magelang duck and Gallang are very significantly different (P<0.01). The difference could be due to the morphometric differences between Magelang duck and Tegal duck, where Gallang duck is the crosses of male Tegal duck and female Magelang duck. Purwantini et al. (2015) reported that the vital body measurement, production performance, and reproduction characteristics of Tegal and Magelang ducks were significantly different. Magelang duck exhibits higher scores than those of Tegal duck [9].

3.1.1. Different egg weight of Magelang and Gallang ducks

The contributing factor to egg size is the different bodyweight of the parent. Bodyweight is positively correlated with egg weight. According to [10] body weight strongly correlated with egg weight; therefore, the heavier the body, the bigger the eggs. Similarly, [11] mention that the light egg weight is due to several factors, such as environment, gene, feed, egg composition, laying period, livestock age, and the bodyweight of the parents because both the male and female parents contribute a balanced number of gene.

Stated that the egg size carries a high heritability value, so improving genetic quality in body weight would result in increased egg weight [12]. A study by [13] reported that egg weight is inherited from the parents to the offspring and it is evident from some genes that affect the egg size.

3.1.2. Different yolk weight of Magelang and Gallang duck eggs

Different egg yolk weight is due to the varied genetic ability of each duck. According to [14], the avian ovary reaches sexual maturation nine to ten days before ovulation. The process of yolk formation is called vitellogenin (vitellogenesis), which is a fatty acid synthesis in the liver controlled by estrogen hormone and accumulated in the ovary as follicles or ovum called yolk. The process of yolk formation produces different weights of egg yolk weight, dependent on the genetic capacity of each bird and the nutrient intake [15].

3.1.3. Different albumen weights of Magelang and Gallang ducks

Albumen weight is the weight of the white egg (albumen). It is measured by separating the white egg from the other parts and weighing on an analytic scale. The different albumen weights are due to the varied capacity of each duck in synthesizing white egg. Synthesis and secretion of white egg occur in the magnum of the oviduct. The magnum is composed of highly sensible tubular glands, while mucus and magnum consist of goblet cells. Goblet cells secreted thick and thin white eggs. Total synthesis and secretion of the white egg are different depending on the total white egg synthesis in each bird [7].

3.1.4. Different Yolk colors of Magelang and Gallang ducks

The yolk color is observed by breaking the duck egg and comparing the color of egg yolk using a Roche yolk color fan. An increased score of yolk color is more favorable to consumers and does not affect the chemical composition of the yolk. Additionally, the higher the score, the higher the vitamin A in the yolk [16]. The difference is assumedly due to the limited physiological process in producing eumelanin or pheomelanin. Mojosari ducks have a more recessive homozygote gene (c/c) with a lower score of yolk color (5.35). The yolk color of the first egg from recessive homozygote duck tends to be paler because of the limited physiological process in producing eumelanin or pheomelanin due to the activity of recessive genes [17]. The yolk color is affected by the ability of each bird to deposition xanthophyll into the egg yolk [7]. The color spectrum of egg yolk covers a range of variation and intensity dependent on the xanthophyll in feed and the genetic ability of the birds to absorb and deposition the xanthophyll from the feed into the egg yolk. Yolk color is correspondent to carotene pigment in the ration [18]. According to [19], the coloring degree in egg yolk is due to the increased percentage of carotene intake. Carotene pigment cannot be synthesized in the birds' body, so it must contain in the feed. Brighter egg yolk contains more carotenoid than that paler. Therefore, the more carotenoid in the feed, the better the egg yolk quality [20].

3.1.5. Different egg shape index of Magelang and Gallang ducks

The egg shape index is varied across individuals. According to [21] the egg shape index varies among individuals in one group and from one egg-laying to another, and the cause of this variation is still vague but may be due to the rotation of eggs in the reproduction system, the pressure rhythm of reproduction organs, or the lumen of reproduction organs. Additionally, the contributing factors to egg shape index, according to [22], include the genus, productive status, gene, and individual variation. Egg shape index is the ratio of egg width and length that affects the appearance of the egg. The ideal egg shape index is around 70-74. The higher the shape index, the rounder the egg, and the lower the score, the more oval the shape. Egg shape index varies from 65-82, the score of the oval egg is around 65 and the round egg is up to 82. Egg index may decrease progressively as the birds are aging, for example, 77 at

Table 1. The mean and standard deviation of eggs weight, yolk weight, albumen weight, eggs index, yolk color and shell thickness (ST) of Magelang duck (F0) and Gallang duck (F1).

Traits	Mean and standard deviation	
	Magelang duck (F0)	Gallang duck (F1)
Eggs weight (g)	$69.42^a \pm 4.97$	$61.57^b \pm 2.30$
Yolk weight (g)	$24.20^a \pm 2.87$	$18.96^b \pm 1.50$
Albumen weight (g)	$32.27^a \pm 4.36$	$33.57^b \pm 1.67$
Eggs index (%)	$79.28^a \pm 2.63$	$81.17^b \pm 1.94$
Yolk color	$5.12^a \pm 1.14$	$7.98^b \pm 0.39$
Shell thickness (mm)	$0.43^a \pm 0.04$	$0.34^b \pm 0.03$

Footnote: Different a and b superscripts within rows indicate significance the first and 74 at the last egg-laying. Eggs with a regular shape are crucial in marketing because an egg that is too round or pointed is difficult for packaging and vulnerable to crack or break [23].

3.1.6. Different Shell thickness of Magelang and Gallang duck eggs

Different shell thickness is affected by varied capacities in synthesizing and secreting the eggshell membrane. According to [24] and [25], the bird capacity to produce and improve the eggshells is correlated to the activity of 25-hydroxy-cholecalciferol-1-hydroxylase, the determinant enzyme to calcium homeostasis. That a female bird could only store a certain amount of calcium into the eggshell, and it is affected by genetic factors and age. The increasing calcium in the feed may not directly increase the quality of eggshells. Regarding the bird's age, the egg size increases if the amount of calcium is constantly distributed across the egg surface [26]. The change in egg weight and age of the parent bird may affect the quality of eggshell. Some contributing factors to the issues regarding eggshell quality are genetic factors, bird age, high environmental temperature, feed, and disease. The bird's age affects the eggshell formation; the older the bird, the thinner the shell because the reproduction function of the bird has decreased correspondingly to age [27]. The ideal shell thickness for egg marketing is around 0.33 – 0.35 mm, so the egg is not easy to break during the transport. The shell thickness in this study is considered ideal (0.36 – 0.39 mm), so it may prevent the eggs from breaking during transport [28].

3.2. Heritability value.

The results of heritability value estimate and standard error of egg weight, yolk weight, albumen weight, eggs index, yolk color and shell thickness (ST) of Magelang duck (F0) and Gallang duck (F1) are presented in Table 2. Table 2 shows that the heritability value of egg quality traits in Gallang duck belongs to the low to the medium category with a relatively low standard deviation.

Table 2. Heritability value and standard error of eggs weight, yolk weight, albumen weight, eggs index, yolk color and shell thickness of Gallang ducks

Traits	Heritability value (h^2) and standar Error
Eggs weight (g)	0.20 ± 0.07
Yolk weight (g)	0.09 ± 0.07
Albumen weight (g)	0.08 ± 0.05
Eggs index (%)	0.03 ± 0.11
Yolk color	0.11 ± 0.05
Shell thickness (mm)	0.21 ± 0.11

The h^2 value ranges from 0 to 1 where h2 < 0.1 is low, h2 < 0.1 < 0.3 is medium, and h2 > 0.3 is high. It shows that the variation in the egg quality traits is affected by the varied environment and only partially affected by genetic variation [2] [5]. The heritability value of egg weight and shell thickness is in the medium category, while the yolk weight, albumen weight, egg index, and yolk color are in a low category. These low to medium heritability values can be increased by improving the genetic factor and remain the probable heritability coefficients when determining the genetic variation in the breeding program of Magelang duck generally and Gallang duck specifically.

Furthermore, [2], heritability is not a constant value or absolute score, so the values are relatively different depending on the population and the observed characteristics, the methods, and analysis models. The heritability value analyzed in the Restricted Maximum Likelihood (REML) model using PEST and VCE 4.2 programs for the first age of egg-laying in Alabio duck was 0.047 ± 0.043, the first egg weight was 0.160 ± 0.098, the egg production at 12 weeks was 0.235 ± 0.087 and h2 egg production at 24 weeks was 0.127 ± 0.088. Therefore, the heritability value of these egg production traits of Alabio duck is low [29]. In contrast, [30] reported that the estimated heritability of body weight, breast weight, and breast meat thickness of Pekin duck were within medium and high categories (0.20-0.53), while the breast muscle weight and breast meat percentage was 0.50 and 0.47, respectively. The h^2 values and standard error of the hatching weight, 8-week bodyweight and growth of Magelang ducks are 0.49 ± 0.073; 0.41 ± 0.098 and 0.58 ± 0.032, respectively [31], while the egg weight and the percentage of egg production of Tegal duck are 0,47 ± 0.032 and 0.512 ± 0.071, respectively [32]. The h^2 value and standard error of the age at first egg-laying and egg weight of Maggal duck are 0.69 ± 0.34 and 0.45 ± 0.19, respectively [33].

4. CONCLUSION

The heritability value of egg quality traits in Gallang duck is within the low to the medium category with a relatively low standard error. However, these traits are the viable heritable coefficients to determine the genetic quality in the breeding program of Magelang duck generally and Gallang duck specifically.

AUTHORS' CONTRIBUTIONS

Dattadewi Purwantini compiled the research ideas, designed the main framework and composed the manuscript. Singgih Sugeng Santosa, Setya Agus Santosa, Agus Susanto and Chandra contribute in coordinating field data collections. Setya Agus Santosa conducted the statistical analysis. Agus Susanto compiled and revised the manuscript from errors. All authors have read and agreed to the final draft.

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