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Original article

Cranium morphometry for distinguishing male and female Muscovy duck (*Cairina moschata*) before sexual maturity

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ABSTRACT

Gender determination of Muscovy duck as early as possible is essential for the efficiency and effectiveness of duck production. This study aimed to determine the morphometric differences in prepubertal male and female Muscovy duck (*Cairina moschata*) as predictors of gender. This study used a split-plot design, with the observed variables cranium length, width and height, mandibular length, and rostrum length and width. This study used a total of 80 samples of duck heads consisting of 40 male and 40 female Muscovy duck heads, with ten heads each in the age group of 2, 4, 6, and 8 weeks, respectively. Results showed that the length, width, and height of the cranium, mandibular length, and rostrum lengthand width were greater in males ($p < 0.05$) than those of the females in all age groups. It could be concluded that the morphometric size of prepubertal male Muscovy ducks head was greater than those of the female ones at the same age; thereby, it could be used to distinguish gender. Based on the morphometrics, further study can also be conducted to measure other body parts of the Muscovy duck apart from the cranium. In addition, it is necessary to study the morphometric measurements of the cranium in other poultry as a basis for identifying sex.

Keywords: cranium, gender determination, mandibular, morphometric, rostrum

INTRODUCTION

Muscovy duck is a waterfowl widely bred in Indonesia as a source of animal protein and for the financial income of the farmer (Ismoyowati *et al*., 2019). Gender determination of Muscovy duck as early as possible is essential for fulfilling their nutrition. The nutrients needed by male and female ducks are different due to differences in the purpose of rearing. The male Muscovy duck is prioritized for the meat, while the female Muscovy duck is the egg production (Fouad *et al*., 2018). Gender determination from an early age needs to be done for the efficiency and effectiveness of duck production (Tanganyika and Webb, 2019). Sex differentiation using the cloacal inspection method is difficult for farmers to do on a duck that has not yet reached sexual maturity due to the difficulty in identifying the penis at a young age (Odwyer *et al*., 2006).

The morphometrics can be applied in forensics to determine gender. Skulls are often used as samples for identification in forensics because the skull is a tough bone to damage caused by fire, humidity, temperature changes, and others (Alvarez *et al*., 2018). Head length could be used to identify gender with an accuracy rate of 88% in young Mucovy and 93% in adult Mucovy (Calabuig *et al*., 2011). So far, no study has been carried out on measuring the cranium to determine prepubertal duck gender. This study aimed to determine the morphometric differences in cranial length, width and height, mandibular length, and rostrum length and width as predictors of prepubertal Muscovy duck (*Cairina moschata*) gender.

MATERIALS AND METHODS

This research is an observational study on the skull size of male and female Muscovy ducks (*Cairina moschata*). The sample used was 80 heads of Muscovy ducks consisting of 40 heads of the male and 40 heads of the female, with ten heads in each age group of 2, 4, 6, and 8 weeks, respectively. The head of the duck was obtained from a duck supplier in Mojosari District, Mojokerto Regency. The sex of the duck was determined based on the anatomy of the reproductive organs after slaughtering the duck. Male Muscovy ducks are marked by a pair of oval testes and a spiral penile (Gerzilov *et al*., 2016), while female ducks are marked with a pair of ovaries and clockwise spirals of the vagina (El Gendy *et al*., 2016; Leisler and Winkler, 2020). The head of the Muscovy duck was soaked with sodium hydroxide 3% to clean the meat attached to the bones (Hartnett *et al*., 2011).

Observed variables in this study were cranium length, width and height, mandibular length, and rostrum length and width. Cranial length is the farthest distance from the tip of the premaxilla to the external occipital protuberance. The width of the cranium is the farthest distance the cranial bones traverse the postorbital process. Cranial height was measured from the basic of os temporale to the highest point of the skull. The width of the rostrum is the farthest distance across the rostrum from the right to the left of the rostrum. The length of the rostrum is the farthest distance of the rostrum measured from the premaxilla to the tip of the maxilla. Mandibular length is the farthest distance from the tip of the mandible to the lateral mandibular process (Figure 1). The measurements of the cranium parts were carried out using a caliper with an accuracy of 0.02 mm. Data obtained were processed by split-plot test using SPSS (Statistical Product and Service Solutions) 23 for windows (IBM Corp., NY, USA).

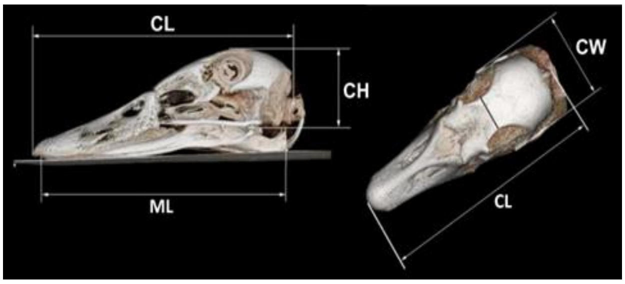

Figure 1 Lateral and dorso-ventral view image of length measurement of the Muscovy duck head; CL: cranial length; ML: mandibular length; CH: cranial height; CW: cranial width (modified from Dayan *et al*., 2014).

RESULTS

The length, width, and height of the cranium, mandibular length, and rostrum length and width were greater ($p < 0.05$) in males than those of the females in all age groups. The biggest difference between males and females in cranial length occurred at 8 weeks with a mean difference of 8.28 mm, while the smallest difference for the cranial length occurred at 2 weeks with a mean difference of 5.12 mm (Table 1). The biggest difference in mean between males and females in the cranial width occurred at 6 weeks, with an average difference of 3.30 mm. The smallest difference occurred at 4 weeks, with an average difference of 2.09 mm (Table 2). The biggest difference between males and females in the cranial height occurred at 2 weeks of age with a mean difference of 2.14 mm, and the smallest difference occurred at four weeks of age with a mean difference of 1.14 mm (Table 3). The mean difference between males and females in the mandibular length was greatest at four weeks of age with a mean difference of 7.46 mm, and the smallest difference occurred at two weeks with a mean difference of 5.36 mm (Table 4). The biggest difference in mean between males and females in the rostrum length occurred at the age of 6 weeks with an average of 5.61 mm, while the smallest average difference occurred at the age of 8 weeks with an average difference of 2.74 mm (Table 5). The biggest difference in mean between males and females in the rostrum width occurred at the age of 2 weeks with an average difference of 2.63 mm, while the smallest average difference occurred at the age of 6 weeks with a mean difference of 1.26 mm (Table 6).

Table 1 Muscovy duck (*Cairina moschata*) cranial length (mm, means ± SD) by gender and age groups

age (weeks)	female	male
2	60.14 ± 3.18 ^{Aa}	65.26 ± 3.20 ^{Ab}
4	74.55 ± 7.58 ^{Ba}	82.11 ± 6.16 ^{Bb}
6	81.99 ± 4.60 ^{Ca}	87.93 ± 1.88 ^{Bb}
8	91.48 ± 6.31 ^{Ca}	99.76 ± 5.07 ^{Cb}

^{a,b} Values with different superscripts in the same row differ significantly ($p < 0.05$); $^{A-C}$ Values with different superscripts in the same column differ significantly ($p < 0.05$).

Table 2 Muscovy duck (*Cairina moschata*) cranial width (mm, means ± SD) by gender and age groups

age (weeks)	female	male
2	15.58 ± 1.58 ^{Aa}	17.72 ± 0.98 ^{Ab}
4	20.24 ± 1.03 ^{Ba}	21.38 ± 1.07 ^{Bb}
6	21.34 ± 0.75 ^{Ba}	22.64 ± 0.81 ^{Bb}
8	21.63 ± 1.68 ^{Ba}	23.30 ± 1.21 ^{Bb}

^{a,b} Values with different superscripts in the same row differ significantly ($p < 0.05$); ^{A,B} Values with different superscripts in the same column differ significantly ($p < 0.05$).

Table 3 Muscovy duck (*Cairina moschata*) cranial height (mm, means ± SD) by gender and age groups

age (weeks)	female	male
2	20.36 ± 0.97 ^{Aa}	22.95 ± 0.67 ^{Ab}
4	24.44 ± 2.23 ^{Ba}	26.49 ± 1.34 ^{Bb}
6	25.69 ± 1.33 ^{Ba}	29.00 ± 0.78 ^{Cb}
8	30.86 ± 1.53 ^{Ca}	32.95 ± 1.04 ^{Db}

^{a,b} Values with different superscripts in the same row differ significantly ($p < 0.05$); $^{A-D}$ Values with different superscripts in the same column differ significantly ($p < 0.05$).

Table 4 Muscovy duck (*Cairina moschata*) mandible length (mm, means ± SD) by gender and age groups

age (weeks)	female	male
2	46.70 ± 3.03 ^{Aa}	52.07 ± 2.68 ^{Ab}
4	62.62 ± 7.68 ^{Ba}	70.08 ± 5.74 ^{Bb}
6	69.47 ± 3.28 ^{Ba}	74.27 ± 1.43 ^{Bb}
8	77.58 ± 5.83 ^{Ba}	83.98 ± 5.10 ^{Cb}

^{a,b} Values with different superscripts in the same row differ significantly ($p < 0.05$); $^{A-C}$ Values with different superscripts in the same column differ significantly ($p < 0.05$).

Table 5 Muscovy duck (*Cairina moschata*) rostrum length (mm, means ± SD) by gender and age groups

age (weeks)	female	male
2	28.58 ± 1.81 ^{Aa}	34.19 ± 0.86 ^{Ab}
4	38.37 ± 3.41 ^{Ba}	42.30 ± 4.23 ^{Bb}
6	42.56 ± 2.97 ^{Ba}	46.58 ± 1.14 ^{Bb}
8	48.59 ± 3.25 ^{Ca}	51.34 ± 2.27 ^{Cb}

^{a,b} Values with different superscripts in the same row differ significantly ($p < 0.05$); $^{A-C}$ Values with different superscripts in the same column differ significantly ($p < 0.05$).

Table 6 Muscovy duck (*Cairina moschata*) rostrum width (mm, means ± SD) by gender and age groups

age (weeks)	female	male
2	13.26 ± 0.70 ^{Aa}	15.90 ± 1.00 ^{Ab}
4	17.83 ± 1.87 ^{Ba}	19.52 ± 1.06 ^{Bb}
6	18.74 ± 1.19 ^{Ba}	20.00 ± 0.68 ^{Bb}
8	20.28 ± 2.96 ^{Ba}	22.41±1.01 ^{Cb}

^{a,b} Values with different superscripts in the same row differ significantly ($p < 0.05$); $^{A-C}$ Values with different superscripts in the same column differ significantly ($p < 0.05$).

DISCUSSION

Bone is a complex tissue consisting of cells and a matrix. Bone matrix is formed by fibers and essential substances that contain mineral salts. Bone mass and thickness are always dynamics of addition and reduction through the remodeling process in the bone matrix reabsorbed and reshaped (Florencio-Silva *et al*., 2015). Remodeling aimed to maintain the bones' shape and structure. Cells that play a role in forming bone are osteoblasts, and cells that play a role in absorbing bone are osteoclasts (Parra-

Torres *et al*., 2013). Normal osteoblasts could synthesize type I collagen and form new bone, whereas osteoclasts have eroded and reabsorbed bone (Florencio-Silva *et al*., 2015). Bone growth was influenced by several hormones, including growth hormones, androgens, and estrogens (Almeida *et al*., 2017). Growth hormone, or somatotropin, is a peptide hormone that stimulates growth, cell reproduction, and cell regeneration. Growth hormone played a role in regulating an increase in the number and size of cells. Growth hormone also played a role in stimulating the production of IGF-1, which functions to stimulate the production of chondrocytes (cartilage cells), resulting in bone growth (Tritos and Klibanski, 2016).

In this study, the morphometric size of male Muscovy duck was greater than those of the female Muscovy duck in all age groups. These results were in line with the study of Oguntunji and Ayorinde (2014) that the body sizes of the Muscovy duck of the male Muscovy duck are more prominent than that of the female. Previous studies reported that weight, body length, body height, body circumference, neck length, and wing length in male Pekin ducks were greater than in females (Kokoszyński *et al*., 2019). This was due to the influence of the male hormone testosterone. Testosterone could stimulate increased growth hormone secretion (Gibney et al., 2005). Growth hormone could stimulate faster growth by accelerating protein synthesis and cell division (Devesa *et al*., 2016). Bone growth and maintenance were significantly affected by testosterone. Chen and co-workers (2019) proved the skeletal effects of androgens-androgen receptors actions based on in vitro and in vivo studies from animals and humans.

This study showed an increasing growth pattern every week, with the highest growth rate occurring from week-2 to week-4 in all variables. Acceleration of bone growth occurs at the time before puberty (Soliman *et al*., 2014). Factors affecting growth rate, shape, and size according to endogenous factors (genetic and hormonal) and exogenous factors (environmental influences and feed) (Bushby *et al*., 2018). The appearance of the duck body can be influenced by heredity and environmental factors (Ackert-Bicknell and Karasik, 2013). This study showed that male and female cranial bones were still increased up to 8 weeks of age. At 8 weeks of age, the size of all variables was larger in males than in females, and there was still the possibility of cranium growth.

CONCLUSION

The morphometric size of male Muscovy ducks head was greater than those of female ones at the same age; thereby, it can be used to distinguish Muscovy duck gender before sexual maturity. Based on the morphometrics, further study can also conduct to measure body parts of the Muscovy duck other than the cranium. In addition, it is necessary to study the morphometric measurements of the cranium in other poultry as a basis for gender identification.

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