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Sex Determination in Male and Female *Melopsittacus undulates* using a Morphometric Method

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Abstract

Parakeets (*Melopsittacus undulates*) are classified parrot order Psittaciformes. Parakeets are monomorphic birds whose sex is difficult to be distinguished. Sex identification is very important for breeding efforts in order to increase the parakeet population. External morphology was determined to identify the sex of the birds. This research was conducted to determine the sex of parakeets (male and female). This study used five male and five female parakeets aged 4 months as the study objects. This study used the quantitative and qualitative method. Results of this study was verified by performing surgery to determine the sex of parakeet based on their reproductive organs. The t-test results of morphometric characteristics showed no significant different in the length of body, upper bill, lower bill, wing, tail, femur, tibial-tarsus, tarsometatarsus and digits as well as the body weight between male and female parakeets. The color of the cere was useful to accurately determine sex in parakeets (blue in males and white in females). This research provided information to the public about the differences between male and female parakeets for the selection of good broodstock in order to increase their population in captivity.

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INTRODUCTION

Parakeets *(Melopsittacus undulates)* are classified parrot order Psittaciformes, and worldwide distribution (Hussain *et al.*, 2017). Parakeets are native birds of an Australian and are monogamous birds. Parakeets are also commonly called budgerigars or budgies. Parakeets are often owned as pets in cages and often praised for their songs as well as their beautiful plumage colors, such as green, yellow, blue-white, and white-black (Adajar *et al.*, 2011). The popularity of parakeets as pet birds has led to high commercial prices for these birds. Male parakeets are used in song contests, while female parakeets are used for breeding (Roldan-Clara *et al.*, 2014).

Breeding parakeets in captivity are one of the efforts to meet the needs of a pet and reduce the supply from the catch in the wild. Parakeet breeding is a promising business because of the ease of maintenance and the high commercial value of the birds. Parakeets are monomorphic, and their sexes are difficult to distinguish. Identifying the sex is very important for breeding efforts to increase the population. Sex determination is also very important for referrals nurseries and data collection. The morphological differences between males and females have been studied as this basic information is necessary for selection and breeding programs (Yakubu, 2011). External morphology can be used to determine male and female parakeets. This method is easy and quick to predict determine the sex of male and female birds (Mischler *et al.*, 2015). This method is also to studies on avian evolutionary, ecology and genetics, population dynamics, behavior, migration and conservation management of species and populations (Calabuig *et al.*, 2013).

Many studies on sex identification in birds have focused on species with extreme sexual dimorphism in such factors as size, plumage coloration, or parental ornamentation. Some adult birds could be sexed by morphometric analysis if the relationship between sex and body size or feather color were quantified (Cerit *et al.*, 2007). Morphometric analysis method has several advantages, including can be applied to adult birds, fast, cheap and can be applied outside the breeding season. The morphometric method has been used for relatively small numbers of samples (Fournier *et al.*, 2013). The parameters measured in this method include body length, upper bill length, lower bill length, wing length, tail length, femur length, tibial-tarsus length, tarsometatarsus length, length of the digits, body weight, number of primary and secondary flight feathers on the wings, and tail feathers. The parameters used to describe parakeets sex include the color of their cere, eye, chest, mantle, rump and wing (Nugroho, 2015). This research was conducted to identify the sex of parakeets based on their external morphology. This research can provide several information about the differences between male and female parakeets for the selection of good broodstock in order to increase the population in captivity.

METHODS

This study used five male and five female parakeets (age 4 months). This study used quantitative and qualitative method. The parameters measured for the quantitative morphometric approach included body length, upper bill length, lower bill length, wing length, tail length, femur length, tibial-tarsus length, tarsometatarsus length, length of digits, body weight, number of primary and secondary flight feather on the wings, and tail feathers. A ruler with a 30-cm scale, calipers with 0.01 mm precision and a digital scale were used to measure the body weight. The qualitative parameters in this study included cere color, eye, chest, mantle, rump, and wing. Observations were carried out for characteristic description parameters in male and female parakeets. The determined sex was then verified by performing surgery to check the parakeets' reproductive organs.

Body length was measured from the tip of the beak to the tip of the longest tail feather using a ruler. The length of the upper bill was measured with calipers from the tip of the beak to the culmen or edge of the cere border. The length of the lower bill was measured with calipers from the tip of the beak to the base end. Wing length was measured with a plastic ruler from the border of the humerus to the tip of the primary wings. Tail length was measured from the base of the tail to the tip of the longest tail feather using a ruler. Femoral length was measured with calipers from the base to the end of the tibial border. The length of the tibia-tarsus was measured with calipers from the femoral border to the tarsometatarsus. The length of the tarsometatarsus was measured with calipers from the border of the tibia to the tarsus. The length of each digit (digit I, II, III, and IV) was measured from the tip to the base of the tarsus with calipers (Nugroho, 2010). The number of primary flight feathers was counted from the tip of the phalanx to the ulna and the secondary flight feathers were counted from the border of the wing to the ulna and to the humerus

border. Tail feathers were measured from the base of the tail to the tip of the longest tail feather (Zuberogotia *et al.*, 2016).

The quantitative morphometric data were analyzed using a *t*-test to determine the differences in the mean value of the measured parameters between males and females. A p-value < 0.05 was considered significant. The statistical analysis was performed using SPSS version 16.0 software (SPSS Inc. Chicago, IL, USA).

RESULTS AND DISCUSSION

Morphometrics of the Parakeets

The data of morphometric parameters calculations for sex determination of male and female parakeets are shown in Table 1.

The *t*-test results revealed no significant different in body weight, body length and wings length between males and females birds. Comparison of external morphological characteristics between males and females in parakeets is associated with the anatomical and physiological functions bird. Male parakeets have longer bodies than females. Body weight, body length, and wing length are related, so the size of the body has a picture of the body shape (Berg *et al.*, 2012). Body weight is also associated with metabolism. This study found that the body weights of females are higher than the males. This is because the female have to incubate eggs while the male spends time looking for food and feeding until the baby birds fledge (Rose *et al.*, 2016). Another factor that influence the weight difference is testosterone hormone. Testosterone in female parakeets stimulates fat production and inhibits bone growth, whereas testosterone in males suppresses the production of body fat and bone. Testosterone affects the hippocampus in male parakeets, which is related to spatial learning and develop the large territory (Dewi *et al.*, 2015). Testosterone hormone also improves the quality of the songs as well as the brilliance of the color of the chest feathers. Differences in body weight between males and females affect the sound frequency of the parakeets (Tu *et al.*, 2011). Testosterone in male birds makes more often twittering, (when approaching the female bird will high frequency) and testosterone also makes the feathers brighter (Isnaeni *et al.*, 2010). The wings of female parakeet are longer than males because female parakeets must incubate and protect eggs as well as hide the eggs from predators. The wings of male parakeets are slimmer, due to the efficiency of flying in search of food (Adajar *et al.*, 2011). Wings and tail length that contribute to lift and drag are also integral parts of maneuvering and stability (Tobalske *et al.*, 2007).

The *t*-test results revealed no significant differences in upper bill and lower bill of male and female birds. The shape and length of the beak are related to the sound produced by birds. Male songs are used to attract females; they are used in sexual selection, male competition, and mate attraction (Chelen, 2009). The shape of the beak is useful for peeling skin of grains that are eaten. The upper beak is longer than the bottom beak

Table 1. Results of morphometrics analysis of male and female parakeets

Parameters	Male		Female		*P*
	r	Mean ± St. Dev	n	Mean ± St. Dev	
Body length (cm)	5	17.32 ± 1.546	5	16.86 ± 0.944	0.581
Upper Bill length (cm)	5	1.03 ± 0.115	5	1.01 ± 0.086	0.742
Lower Bill length (cm)	5	0.86 ± 0.093	5	0.85 ± 0.088	0.973
Wings Length (cm)	5	11.49 ± 0.900	5	11.63 ± 0.489	0.771
Tail Length (cm)	5	9.48 ± 1.062	5	9.12 ± 0.701	0.538
Length of femur (cm)	5	1.32 ± 0.258	5	1.26 ± 0.194	0.690
Length of tibia-tarsus (cm)	5	3.52 ± 0.286	5	3.42 ± 0.420	0.672
Length tarsometa tarsus (cm)	5	1.12 ± 0.238	5	1.06 ± 0.089	0.613
Length of digit I (cm)	5	0.76 ± 0.054	5	0.70 ± 0.100	0.273
Length of digit II (cm)	5	1.34 ± 0.134	5	1.28 ± 0.228	0.626
Length of digit III (cm)	5	1.96 ± 0.364	5	1.76 ± 0.288	0.464
Length of digit IV (cm)	5	1.60 ± 0.282	5	1.40 ± 0.223	0.250
Body weight (g)	5	36 ± 5.477	5	38 ± 4.472	0.545

Note: No significant differences were observed between males and females (P > 0.05).

(Danner *et al.*, 2016). The shape and length of the beak are adaptations for food, thermoregulation, and sound production functions (Tattersall *et al.*, 2016). The male sings territorial bird songs more aggressively compared to females. Male songs are long with complex vocalizations, whereas female songs tend to be simpler (Hoeschele *et al.*, 2016).

The *t*-test results revealed no significant differences in length of femur, tarsometatarsal, tibia-tarsus and digits of male and female parakeets. Most birds have digits I to IV. The first finger is precisely at the back. Radius position in taxonomic associated with the position birds when perching or not (Sinyo *et al.*, 2014). Tarsometatarsus forms the legs and fingers that are useful for perch. The bird's leg bone is the most severe bone, contributing to support the body weight of birds (Saraswati *et al.*, 2018).

The numbers of tail, primary and secondary flight feathers of male and female parakeets are shown in Table 2.

Table 2. Numbers of tail, primary and secondary flight feathers

Amount of feathers	Mean	
	Male	Female
Primary flight feathers	9	9
Secondary flight feathers	9	9
Tail feathers	6	6

Both primary and secondary flight feathers were not different between males and females. Primary wings were lighter and predominantly black, whereas the secondary feathers were black with white stripes. Tail feathers in males and females are predominantly black. Pilastro (1995) reported that parakeet wings have the same shape and structure of axis components, so the number of feathers between males and females is the same. Trail (2001) the wing flight feather songbird 9-10 and secondaries varying 9-15 depending on the length wing. Tobalske (2007) wings on birds are used to maneuvers and control position on the air. The morphology of the wing which is useful for maneuvering is related to escape performance under the threat, so the wings response turbulent is needed.

Description of the parakeet morphology

The qualitative characteristics of male and female parakeets are shown in Table 3.

Table 3. Qualitative characteristics of male and female parakeets

Characteristics	Sexes	
	Male	Female
Cere color	Blue	White
Eye color	Black-White	Black-White
Chest color	Light Blue	Blue-White
Mantle color	Black dominant	Black and blue
Wings color	Light Black	Black-White
Rump color	Light Blue	Blue-White

Eye and Cere Color to Verify the Sex of Parakeets

Based on observations of the color of the cere in parakeets, there were five blue and five white ceres. The cere is on top of the beak and works like a nose. In order to verify sex determination in male and female parakeets, the surgery was conducted to identify the sex of the parakeets by their gonads. Adajar (2001) distinguished parakeets by looking at the color of the cere; the male parakeet had a blue cere, whereas the females had white or beige. Lahaye *et al.*, (2014) stated that the color of ceres in parkakets were affected by testosterone hormone. High levels of testosterone can increase blue in cere.

The eyes of male and female parakeets were black with white color as the outer circle. Nogueira (2008) reported that white color in the eyes of adult parakeets is a breeding indicator reflecting the age of the birds. Lind *et al.*, (2013) stated that birds have an excellent spatial acuity and colour vision compared to other vertebrates, while their spatial contrast sensitivity is relatively poor for unknown reasons. Contrast sensitivity describes the detection of gratings of varying spatial frequency. Cere and eyes color in male and female parakeets are shown in Figure 1.

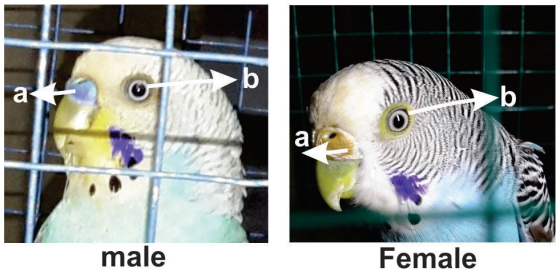
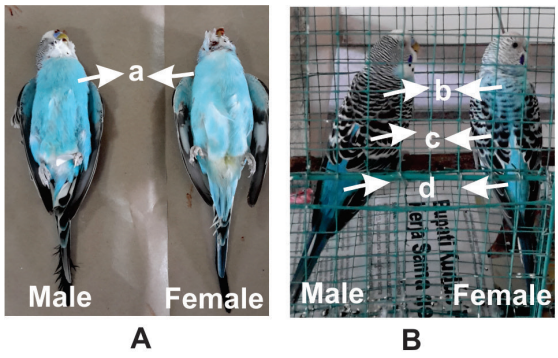


Figure 1. a. Blue colored cere in male and white colored cere in female; b. black with white color as the outer circle.

Chest, Mantle, Wing, and Rump-colored

Feathers

Chest feathers and rump feathers in the male are a lighter blue than female. The color of the mantle was predominantly black in males and blue in females. The wings of males were predominantly black with light colored, whereas the wings of the female were black and white. Bendoy *et al.*, (2010) reported that the feathers of male parakeets are lighter and look more ornamental. Igic *et al.*, (2016) stated that males of many species often use colorful and lighter. This ornament is useful for attracting female attention. Sexual selection is the primary evolutionary driver of ornamentation among animals, and has produced some of the most extraordinary colours in nature. Griggio *et al.*, (2009) stated that feather color can derive from pigments (usually melanin or carotenoids) deposited in the protein matrix of the feathers during growth. Plumage colours often resulted from a combination of light reflected by the structural components of the feathers and the light absorption by incorporated pigments. Chest, mantle, wing, and rump-colored feathers in male and female parakeets are shown in figure 2.



A B

Figure 2. A. The color of the chest (a); B. color of the mantle (b), wings (c), and rump feather (d).

The result of this study showed that there was no significant difference between male and female parakeets on morphometric measurements. Sex determination in male and female parakeets used morphometric method showed no differences from posterior extremists. Qualitative parameters showed in color ceres blue for male and white for females. This research provided information to the public about the differences between male and female parakeets for the selection of good fledgling in order to increase the population in captivity.

CONCLUSION

From the data shown, it can be inferred that there is no significant difference between male and female parakeet related to their morphometric characteristic. The difference between male and female can be seen from the qualitative characteristic. Parakeets *(M. undulates)* can be identified as male and female in accordance with the features contained in the cere, which is blue in males and white in females.

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