Egg shape index for sex determination of post-hatch chicks in Pekin ducks: a solution for smallholder duck farming in Lombok Indonesia

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Abstract

This study was conducted to assess how the egg shape index determines the sex of newly hatched chicks of Pekin ducks. Three hundred and sixty fertile duck eggs were incubated with a local electric hatching machine and 340 Pekin ducklings post-hatch were used. Multiple logistic regression, Chi-square test and Pearson's correlation were applied for evaluating egg weight, egg length, egg width and egg shape index in relation to gender determination. Results showed that the average weight of Pekin duck eggs was 67.5 ± 5.9 g, with a mean length of 60.7 ± 3.1 mm, mean width of 44.7 ± 0.9 mm and an average shape index of 76.2 ±1.7 and 70.9±2.8 for rounded and elongated eggs respectively. Rounded eggs had 82.0% conformation rate for female offspring, while elongated eggs had 77.7% confirmation for male offspring. The correlation coefficients were highly positive (0.71) and highly significant ($p<0.001$) for the shape index as predictor of sex of the offspring implying that egg shape index is a suitable parameter for sex identification.

Keywords: *egg shape index, egg weight, egg width*

Introduction

Pekin duck farming in Lombok is relatively new and dominated by small farms. The ducks are a genetic strain selected for meat producers, but they are also raised as layer ducks to fulfill the increasing demand for table eggs. For this reason, female ducks are preferred. However, the availability of female Pekin ducklings for replacement is limited because of the lower hatchability of Pekin duck eggs compared to local chicken eggs, namely 62.9% (Rashid et al. 2009) and between 74 to 84% for local chickens, depending on the rearing system (Sartika and Noor 2005). Differences in thickness and porosities of the eggshell seem to be the challenge for a successful incubation process. Moreover, sexing of newly hatched ducks is also more difficult than sexing of chickens. This is because of the different anatomy of the reproductive organ. To differentiate the sex of ducklings, the farmers normally keep the ducklings until the sex is obvious, at about 3 weeks of age; therefore, hatching business operations for Pekin duck eggs is less attractive to duck farmers. A number of studies have been carried out in gender identification of poultry. For instance, Weissmann et al (2014) observed sexing day old chick can be distinguished by endocrine analysis. Liu et al (2018) used genotyping analysis to differentiate the sex in chickens; Al-Shahie (2018) studied yolk hormones and egg weight in quails; Galli et al (2018) used laser spectroscopy in chickens; Mappatao (2018) used egg eccentricity with the aid of computer software. These methods are useful for developing solutions based on advanced science and technology but are not suitable for smallholders. Other studies used morphological characteristics of the eggs (eg: egg shape index) as a determinant of the sex of newly hatched chicks: Mead et al (1987) in sparrows; Arhin et al (2018) in Guinea fowls; Yilmaz-Dikmen and Dikmen (2013) in white

layer hens; and Milojević et al (2019) in Isa Brown hybrid parent stock. It seems that the shape index is generally applicable for most poultry egg sex identification purposes. To our best knowledge, no one has studied the morphological characteristics of egg and its relationship with sex in Pekin ducks, until today. Therefore, evolving appropriate techniques to predict the sex of duck eggs. pre-incubation, is promising and may augment the availability of day-old-ducklings for the smallholders.

Material and methods

Preparation for incubation

Three hundred and sixty fertile eggs were procured from a commercial duck breeder who raised Peking ducks under traditional management with simple housing, feeding with local feed stuffs asis local farmer practice and storage of collected eggs (Photo. 1 and 2). Eggs were individually washed and marked with indelible ink before setting in an incubator. The width and length of eggs were measured with a digital caliper (Mutitoyo, Japan) (±0.01 mm) and the shape index was calculated using the formula: SI = (W / L) × 100, where SI= shape index, W= width of the egg, and L= length of the egg. Based on the egg shape index, the eggs were grouped into spherical/sharp/elongated/narrow (index ranging from 68.1 to 73.7 %) and rounded/spherical/wide (>73.7) categories (Photo 3). One hundred and eighty fertile eggs per category were used and three incubation times as replicates were assigned. A local incubator with 300 egg capacity was used to incubate the eggs. The eggs were placed on a rack with the blunt part on the top. The eggs were kept in this position from days 1 to 4 at a constant temperature of 38^{o}C without being turned around. For candling the eggs to evaluate the fertility of the set eggs, a mobile phone flashlight was used on the 5th day (Photos 4 and 5). A clear picture was considered infertile (Photo 4). The next candling to evaluate the development of the embryo was on the 7th day. If the embryo died in the early phase, such eggs were discarded. A third candling was carried out on the 14th day to find out the development of the embryo and the death of the middle phase embryo. The fourth candling was carried out on the 21st day to assess the development of embryo and embryonic mortality. The eggs were turned twice at 08:00 am and 16:00 pm during the period from 5 to 26 days of incubation. To increase the incubator humidity as the hatching time was approaching, the eggs were sprayed with water or wiped with a wet cloth on the 25th day. Turning was stopped on the 26th day. The hatched DOD (day- old -ducks) on the 28th day were removed and wing banded, and kept until two weeks of age to observe the predicted sexes. During the process of incubation, 20 eggs were found to be either infertile or that they showed embryonic mortality, leaving only 340 chicks for determining the sex post hatching.

Assessment of the sexes of ducklings

The sex of the newly hatched DODs was assessed when they were two weeks-old. The vent method was used where the male was characterized by the presence of a bulge in the vent and females with no bulge (Photo 6 a and b). Of the 360 fertile eggs, 340 eggs hatched to ducklings, which were sexed and accounted to be further analyzed statistically.

Data analysis

Data were analyzed using descriptive statistics in SPSS 16.0 (2006). Multiple logistic regression analysis was used to determine the effects of each independent factor following Yilmaz-Dikmen and Dikmen (2013) and Alaşahan and Akpinar (2014). Shape index, width, length, and weight of the egg were continuous variables; the odds ratio was calculated using the regression coefficients between pairs of variables. Chi-square (X^2) test was employed to test the association of different categorical variables included in this study.

Pearson's correlation analyses were carried out to test the relationship between variables.

Photo 1. Pekin ducks under small holder rearing management

Photo 2. Collected fertile Pekin duck eggs

Elongated

Rounded /spherical

Photo 3. Elongated (left) and rounded eggs (right)

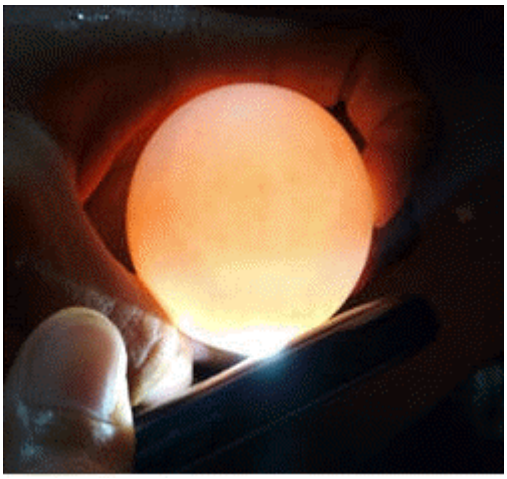


Photo 4. First candling on day 5 used a flashlight of a mobile phone (a clear picture showed infertile)

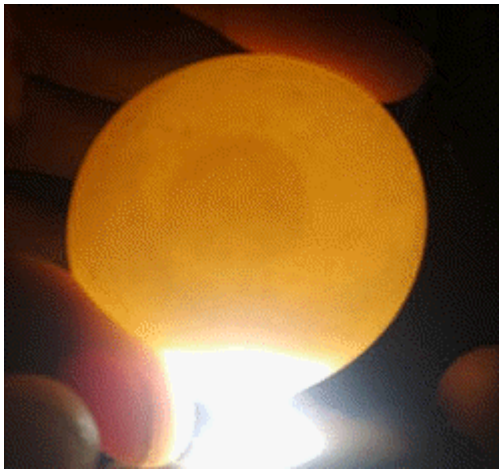
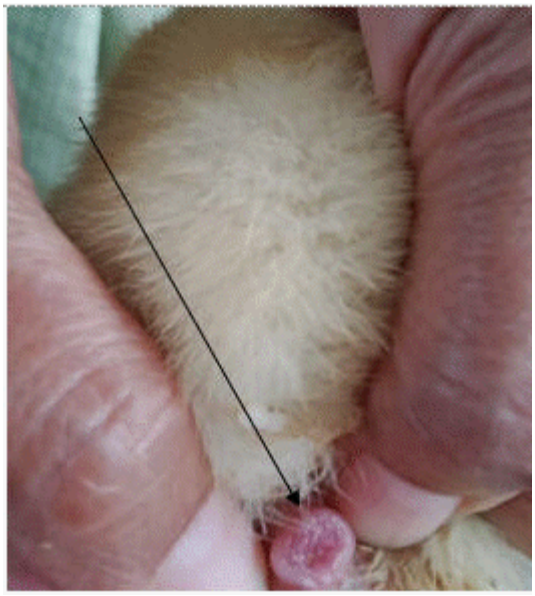
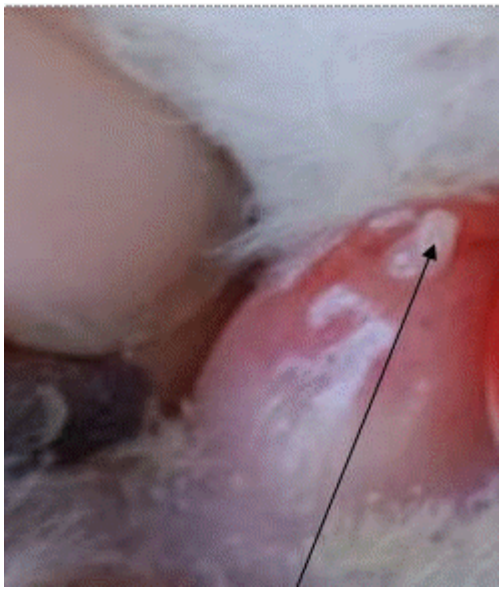


Photo 5. First candling on day 5 used a flashlight of a mobile phone (dark egg showed fertile)



a. Female ducks at 2 weeks of age with no bulge



b. Male ducks at 2 weeks of age had a small bulge (in white color)

Photo 6. Sex determination using vent method in Pekin ducks

Results and discussion

Egg weight and length were higher for male eggs than for female eggs, while egg width and egg shape index were higher for the females than the males (Table 1). This observation is consistent with that of Milojević et al (2019).

Table 1. Descriptive statistics of the fertile eggs used in the study

Variable	Sex	Mean	SD	Min	Max
Egg mass, g	Female	65.4	6.7	51	76
	Male	69.6	3.9	63	76
	Overall	67.5	5.9	51	76
Egg length, mm	Female	59.1	2.7	54	65
	Male	62.7	2.2	57	65
	Overall	60.7	3.1	54	65
Egg width, mm	Female	44.9	1.1	42	46
	Male	44.5	0.7	43	45
	Overall	44.7	0.9	42	46
Egg shape index, %	Female	76.2	1.7	70.8	79.3
	Male	70.9	2.8	67.7	78.9
	Overall	72.5	3.7	67.7	79.3

The chi-square test showed that the predicted value for female eggs was 82.8 percent, and for male eggs it was 77.8 percent, with overall prediction success of 80.9 percent (Table 2), or more than 50% the expected prediction in terms of sex probability or sex ratio. It means that the predictive accuracy was quite high suggesting that using the shape index is much more advantageous compared with the traditional technique of incubation. Increasing the incubation volume by decreasing the culled number male chicks especially for layer poultry is another advantage of using the shape index technique (Abbas et al 2019). Other advantages include an efficient management system that will reduce both feed cost and daily care of ducklings as no male birds are to be kept, besides lower floor space requirement. In short, the present study revealed that the egg shape index is a simple and easy method for determination of sexes in poultry chicks. Our results show that elongated and narrow eggs tended to be males and the round and wide eggs gave rise to female offspring as reported earlier by Yilmaz-Dikmen and Dikmen (2013). The male birds with elongated egg shape were due to the ratio of surface area to volume which is smaller as the elongated eggs are smaller than the rounded

eggs (Maclatjry et al 1973). The male birds have higher fluorescence intensity compared to the females (Galli et al 2018), implying the validity of this approach.

Table 2. Chi-Square test for observed and predicted sexes

Sex (Observed)	Sex (Predicted)		Confirmation rate (%)
	Female	Male	
Female	174	36	82.8
Male	29	101	77.7
Total	203	137	80.3

As for the Pearson's correlation of multiple logistic regression for all factors affecting the sex determination, the egg shape index showed high positive correlation ($r = 0.71$) and was highly significant ($p<0.001$). Other factors such as egg mass, egg length and egg width were low-negative, high-negative and low-positive respectively (Table 3). Thus, shape index is apparently suitable to determine the sex of an egg prior to incubation.

Table 3. Correlation coefficients of egg morphometric measurements for gender determination post hatch in Pekin duck eggs

Dependent (Y)	Variable Independent (X)	Pearson Correlation (r)	*p*
Sex	Egg mass (g)	-0.37	0.070
Female / Male	Egg length (mm)	-0.60	0.001
	Egg width (mm)	0.26	0.216
	Egg shape index (%)	0.71	0.000

Conclusions

- Pekin ducks can be sexed at pre-incubation stage using egg shape index measurements.
- Elongated eggs were males and rounded eggs tended to be female

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