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Original article

Sex difference, growth pattern, and cephalic index of Turi ducks at different ages based on head morphometry

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ABSTRACT

This study aims to determine the morphometric differences in the head of male and female Turi ducks. Ten male and ten female day-old ducks (DOD) were randomly selected by a lottery system from the population, raised, and had their head morphology measured using a digital caliper with an accuracy of 0.01 mm on the first day, and at the age of 2, 4, 6, and 8weeks. The result showed that male Turi duck had wider ($p < 0.05$) head at the ages of 1 day, 2 and 6 weeks, head length and head height at the ages of 1 day, 2, 4, 6, and 8 weeks, rostrum width at the ages of 1 day, 4, 6, and 8 weeks, and rostrum length at the age of 2, 4, 6 and 8 weeks. There were no significant differences ($p > 0.05$) in the head width at the ages of 4 and 8 weeks, rostrum width at 2 weeks, and rostrum length at 1day old male and female Turi ducks. Morphometric growth pattern showed that older Turi ducks (at a range of 1 day to 8 weeks) had larger ($p < 0.05$) head morphometry. However, the cephalic index in male and female Turi ducks was not significantly different ($p > 0.05$) at all ages. It could be concluded that in general head morphometry was useful for determining male and female Turi ducks at the ages of 1 day, 2, 4, 6, and 8 weeks.

Keywords: head height, head length, head width, rostrum length, rostrum width

INTRODUCTION

Turi Duck *(Anas domesticus)* is a germplasm of Indonesia, that was raised in urban farming in the regency of Kulon Progo, Sleman, Purworejo, Kutoarjo, Kebumen, and Special Region Yogyakarta (Hanif and Nugroho, 2018). Turi ducks was domesticated from Mallard ducks *(Anas platyrhynchos)* many centuries ago. Decree of the Minister of Agriculture of the Republic of Indonesia No. 665/ Kpts/ SR.120/ 6/ 2014 assigned that Turi duck was one of the duck families of Indonesia (Dewanti, 2010). Turi duck had a slender body shape with a body perpendicular to the horizontal lane, a long and small neck shape makes the size of the neck asymmetrical with the size of the head. The prominent characteristic of the adult Turi duck was its relatively smaller body size compared to the average duck. The body weight of Turi duck

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ranged from 1.3 kg - 1.8 kg. Adult male Turi ducks had black feathers on their necks and blackish-brown feathers on their bodies. Adult female Turi ducks had brown or light brown feathers on their necks and brown stripes on their bodies. Meanwhile, the color of the plumage of male and female Turi ducklings was relatively the same, namely light brown (Hanif and Nugroho, 2018).

Determining the sex of duckling was important because of the purpose of breeding them. Raising broiler ducks required male ducks because their body size was larger and they had more meat than female ducks. Meanwhile, raising laying duck prioritized egg productivity rather than carcass percentage and quality (Ungkusonmongkol and Wattanachant, 2024). Raising laying ducks required a larger number of female ducks than male ducks (Abd El-Hack *et al*., 2019). Determining the sex of ducks is important to be done early so that breeders could determine the right way to manage duck rearing and ultimately duck productivity would be optimal. The difference between male and female birds could be determined based on their reproductive organs. Male birds had a phallus which is located on the ventral wall of the cloaca or the base of the proctodeum (Diaz-Figueroa and Mitchell, 2006). However, determining the sex of day-old ducks (DODs) required a special expertise, so farmer had difficulty with that.

Sexual dimorphism referred to differences in size, shape, characteristics, and color between male and female animals of the same species. Sexual dimorphism in birds could be seen in feathers, voices, and differences in body size (Mori *et al*., 2017). However, sex determination of bird species with monomorphic plumage such as in the Turi duck is challenging. Therefore, the sexing of birds based on sexual size dimorphism was often used to develop morphometric-based sexing tools (Pagnon *et al*., 2024). Firdaus *et al*. (2022) reported that cranium morphometry was different between male and female muscovy ducks (*Cairina moschata*) before sexual maturity.

Morphometric techniques could be used to determine the cephalic index. However, there had been no publications regarding the avian cephalic index. The cephalic index was the ratio of head width divided by head length and multiplied by 100 (Akinbami *et al*., 2014). The cephalic index was useful in determining craniofacial growth. The cephalic index could be used to determine the shape of an individual's head (Marugán-Lobón *et al*., 2022). To the best of our knowledge there had been no publications regarding the sex and head morphometry of Turi ducks, therefore this study aims to determine the morphometry of Turi duck heads to determine sex.

MATERIALS AND METHODS

Turi ducks were obtained from Mr. Darmadi's farm located in Imogiri district, Bantul regency, Special Region of Yogyakarta (Figure 1). Bantul regency has a tropical monsoon climate according to the Koppen climate classification (Beck *et al*., 2020). The rainy season started from October to March, and the dry season from April to September. The average rainfall in Bantul was 90.76 mm, and the months with the highest rainfall are December, January, and February. Air temperature ranged between 26-32 degrees Celsius, with air humidity 62-93% (MCGA, 2024).

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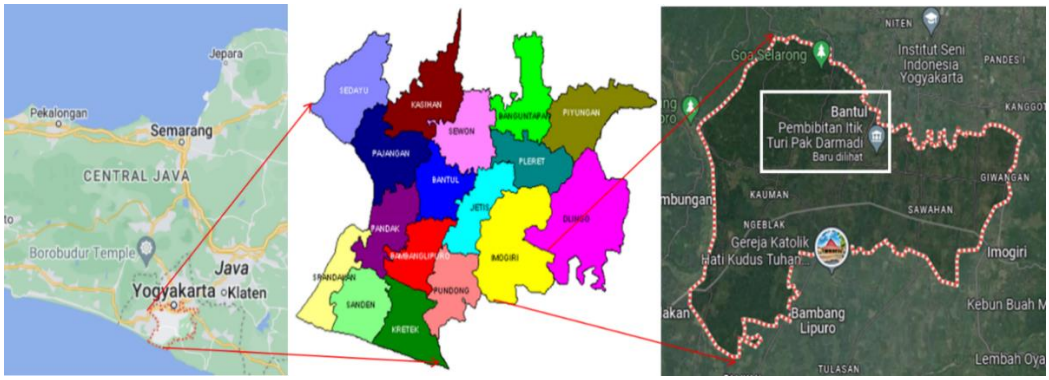

Figure 1 Map of Turi duck farming site in Imogiri district, Bantul regency, Special Region of Yogyakarta (Source: Google Maps); white box: location of Mr. Darmadi's duck farm.

This observational study was carried out using the morphometric observation method of Turi duck heads at different ages. This study design used a completely randomized design. Samples were determined randomly from the population using the lottery method. Proving the sex of a duck was conducted by observing the presence of phallus in the cloaca of males, and or absence of phallus on female ducks.

There were twenty Turi ducks used, consisting of 10 male and 10 female ducks. Each duck sample had its head morphometry measured using a digital caliper with an accuracy of 0.01 mm at the ages of 1 day, 2 weeks, 4 weeks, 6 weeks, and 8 weeks. Head width was measured from the distance between the left and right quadrate bones across the cranium (Figure 2). Head length was measured from the distance between the atlanto-occipital joint to the edge of the beak. Head height was measured from the distance between the supraoccipital to the angle of the mandible (Dayan *et al*., 2014). Rostrum width was measured from the distance of the rostrum from the right lateral to the left lateral, measured horizontally. The length of the rostrum was measured from the craniofacial hinge to the tip of the premaxilla (Bourgeois *et al*., 2017). Cephalic index was calculated by dividing head width by head length multiplied by 100% (Hecht *et al*., 2019).

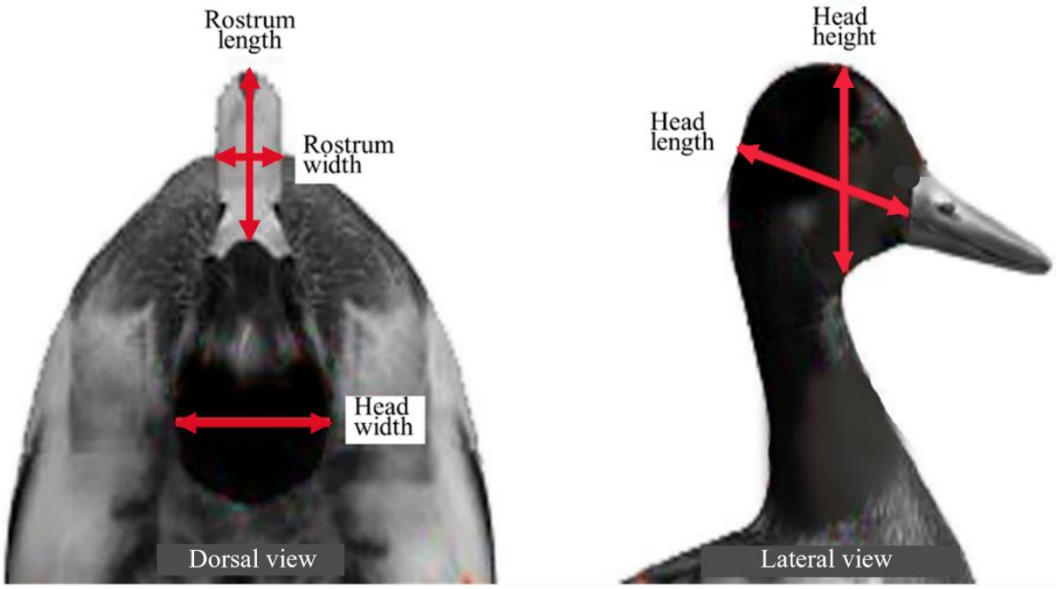

Figure 2 Duck head morphometry measurement points (Livolsi *et al*. 2015).

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Data analysis

Data were analyzed using Manova Repeated Measure at a 95% confidence interval in Statistical Product and Service Solution (SPSS) software for Windows version 25.

RESULTS

Head morphometry

The average head width of male Turi ducks aged 1 day, 2 weeks and 6 weeks was greater than that of the female Turi ducks ($p < 0.05$). There were no significant differences ($p > 0.05$) in head width of male and female Turi ducks aged 4 weeks and 8 weeks (Table 1). Female Turi ducks had a lower ($p < 0.05$) head length at the ages of 1 day, 2, 4, 6, and 8 weeks, respectively (Table 2). Male Turi ducks had a greater ($p < 0.05$) head height at each age group (Table 3). Table 4 showed that male Turi ducks had a greater ($p < 0.05$) rostrum width than the female ones at the age of 1 day, 4,6, and 8 weeks. Rostrum width of male and female Turi ducks aged two weeks was not different significantly ($p > 0.05$). Rostrum length of male Turi ducks was greater ($p < 0.05$) than the female ones at ages of 2, 4, 6, and 8 weeks. The length of the rostrum of male and female DOD was not significantly different ($p > 0.05$) (Table 5).

Table 1 Differences in head width (cm, means ± SD) of male and female Turi ducks

	1 day	2 weeks	4 weeks	6 weeks	8 weeks
male	1.73 ± 0.06 [a]	2.24 ± 0.04 [a]	2.49 ± 0.07 [a]	2.78 ± 0.06 [a]	2.83 ± 0.05 [a]
female	1.67 ± 0.04 [b]	2.11 ± 0.05 [b]	2.43 ± 0.07 [a]	2.72 ± 0.05 [b]	2.79 ± 0.10 [a]

Different superscripts (a and b) in one column indicate differences ($p < 0.05$).

Table 2 Difference in head length (cm, means ± SD) of male and female Turi ducks

	1 day	2 weeks	4 weeks	6 weeks	8 weeks
male	4.70 ± 0.16 [a]	7.62 ± 0.33 [a]	9.76 ± 0.29 [a]	10.93 ± 0.36 [a]	11.84 ± 0.44 [a]
female	4.56 ± 0.06 [b]	7.31 ± 0.20 [b]	9.37 ± 0.14 [b]	10.41 ±0.09 [b]	11.19 ± 0.27 [b]

Different superscripts (a and b) in one column indicate differences ($p < 0.05$).

Table 3 Differences in head height (cm, means ± SD) of male and female Turi ducks

	1 day	2 weeks	4 weeks	6 weeks	8 weeks
male	2.17 ± 0.03 [a]	2.88 ± 0.06 [a]	3.53 ± 0.08 [a]	3.73 ± 0.09 [a]	3.84 ± 0.07 [a]
female	2.12 ± 0.05 [b]	2.74 ± 0.07 [b]	3.45 ± 0.09 [b]	3.60 ± 0.06 [b]	3.74 ± 0.08 [b]

Different superscripts (a and b) in one column indicate differences ($p < 0.05$).

Table 4 Differences in rostrum width (cm, means ± SD) of male and female Turi ducks

	1 day	2 weeks	4 weeks	6 weeks	8 weeks
male	1.08 ± 0.34 [a]	1.86 ± 0.73 [a]	2.37 ± 0.11 [a]	2.55 ± 0.08 [a]	2.72 ± 0.07 [a]
female	1.05 ± 0.02 [b]	1.79 ± 0.08 [a]	2.26 ± 0.43 [b]	2.44 ± 0.06 [b]	2.59 ± 0.05 [b]

Different superscripts (a and b) in one column indicate differences ($p < 0.05$).

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Table 5 Difference in length (cm, means ± SD) of rostrum in male and female Turi ducks

	1 day	2 weeks	4 weeks	6 weeks	8 weeks
male	1.72 ± 0.09 [a]	3.53 ± 0.09 [a]	4.77 ± 0.25 [a]	5.46 ± 0.12 [a]	5.81 ± 0.20 [a]
female	1.68 ± 0.05 [a]	3.30 ± 0.09 [b]	4.49 ± 0.14 [b]	5.12 ± 0.21 [b]	5.49 ± 0.23 [b]

Different superscripts (a and b) in one column indicate differences ($p < 0.05$).

Morphometric growth pattern

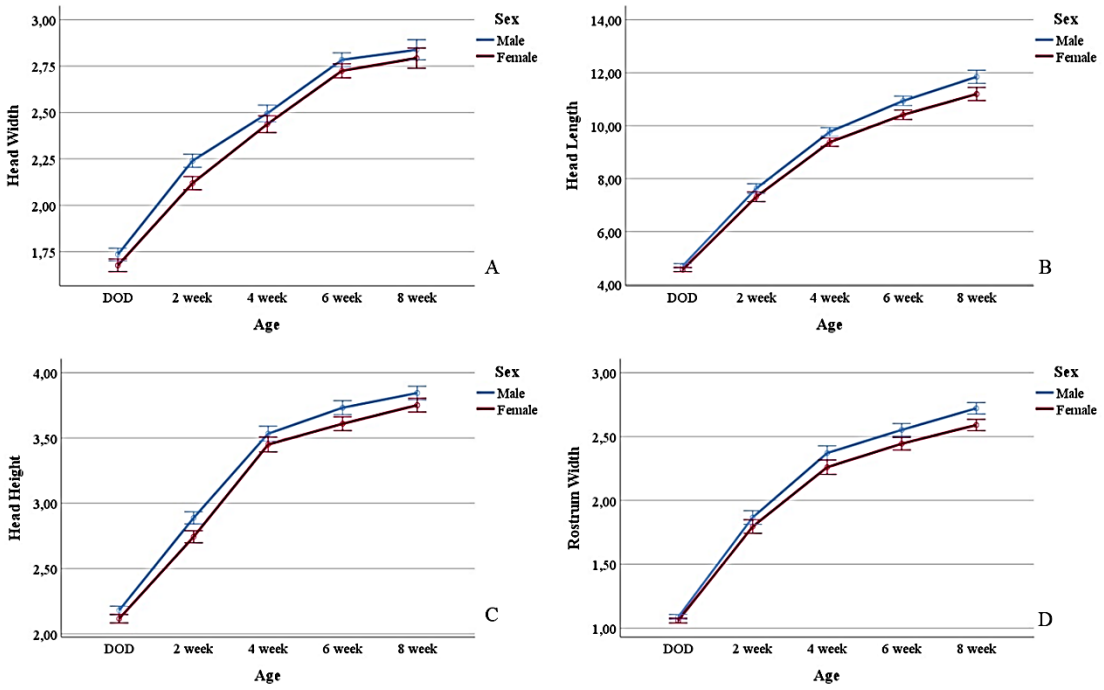
The morphometric growth of the Turi duck's head in this study can be seen from the morphometric growth curve (Figures 2 A-E). The Manova Repeated Measure analysis of the interaction of age with head morphometrics showed significance ($p < 0.05$). This means that there were differences in the morphometric size of each Turi duck's head at different ages from 1 day to 8 weeks. The older the Turi duck is (in the range of 1 day to 8 weeks), the larger the morphometric parameters of the head.

Cephalic index

The cephalic index in male and female Turi ducks did not show a significant difference ($p > 0.05$) in Turi ducks aged 1-day, 2-, 4-, 6-, and 8-weeks (Table 6).

Table 6 Cephalic index of male and female Turi ducks at different ages

	1 day	2 weeks	4 weeks	6 weeks	8 weeks
male	58.20 ± 2.78	55.23 ± 5.74	50.08 ± 3.06	51.01 ± 2.53	47.15 ± 2.07
female	58.06 ± 1.89	52.91 ± 2.99	49.90 ± 3.06	51.72 ± 3.29	48.98 ± 2.27



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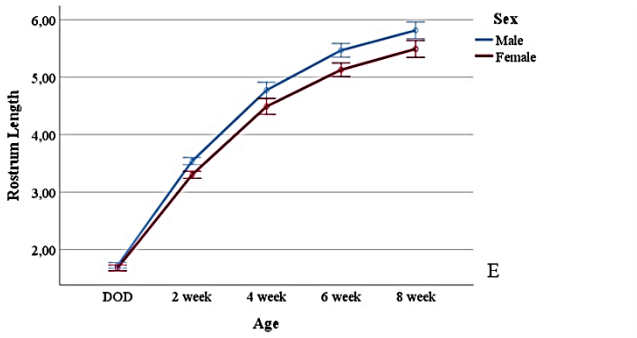

Figure 3 Growth pattern of head width (A), head length (B), head height (C), rostrum width (D), and rostrum length (E) of Turi ducks

DISCUSSION

The morphometric differences in male and female ducks were influenced by factors such as body weight and skeletal size (Kadurumba *et al*., 2021). Growth hormone (GH) had an important role in determining sexual dimorphism, maturation, gametogenesis, and ovulation (Ismoyowati *et al*., 2016). Hormones that influenced the growth and development of birds were steroids, estrogens, and androgens. Sexual dimorphism in birds could also occur because male birds have a more dominant testosterone hormone (Zhang *et al*., 2023). Head length and rostrum width were greater in males than females of Larus michahellis gulls (Pazvant *et al*., 2022).

Head morphometry

These results are in accordance with a study conducted by Kokoszyński *et al*. (2019) that the body size of ducks, including the head, in male ducks was greater in all aspects compared to female ducks. Firdaus (2021) reported that there were significant differences between male and female muscovy ducks at the ages of 2, 4, 6, and 8 weeks. The morphometric data measured were head length, head width, head height, rostrum length, rostrum width, and mandible length. The results of this study supported the results of this study which stated that at different ages the head width, head length, head height, rostrum length and rostrum width of male muscovy ducks were greater than those of female muscovy ducks.

Differences in morphometric size could be caused by body weight and body frame size. The growth of male Turi ducks was faster than that of female Turi ducks due to the testosterone hormone which was more dominant in male Turi ducks. Growth hormone (GH) secretion could be stimulated by the presence of testosterone. Testosterone had an important role in the formation of the poultry skeleton (Ghassani *et al*, 2022). The testosterone hormone in the starter phase would synergize with GH and would ultimately stimulate growth by accelerating cell division and protein synthesis so that male birds grew larger than female birds (Ismoyowati *et al*., 2016). The hormones testosterone and estrogen had been shown to influence the growth, maturation, and maintenance of the skeleton. These two hormones had an important role in bone growth and achieving peak bone mass (Squire *et al*., 2017).

In female birds that were in the egg production period, the hormone estrogen in the bird's body would stimulate the formation of medullary bones. Estrogen during sexual maturity influenced bone growth and sexual dimorphism of the body skeleton (Canoville *et al*., 2019). The process of bone formation in poultry required calcium. Calcium during the female bird's egg production period would be used as a material for forming eggshells in the oviduct. Calcium absorption would increase in female birds. This statement could be interpreted to mean that calcium absorption that occurs in female birds was not only used in the bone growth process but was also used for reproductive development (Fu *et al*., 2024). This was the reason why there could be differences in

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size between the skeletons of female and male birds, therefore body size of female birds was smaller than male birds (Atterholt and Woodward, 2021).

Morphometric growth pattern

The growth patterns of male and female Turi ducks in this study showed that after the ducks were 8 weeks old, the head of male and female Turi ducks were still increasing in size. The increase in size in 8-week-old Turi ducks could be caused by the immature condition of the Turi ducks. At the age of Turi ducks in this study, there is still the possibility of experiencing growth in head. The results of head morphometric measurements of male and female Turi ducks showed growth patterns at each age with the highest growth speed at DOD (day-old ducks) up to 4 weeks of age for almost all variables. The results of this study were in accordance with the statement of Firdaus (2021) which stated that head growth in male and female ducks has the same growth pattern. Birds would experience a high growth and development process at different ages until they become sexually mature. The highest growth period occurred before the livestock reached sexual maturity, and then a slowdown occurred, precisely when body maturity had been reached (Kokoszyński *et al*., 2019). After sexual maturity, the growth of birds would continue, although growth would be slower, even to the point that bone and muscle growth stopped when the bird reached body maturity (Ball and Wade, 2013).

The sexual maturity had a positive effect on the duck growth. Ducks that entered the sexual maturity phase would continue to grow, even though growth was relatively slower and relatively constant than before (Ancona *et al*., 2020). The fastest growth rate in ducks occurred at the age of 4-6 weeks (Lv *et al*., 2022). Skeleton was the body component that experienced the earliest growth compared to other body parts. The growth and development of the livestock body began with the head and legs, then continued with body length and muscle and fat were the final parts of the body (Kokoszyński *et al*., 2019). The growth of the poultry skeleton began at DOD (day-old ducks) and peaked at the ages of 6 to 7 weeks, at which age their skeleton was 80% formed. Poultry muscle growth reached its peak at 9 to 13 weeks of age. Fat growth in poultry peaked at 12 to 14 weeks of age (Yin *et al*., 2021). There was a relationship between growth and feed consumption which could describe how much nutritional content they consumed. The perfect amount of nutritional content contained in the ration was very important to obtain optimal growth results (Fouad *et al*., 2018). Phosphorus and calcium content had a big influence on skeletal growth. The difference in posture between male and female birds was caused by the high level of feed consumption and aggressiveness in the males. This could cause male birds to be larger than female birds (Zhu *et al*, 2018).

Cephalic index

Cephalic index is useful in determining craniofacial growth. In humans, it was observed that there was a sex difference with males having a higher cephalic index compared to females in the Nigerian population (Akinbami *et al*., 2014). The mean cephalic index for males was lower than for females in the North Indian Population (Seema and Verma, 2016); and Southwest Iran (Absalan *et al*., 2023). Meanwhile, the cephalic index of dogs was relatively the same in Boxer, Maltese, and Miniature schnauzers, the female had a higher cephalic index in Dachshund, Greyhound, and Labrador retriever dogs (Hecht *et al*., 2019). The cephalic index could be used to determine the shape of an individual's head, brain size, and allometry in avian craniofacial evolution (Marugán-Lobón *et al*., 2022). In this study, no significant difference in the cephalic index between male and female Turi ducks, which means male and female Turi ducks had relatively the same head shape. A study on the cephalic index in turkey reported that there was no real difference in the cephalic index between male and female turkey. Poultry have relatively small, dense heads with a round, slightly oval shape (Süzer *et al*., 2018).

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CONCLUSION

Male Turi duck has a greater head width at the age of 1-day, 2- and 6-weeks, head length and head height at the age of 1-day, 2-, 4-, 6-, and 8-weeks, rostrum width at the age of 1-day, 4-, 6- and 8-weeks, and rostrum length at the age of 2-, 4-, 6- and 8-weeks. These parameters could be used to determine the sex of the Turi duckling. However, the head width at the age of 4- and 8-weeks, rostrum width at the age of 2-weeks, and rostrum length at the age of 1-day, and cephalic index could not be used to distinguish the sex of Turi ducks.

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AUTHOR'S CONTRIBUTIONS

Bangun Nur Wijaya (BNW), Yeni Dhamayanti (YD), Sri Mulyati (SM), Soeharsono Soeharsono (SS), Sunaryo Hadi Warsito (SHW), Sri Hidanah (SH)

BNW, YD, and SM: conceived the idea, designed the mainframe of this manuscript, acquisition, analysis and interpretation of data. SS, SHW and SH: critically read and revised the manuscript for intellectual content. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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