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## Characteristics of the Physical Changes of Muscovy Duck Eggs During the Natural Hatching Process and their Effect on Hatchability

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### ABSTRACT

This research aimed to determine the alteration of physical characteristics of Muscovy duck hatching egg of natural hatching. The information obtained will be used as a reference to modern hatching (artificially). Muscovy ducks as one of a poultry's meat producer needs to be improved by population breeding with modern hatching. To be able to artificially incubate the eggs and achieve high hatchability, it is necessary to observe the natural hatching by mother duckling. The observation method was on egg shape index, hygiene of eggshell, shell temperature, egg weight loss, and hatchability. Ten mother ducklings were used during brood time with 15 eggs on each duck. The results showed the eggs that successfully hatched in this research had egg shape index equal 73.6%, egg weight loss 9.6%, eggshell temperature 36.9-38.0°C, and hatchability 86%. The conclusion of this research during the natural hatching, the eggs undergo physical alteration that were egg weight loss, alteration in the eggshell appearance, and the temperature of the eggshell increased from day one to 28 but decreased at the end of the hatching process.

Keywords : Hatchability, Hatching, Muscovy duck, Natural hatching

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### Introduction

Muscovy duck (*Cairina moschata*) is a type of poultry product originating from South America. Male ducklings weigh around 5-5.5 kg, while females weigh around 2.5-3 kg. Female Muscovy ducks begin laying eggs at the age of 6-7 months (Holderread, 2011). In general, among traditional Indonesian breeders, Muscovy ducks are used only as chicken and duck egg incubators. Female Muscovy ducks are known to be the best incubators among birds, because they can incubate eggs 5-7 times in a row (Yana, 2016; Harun *et al.*, 1998). In terms of poultry population development and meat production, the brooding nature of the Muscovy duck is not profitable, because it does not lay eggs at the time of incubation. The use of duckling as a meat producer needs to be increased by enhancing the Muscovy duck population.

The highest domestic production of poultry meat in 2019 came from the broiler sector, amounting to 3,495.1 tons, while ducks and muscovy duck were 39,8 tons and 6,8 tons, respectively (Dirjen PKH, 2020). This aspect

proves that meeting the demand for meat in Indonesia is very dependent on purebred chickens. Increasing the production of local poultry meat, one of which is duck meat as an alternative meat source, is expected to reduce dependence on purebred chicken meat. The main product expected from the maintenance of Muscovy ducks is meat because they have a higher body weight than chickens and ducks (Harun *et al.*, 1998). Increasing the Muscovy duck population can be achieved by replacing the Muscovy duck function as an incubator with an incubation tool. To be able to hatch Muscovy duck eggs using a tool, basic information is needed about how to hatch Muscovy duck eggs. One way to obtain this information is by observing the natural hatching of Muscovy duck broodstock for variables affecting hatchability.

Artificial hatching of Muscovy duck eggs has been widely practiced abroad. However, differences in the quality and physical characteristics of eggs (foreign and local) in Indonesia mean that foreign hatching machine references cannot be directly applied at the domestic level. Weis *et al.* (2011), using Muscovy

duck eggs originating from Slovakia, showed that in the same environment different egg weights produced different responses. Small egg weights (70.0–76.99 g) have high hatchability and egg weight loss rates (88.38% and 15.92%) compared to large egg weights (84.00–90.99g) with a hatchability of 84.62% and a weight loss of 14.33%.

In Indonesia, duck breeding is still being practiced by smallholder farms, so that the multiplication of the duck population among breeders still relies on broodstock or natural hatcheries. Unlike the cases in other countries, the hatching of eggs has been carried out artificially. Lestari *et al.* (2013) reported that during the hatching of local duck eggs with a weight of 63.80 g, they were depreciated by 7.38%. Differences in egg weight occur due to the influence of environment, genetics, broodstock feed, egg composition, egg-laying period, age, and body weight (Rodenburg *et al.*, 2005). Broodstock and nutrition factors are thought to affect the quality of local duck eggs. Thus, observations were made to obtain information to increase the hatchability of Muscovy duck eggs. This information is carried out by adopting information from natural hatcheries using broodstock and Muscovy duck eggs. The information obtained from the natural hatchery is used to artificially increase the hatchability of Muscovy duck eggs. The variables observed included egg shape index, changes in shell appearance, egg weight loss, shell temperature, and hatchability.

## Materials and Methods

### Materials

The tools used in this study were a box-shaped incubation nest measuring 30 x 60 cm covered with rice husks (IPB Bogor diploma campus livestock cage), a digital scale with an accuracy of 0.02 g (AJ 3000, Osuka, Japan), a dry ball thermometer and wet ball (PD Tani Jaya, Indonesia), the digital caliper of 150 mm x 60.01 mm (Krisbow, Indonesia), infrared thermometer (IRT 4520, Thermoscan Braun, Germany) and digital hygrometer (HTC-1, China). A total of 10 Muscovy duck broodstock was used in this study as incubators and 150 Muscovy duck eggs (livestock cages at IPB Bogor diploma campus). Each broodstock hatched 15 eggs, referring to Harun (1998) according to whom Muscovy duck is a good incubator because it can hatch 15-20 eggs. The broodstock used as incubators were those having the same time to incubate. The hatching eggs used were fertile eggs obtained from broodstock that are reared in an intensive housing system. The broodstock used was that with signs or incubation characteristics. Egg collection was carried out for 7 days (Alsoyabel *et al.*, 2013).

### Method

The present research used descriptive data analysis. It began with the preparation of incubation facilities, hatching egg collection, and further observation of hatching for 35 days. Preparation of incubation facilities begins by providing incubation nests that have been disinfected to prevent contamination of microorganisms. Each egg is marked with an X and O on the equator side of the egg. The eggs were weighed to determine the initial weight, shape index, hatch temperature, and binoculars were performed to mark the air sacs on the eggs. A total of 10 Incubation nests were used. Each broodstock incubated 15 eggs in the incubation nests that have been prepared. The incubator was placed in the incubation nest, and during the hatching process, observations were made on the incubated eggs. The observation was done simultaneously during the day by removing the hatched eggs one by one from the incubation nest. Observations were performed for  $\pm 2$  minutes so that the temperature of the hatched eggs did not decrease during the observation. The environmental conditions of the cages are adjusted so that the house temperature ranges from 24-25°C and the humidity ranges from 70-71%. Observations were made on days 0, 7, 14, 21, 28, and 32.

### Observed variables

The variables observed in this study were shell cleanliness, egg shape index, egg weight loss, shell temperature, air sac depth, and hatchability.

### Egg shape index

Egg index is measured by calculating egg width versus egg length times 100% (Narushim and Romanov, 2002). The width and length of the eggs are measured with a digital caliper. Measurements are made before the eggs are placed into the incubation nest.

### Change in appearance of the shells

The cleanliness of the shells was assessed based on the score and observed on days 0, 7, 14, 21, 28, and 32. The score given was SK = very dirty (score 3), K = dirty (score 2) and B = clean (score 1). SK was stated if almost all over the surface of the shell there is dirt sticking. Egg category K has stated if part of the shell surface has dirt spots adhering to it but not as many as in the SK category. Category B eggs if there is no dirt on the surface of the eggshell, the color of the shell is natural and looks shiny.

### Egg weight loss

Eggs are weighed on day 0 or before being placed into the incubation nest. The weighing was carried out using electric scales with an accuracy of 0.01 g. It was done to get the egg weight loss (gr) done 5 times, namely on the 7th, 14th, 21st, 28th, and 32nd day. The calculation of the

percentage of egg weight loss refers to Pool *et al.* (2013), namely:

Egg weight loss (%) =

$$\frac{\text{initial egg weight} - \text{egg weight on day 32}}{\text{initial egg weight}} \times 100 \%$$

### Shell temperature

The initial shell temperature was measured at the time before the eggs were placed into the incubation nest (temperature data 0 days). Temperatures were measured on days 7, 14, 21, 28, and 32 using a Braun thermometer. The temperature of the broiler is measured by removing the eggs from the incubation nest. However, efforts are made not to disturb the comfort of the broodstock. Shell temperature is measured on the upper and lower surfaces of the ovary (Nickolova, 2005).

### Hatchability

The calculation of hatchability refers to Hanoun and Mossad (2008), namely:

$$\text{Hatchability (\%)} = \frac{\text{number of hatched eggs}}{\text{number of fertile eggs}} \times 100\%$$

### Data analysis

The data obtained were analyzed descriptively (Mattjik and Sumertajaya, 2002) and presented as means and standard deviations (Steel and Torrie, 1991).

## Results and Discussion

### Egg shape index

The egg shape index is the ratio between the width and length of the egg and is an important factor affecting the hatchability of eggs. A normal egg shape index can produce high hatchability compared to an abnormal shape index (Narushim and Romanov, 2002). In general, the eggs used in this study are elliptical. The egg

shape index of successfully hatched eggs during 35 hatching days is presented in Table 1.

Based on Table 1, the egg shape index for hatching success in this study was 73.6% which resulted in a hatchability of 86%. In this study, it was also found that the unsuccessful egg shape index was 72.7% (Table 2). These results are consistent with those reported by Etuk *et al.* (2012), stating that the index of egg shape which produced high hatchability in intensive care was 74%. Normal poultry eggs are elliptical, consisting of a round end and a more pointed end (King'ori, 2012). Each bird species has a different egg shape index and younger birds tend to have a smaller shape index than older ones.

### Change in appearance of the shells

The results of observations of changes in the appearance of hatched Muscovy duck eggs during natural hatching are presented in Table 3. The observations on changes in the appearance of the shells indicated that the eggs changed in appearance during hatching. This aspect can be seen from the average value of the eggshell cleanliness score which decreased each observation period. During the 7 days of hatching, most of the eggs were dirty and very dirty, and from the 14<sup>th</sup> day to the 32<sup>nd</sup> day before hatching the eggshells were clean (Table 2). Changes in the appearance of the shells in this study are following those reported by Reijrink (2008), according to which in natural hatching by the broodstock, there is a bacterium *Bacillus licheniformis* which plays a role in thinning the cuticle layer of the eggshell. These bacteria will change the appearance of the dirty shells at the beginning of the hatching to clean at the end of the hatching because they play a role in thinning the thick cuticle layer on the shells.

The hatching eggs in this study were generally dirty. The appearance of dirty eggs is caused by ducks laying their eggs on a dirty floor (Yana, 2016). Eggs with dirty shells are a source

Table 1. Shape index of hatched egg

Variable	Egg shape index		
	Mean	Minimum	Maximum
Breadth (mm)	45.6±1.7	42.8	51.5
Length (mm)	62.0±2.5	55.4	68.7
Index (%)	73.6±2.4	66.0	80.5

Table 2 Shape index of unhatched eggs

Variable	Egg shape index		
	Mean	Minimum	Maximum
Breadth (mm)	42.43±1.6	40.6	45.3
Length (mm)	60.45±1.5	58.0	64.9
Index (%)	70.23±3.2	62.7	74.6

Table 3. Appearance changes of eggshell during the natural hatching

Day	Mean score	Mean value
0	1.7	K
7	1.5	K
14	1.4	B
21	1.4	B
28	1.1	B
32	1.0	B

B (clean) = 1; K (dirty) = 2.

of bacteria and fungi that can affect hatchability (Joseph, 2007). *Bacillus licheniformis* is a bacteria that is found in the soil, so this bacteria sticks to the chest and back hair of the Muscovy duck (Qiu *et al.*, 2013). The quality of the hatched eggs is related to the cleanliness of the shells (Koelkebeck, 2010). Microbiological contamination is strongly influenced by the ability of the eggs to prevent microorganisms and bacteria from entering the egg cells through the pores in the shells.

### Eggs weight loss

Depreciation of weight and the total percentage of eggs weight loss that have successfully hatched are presented in Table 4. This study showed a 9.6% eggs weight loss. This result was higher than that reported by Lestari *et al.* (2013) who reported that during the hatching of Muscovy duck eggs with a weight of 63.80 g, weight loss was 7.38%. This difference in weight loss is thought to be due to differences in the weight of the eggs used. The egg weight used in this study was higher than that of Lestari *et al.* (2013). In this study, the weight loss of eggs that failed to hatch was also found at 7.49% (Table 5). Tullet and Burton (1982) reported that weight loss occurs due to the evaporation process in embryo metabolism. During the process of embryo metabolism, the waste products of metabolism in the form of water will be removed through evaporation from the eggshells (Prasetyo and Susanti, 2000). The weight loss that occurs is also followed by changes in the depth of the air sacs in the eggs. Air sacs during hatching are formed due to eggs weight loss due to water evaporation during embryonic metabolism (Meir and Amos, 1990). The air sacs expand along with the egg weight loss. Before hatching, the chicks will pipe and breathe oxygen (O<sub>2</sub>) which is available in the air sacs. This result is supported by Bucher and Barnhart (1984) who reported that the air sac acts as a source of oxygen for respiration when the chicks are piping and ready to hatch.

### Shell temperature

The results of observations on eggshell temperature successfully hatched eggs during natural hatching, are presented in Table 6. Shell temperature was noted to increase in the second half of hatching (day 14 to day 32 of hatching) compared to the first half of hatching (day 1 to day 14). In the second half of hatching, the average temperature of the shells increases then decreases on the 32<sup>nd</sup> day. This increase in temperature from the first half to the second half of the hatching is due to the use of egg yolk fat by the embryo, causing more heat to be released through the eggshell. This result is supported by Prasetyo and Susanti (2000) who stated that during the embryonic metabolic process, heat release occurs in the form of water evaporation through the eggshell.

The temperature of the developing embryo can be measured through the eggshell (Harun *et al.*, 2001). The temperature increase in the second half of hatching is following results reported by Nickolova (2005) according to which the temperature of the Muscovy duck embryo varies with its metabolism. In the first 15 days, the temperature is around 36.4°C and 37.0°C; it becomes 35.6°C and 37.97°C from day 15 to day 30, and between 37.9°C and 38.8°C three days before hatching. In this observation, the temperature of the shells decreased on the 32<sup>nd</sup> day, presumably because the metabolism of the embryos was complete so that heat release from the embryos decreased. This study also looked at eggs that did not hatch successfully (Table 7).

Most embryo mortality occurred between the 28<sup>th</sup> and the 32<sup>nd</sup> day of hatching. At the age of hatching, the temperature of the shell also decreased. Embryo mortality was suspected because the embryo did not get the optimal temperature to develop. This sub-optimal temperature resulted in disrupted oxygen consumption for the growing needs of the embryo, weakening the embryo. This result was consistent with the statement of French (1997) according to whom embryos die when the temperature required

Table 4. Weight loss of hatched eggs

Variable	Age(day)					
	0	7	14	21	28	32
Egg weight (g)	71.2±3.7	69.9±3.7	68.6±3.6	67.1±3.6	65.5±3.6	64.3±3.5
Egg weight loss (%)	0.0±0.0	1.7±0.7	3.6±0.7	5.7±0.9	8.0±1.1	9.6±1.4

Table 5. Weight loss of unhatched eggs

Variable	Age(day)					
	0	7	14	21	28	32
Egg weight (g)	71.1±3.6	69.8±3.6	68.5±3.4	66.6±3.6	66.5±3.6	65.3±4.6
Egg weight loss (%)	0.0±0.0	1.5±0.7	2.5±0.9	3.2±1.9	6.6±1.0	7.4±1.1

Table 6. Temperature of hatched eggshells

Temperature eggshell (°C)	Age(day)					
	0	7	14	21	28	32
Top	30.1±1.7	37.0±1.0	36.5±1.4	36.9±1.5	37.9±1.2	37.7±2.7
Bottom	30.4±1.7	36.7±1.0	36.4±1.1	37.0±1.6	38.0±1.2	37.9±1.4
Mean	30.2±0.2	36.8±0.2	36.5±0.1	37.0±0.0	38.0±0.1	37.9±0.0

Table 7. Temperature of the eggshell that unhatched eggs

Temperature eggshell (°C)	Age (day)					
	0	7	14	21	28	32
Top	30.6±1.9	37.0±1.1	36.5±0.4	36.6±1.5	37.3±0.7	35.7±1.3
Bottom	30.7±1.9	36.8±1.0	36.3±1.0	36.6±1.3	36.7±1.9	36.1±1.2
Mean	30.7±0.1	36.9±0.2	36.4±0.2	36.6±0.0	37.0±0.4	35.9±0.3

is too high or too low. The decrease in shell temperature in eggs that fail to hatch is thought to be due to the underdevelopment of the embryos so that the waste product (heat) from the embryo's metabolic process does not occur. This result is following that of Nickolova (2005) who stated that the temperature of the Muscovy duck embryo increases along with its metabolism.

### Hatchability

This study revealed a hatchability of 86%. During hatching, some eggs had gone bad so that they did not hatch successfully. This result was caused by a crack in the eggshell so that it became rotten. Cracking can be caused by the holding of the eggs on top during hatching. Some incubation nests contained nests that were incubated by more than one broodstock. The nature of incubating more than two eggs is called brood parasitism. The brood parasitism behavior was not different among broodstock. Because it involved two broodstocks in one nest, it caused the incubated eggs to crack and break. The behavior of the broodstock and the conditions of the incubated eggs during hatching were very helpful for producing high hatchability (Harun *et al.*, 1998). During hatching, the Muscovy duck broodstock performed body movements, shifted the position of the body, and rotated the egg. These aspects were understood as ways for the broodstocks to cool the incubating eggs (Yana, 2016). Based on observations, the broodstock leaves the eggs for the cooling process when the shell temperature is too high (over 38°C). In addition, the broodstock also rotated the eggs, allegedly as an effort to regulate the even distribution of heat in the eggs. According to Yana (2016), during hatching, the broods rotate the eggs 26-30 times per day.

### Conclusions

During hatching, Muscovy duck eggs undergo physical changes in the form of weight loss, changes in shell appearance, shell temperature, and enlargement of the depth of the air sacs. The egg shape index of successfully hatched eggs in this study was 73.6%. During hatching, there was a change in the appearance of cleanliness of the shells, from dirty to clean, with a total eggs weight loss of 9.6%. The shell temperature ranges from 36.8-38°C with a hatchability of 86%.

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