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Morphometric Study and Sexual Dimorphism in White-Cheeked Turtles (*Siebenrockiella Crassicollis*) in the Conservation Area of Bengkulu University

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ABSTRACT

White-cheeked turtle Siebenrockiella crassicollis, known as the "smiling turtle" is one of the endangered turtle species in the world. Conservation efforts are needed to protect this species from the threat of extinction. Conservation is a complex process and involves various disciplines. The location of this study was in the Turtle Learning Center (TLC) conservation area of Bengkulu University, to determine the morphometrics and sexual dimorphism of male and female *S. crassicollis* based on body size as a conservation effort. The study subjects were 10 *S. crassicollis* (5 males and 5 females). Several morphometric measurements that have been carried out include head width, carapace length, carapace width, carapace arch length, carapace arch width, carapace height, plastron length, plastron width, midline on all plastron scales (gular, humeral, pectoral, abdominal, femoral, and anal), tail length, tail thickness, and body weight. A t-test was conducted to ensure the morphometric characteristics of male and female *S. crassicollis*. The results of the analysis showed significant differences. Male *S. crassicollis* have a longer humeral scale diameter and a longer tail.

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1. INTRODUCTION

Turtles are one type of reptile that has a distinctive body shape, with characteristics, namely, the presence of a shell called the carapace, a dorsal part, and a plastron on the ventral part. (Setiadi, 2014). One of the species of freshwater turtles is kThe white-cheeked turtle has the international name Black Marsh Turtle, the local name is white cheek.(Hasan & South, 2023). *S. crassicollis*It also known as the black swamp turtle, smiling turtle, and Siamese temple turtle, among others, is a freshwater turtle endemic to Southeast Asia. *S. crassicollis* is abundant in most of the rainforests of Southeast Asia (Thailand, Sumatra, Borneo, Java, and the Malay Peninsula) and has heteromorphic sex chromosomes of the XY/XX type. (Kawaguchi et al., 2012). S. crassicollis has other names, namely Siamese Temple Turtle, Black Marsh Turtle, and Dickhalsschildkröte which is an oviparous animal (reproduces by laying eggs) that lives in fresh water and is active at night.(Nurani et al., 2023).

S. crassicollis have small to medium-sized bodies, with an average carapace length of 17–20 cm. (Derooij, 2001). This species usually inhabits shallow, slow-flowing waters in freshwater marsh habitats. *S. crassicollis* is primarily a submerged predator, feeding on invertebrates and small fish, although it occasionally preys on decaying plants, fruits, or carcasses of larger animals that fall into the water.(Dody & Syukur, 2023).*S. crassicollis*has is a morphology, the shape of the upper jaw (lip) is curved like a smile. Its body is relatively small, and the length of its shell reaches 200 mm. The core (neck) is narrow and narrows towards the front. The spinal cut is also narrow, about 40% of the width of the skull in the middle of the body(Widiya et al., 2022). There are differences in characteristics between the sexes of *S. crassicollis*, with males being considered sexually mature

when they reach 4 inches in length (at about two to five years of age), while females are sexually mature when they reach 6 to 7 inches in length (which may take five to seven years). Females will grow larger than males. In order to use shell size as a factor in determining the sex of a turtle, the turtle must have reached adult size.(Silahooy & Huwae, 2020).

Illegal trade has caused the number of this species to continue to decline, this is because in the international market, *S. crassicollis* meat is in high demand for consumption and its carapace is used as a raw material for Traditional Chinese Medicine (TCM). Indonesia is one of the main exporting countries for *S. crassicollis* in the Indonesian domestic market, *S. crassicollis* is traded as a pet, but the extent of its trade in Indonesia is not yet known.(Tartusi et al., 2020). So the International Union for Conservation of Nature (IUCN) has included *S. crassicollis* in the Vulnerable (VU) category, namely a species that is at risk of extinction in the medium term and at risk of becoming Endangered (EN)(Jabidi et al., 2019), globally *S. crassicollis* has been included in the EN category. In 2003 this species was officially included in Appendix II by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which means this species is not yet classified as rare but has the potential to become rare if its trade is not controlled (Ernst et al., 2016).

Figure 1. 1 *S. Crassicollis* in the TLC area of Bengkulu University

Turtle Learning Center (TLC) Bengkulu University is a place to preserve turtles, particularly crassicollis. TLC *Conservation is a place of learning and conservation that is outside its natural habitat. The conservation carried out at the University of Bengkulu is the result of cooperation between universities, especially the University of California Greensboro, United States. In the research conducted by* (Sari et al., 2019), the role of this conservation is as a protector or means to save the Sumatran turtle species obtained from the findings of the community and animal lovers' groups in Bengkulu Province and its surroundings. Conservation activities also carry out captive breeding efforts to maintain the population. crassicollis in the Bengkulu Province area. According to (Ruyani et al., 2022), The results of conservation breeding can be returned to their natural habitat to restore the animal population in the wild.

Knowing the sex of turtles plays a role in conservation efforts, so this research on the sexual dimorphism of *S. crassicollis* helps conservation efforts. Dimorphism itself according to(Frayer & Wofpoof, 1985)Sexual dimorphism is the systematic external differences between individuals of different sexes within the same species. Examples include size, coloration, and the presence or absence of body parts used in courtship displays or fighting.

One of the activities that supports ex-situ conservation of Sumatran turtles, especially *S. crassicollis*, is conducting research on morphometric differences and sexual dimorphism in *S. crassicollis* turtles at the Turtle Learning Center (TLC) or ex-situ conservation of Sumatran turtles at the University of Bengkulu. This study aims to determine the differences in sexual dimorphism in white-cheeked turtles. *S. crassicollis.*

2. RESEARCH METHOD

a. Method, Time, and Place of Research

This study uses a quantitative approach with morphometric methods. This study used a sample of 10 (5 males and 5 females) of adult age. The location of turtle research was carried out in the Turtle Learning Center (TLC) area of Bengkulu University with samples taken, namely turtles of the type *S. crassicollis. This study was conducted from January 2023 to September 2024.*

b. Morphometric Measurement

S. crassicollis measured by traditional morphometrics using scales, calipers, and measuring tape. The measurement objects consist of 20 morphometric patterns divided into 5 aspects, namely head, carapace, plastron, tail, and body weight. (Ernst et al. 2016). There are 2 ways to measure the length and width of the carapace, namely straight line and curved line measurements. Straight-line measurements are carried out with a 0.1 mm caliper. The variables measured: Head Width (HW); the longest carapace length (CL) does not have to be in the middle of the line; carapace width (CW); carapace height (CH) on the line separating the second and third vertebral scales; the longest plastron length (Plastron Length/PL) does not have to be in the middle of the line; Plastron width (Plastron Width/PW) at the thoracic fracture between the pectoral and abdominal scales; and the length of the medial suture of all plastron scales (Figure 2). The arrangement of all plastron scales according to toDuro et

al. (2021) starts from Gular (Gul), Humeral (Hum), Pectoral (Pect), Abdominal (Abd), Femoral (Fem), and Anal (An); Tail Thickness (TT) is measured at the bottom of the cloaca and the top of the tail; and Tail Length (TL) is measured from the cloaca opening to the tip of the tail. The base of the tail to the cloaca (AB); Cloaca diameter (BC); cloaca to the tip of the tail (CD). Other measurements using a measuring tape include the length of the carapace curve (Curved Carapace Length/CCL) measured from the tip of the anterior to posterior scales; Curved Carapace Width (CCW) from the tip of the rightmost marginal scale to the left and Weight (Weight/W), the turtle is weighed by placing it on a digital scale (maximum capacity of 10 kg).

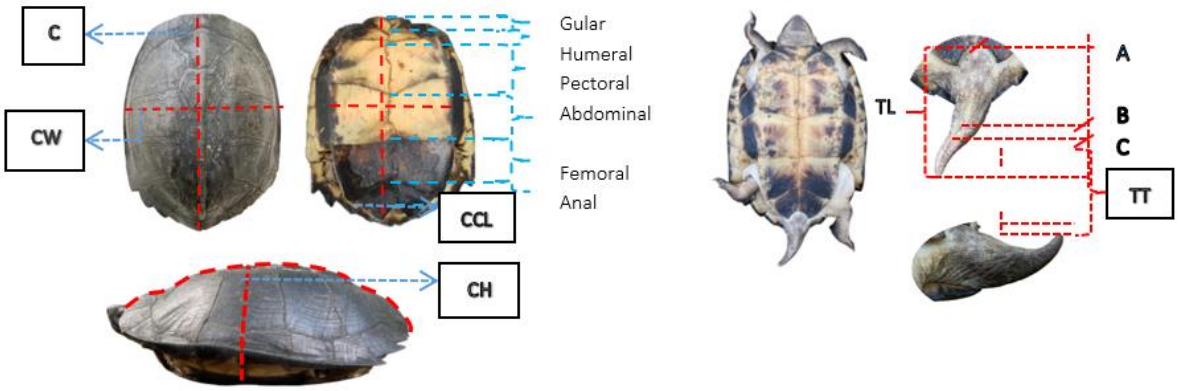

Figure 2. 1 Measurement Morphometry CL: Carapace Length. CW: Carapace Width, PL: Plastron Length, PW: Plastron Width, CCL: Curved Carapace Length. CH: Carapace Height and TL: Total Tail Length, AB: Tail Length From Base To Cloaca, BC: Cloaca Diameter, CD: Tail Length From Cloaca To Tip Of Tail, TT: Tail Thickness

c. Data Analysis

Analysis of morphometric data with minimum-maximum range, average, and standard deviation, to see dimorphism data on the morphometric patterns obtained. The real dimorphism in *S. crassicollis* is determined by a t-test, which includes normality and homogeneity tests that are useful for ensuring data is normally distributed and homogeneous. This analysis uses IBM SPSS Statistics 25 software. The index calculation is carried out on the carapace and plastron sections by comparing the length of the midline of all plastron scales (gularis, humerus, pectoral, abdomen, femoral, and anal) with the length of the plastron and on the carapace by comparing the sections (carapace width, carapace arch length, carapace arch width and carapace height) with the carapace length using the formula:

$$\textbf{Indeks I} = \frac{\mathbf{A}}{\mathbf{B}}$$

Catatan:
I = Indeks
A = Length of Plastron Scales
B = Plastron Length

The results of observations and calculations are displayed in the form of (Tables 1 and 2) and (Figures 1 to 5) as support.

3. RESULTS AND DISCUSSION

General morphometric data of *S. crassicollis* in the TLC area of Bengkulu University can be seen in table 1. The morphological characteristics of *S. crassicollis* can be identified based on the shape of the head, body, and tail. The head has a width of 26.40 - 30.80 mm; the body consists of the carapace and plastron. The carapace length is 162.20 - 173.60 mm with a carapace width of 126.20 - 132.00 mm and a carapace height of 63.40 - 71.60 mm. The carapace of *S. crassicollis* is oval with a carapace curve length of 181.60 - 191.60 mm and a carapace curve width of 158.20 - 170.60 mm. In the plastron section, there are 6 scales that have different sizes, namely the plastron length of 145.20 - 159.60 mm with a plastron width of 74.80 - 83.80 mm. *S. crassicollis* has a cone-shaped tail with a larger tail base with an average tail length of 21.49 - 15.48 mm. The average weight of adult *S. crassicollis* is 703.40 - 804.60 g. In detail, the morphometric measurements obtained can be seen in the following table 3.1.

Table 3. 1 Morphometric data of adult white-cheeked turtles living in the TLC area of Bengkulu University (n= 10)

Part	Morphometrics	(X̄ ± SD)		Min-Max		Sig
		Male	Female	Male	Female	
Head	Head width (HW)	30,8 ± 1,6	26,4 ± 1,1	29,00-33,0	25,0 - 28,0	0,24
Carapace	Carapace length (CL)	173,60± 4,5	162,2 ± 2,4	168,0- 178,0	160,0 - 166,0	0,12
	Carapace width (CW)	126,2 ± 3,0	132,0 ± 1,8	121,0 - 128,0	130,0 - 135,0	0,36
	Length of the curve carapace (CCL)	191,6 ± 6,2	181,6 ± 2,3	185,0 - 200,0	179,0 - 184,0	0,07
	Arch width carapace (CCW)	158,2 ± 3,8	170,6 ± 5,5	152,0 - 162,0	165,0 - 179,0	0,53
	Carapace height (CH)	63,4 ± 2,8	71,6 ± 3,4	60,0 - 67,0	69,0 - 77,0	0,67
Plastron	Plastron length (PL)	145,2 ± 6,1	159,6 ± 5,5	135,0 - 150,0	155,0 - 168,0	0,94
	Plastron width (PW)	74,8 ± 3,7	83,8 ± 2,5	70,0 - 80,0	81,0 - 88,0	0,50
	Gular (GUL)	18,0 ± 1,2	14,6 ± 1,5	17,0 - 20,0	13,0 - 16,0	0,30
	Humeral (HUM)	10,0 ± 0,0	9,6 ± 1,1	10,0- 10,0	8,0 - 11,0	0,00*
	Pectoral (PECT)	31,2 ± 0,8	38,8 ± 3,0	30,0 - 32,0	34,0 - 42,0	0,07
	Abdominal (ABD)	33,6 ± 1,1	29,2 ± 2,4	32,0 - 35,0	25,0 - 31,0	0,26
	Femoral (FEM)	27,6 ± 3,7	30,6 ± 3,7	25,0 - 34,0	24,0 - 33,0	0,95
	Anal (AN)	22,4 ± 2,4	27,8 ± 1,7	20,0 - 25,0	26,0 - 30,0	0,19
Tail	Total tail length (TL)	55,33± 3,5	37,3 ± 5,8	50,8 - 58,8	28,3 - 43,4	0,31
	Cloacal diameter (BC)	9,34 ± 0,6	7,3 ± 1,3	8,6 - 10,1	5,9 - 9,0	0,04*
	Length of tail base to the cloaca (AB)	28,8 ± 3,3	17,5 ± 3,5	23,0 - 31,4	13,6 - 21,0	0,59
	Cloaca Length to the tip of the tail (CD)	21,4 ± 2,0	15,4 ± 1,8	19,2 - 24,8	13,0 - 17,1	0,00*
	Thickness of tail (TT)	10,6 ± 1,1	10,6 ± 3,6	9,60 - 12,4	8,8 - 17,1	0,13
Weight (W)= (g)		703,4 ± 80,3	804,6 ± 67,8	790,00 - 804,6	750,00 - 887,0	0,93

Based on table 3.1 the morphometrics above, there are several parts that can be used as determinants to distinguish the secondary sexual characteristics of the sex of *S. crassicollis*. Male and female turtles have different sizes in each morphometric part. Male turtles morphometrically have larger sizes, including head width, carapace length, carapace arch length, gular, humeral, abdominal, and overall tail length, tail length from base to cloaca, tail length from cloaca to tip of tail, tail thickness, and cloaca diameter. In the female sex morphometrically, namely: carapace width, carapace arch width, carapace height, plastron length, plastron width, pectoral, femoral, anal, and body weight.

Crassicollis Males have a longer humeral scale midline length compared to female *S. crassicollis* table 3.1. The difference in the length of the humeral scales of males and females shows a significant difference with a significant value of 0.00. Based on the results of the t-test, a very significant difference is also shown in the tail section measured from the cloaca to the tip of the tail (BC). *S. crassicollis* Males have longer tails compared to females with a significant value of less than 0.05, namely 0.00 (Table 3.2).

Table 3.2 Results of comparison of morphometric indices of plastron and carapace scales *S. Crassicollis* male and female

Indeks(X̄± SD)	Male	Female
Carapace width (CW)	0,7	0,81
Length of the curve carapace (CCL)	1,1	1,12
Arch width carapace (CCW)	0,9	1,05
Carapace height (CH)	0,3	0,44
Plastron width (PW)	0,5	0,53
Gular (GUL)	0,1	0,09
Humeral (HUM)	0,0	0,06
Pectoral (PECT)	0,2	0,24
Abdominal (ABD)	0,2	0,18
Femoral (FEM)	0,1	0,19
Anal (AN)	0,1	0,17

Morphometrics and Dimorphism are divided based on five aspects of measurement, namely: head, carapace, plastron, tail, and body weight.

a. Head

*S. crassicollis*has morphological characteristics of a black head with white spots on the cheeks and above the eyes, and has an upper jaw (lip) edge that curves like a smile, so it is also called the Smiling Terrapin turtle.In the head width measurements that have been carried out, the significance results obtained (Table 1) were 0.24, which is greater than 0.05, so the data is stated to be statistically insignificant.

b. Carapace

Figure 3. 1 *S. crassicollis* carapace: (a) Male (b) Female

From the results of morphological observations on *S. crassicollis* the oval carapace shape (dorsal shell) is widest just behind the middle, with a highly serrated posterior edge. On the carapace there is a protrusion in the middle that appears prominent and stretches across the middle of the carapace. The carapace is almost entirely black or dark brown with a radiating black pattern.

Based on the results of the index ratio table 3.2 the size of the carapace of *S. crassicollis* tends to be unequal. However, from the results of this observation, it was also found that the carapace of male turtles has a convex line in the middle of the carapace that looks prominent. The convex line on the carapace of turtles is often referred to as the dorsal or growing spine (Chen et al., 2015). Morphological measurements of male *S. crassicollis* have a thickness of protrusions on the carapace with an average of 4 mm–6 mm.

c. Plastron

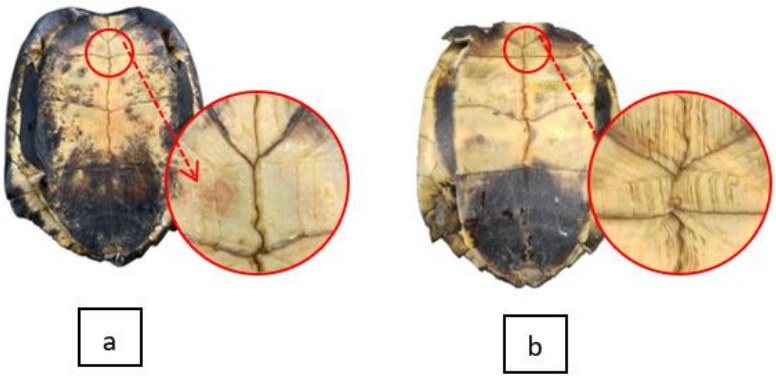

Figure 3.1 Differences in the length of the midline of the humeral plastron scales in the Plastron of *S. crassicollis*; (a) Male (b) Female

In plastron morphometry, there are seven measurement variables table 3.2. Plastron was analyzed based on the ratio index of plastron scales to plastron length in male and female *S. crassicollis*. The comparison index data consists of 7 morphometric characters on the plastron.

The plastron scale sizes of male and female *S. crassicollis* tend to be different table 3.2. This difference in plastron scale size is a secondary characteristic for freshwater turtles. The difference in the size of the plastron scales is influenced by the biological factors of the turtle; male *S. crassicollis* has a concave plastron while females have a flatter plastron; this is a secondary sexual characteristic for turtles. A concave plastron will make it easier for male *S. crassicollis* to mount the female during the mating process. The flat plastron in female *S. crassicollis* functions to provide more space for the reproductive organs when storing eggs. Morphometric plastron on the humeral scales shows a significant difference between male and female sexes in *S. crassicollis* table 3.2.

Measurement of 7 variables table 3.1 namely the width of the plastron, gural, humeral, pectoral, abdominal, femoral, and anal. Only the humeral part showed significant results from the t-test results of less than 0.05 with a significant value of 0.00, and then there is a real (significant) difference between the length of the humeral scales of male and female turtles. Male turtles have longer humeral scales (the center line on the plastron) compared to female turtles.

d. Tail

Figure 3.2. Differences in tail length and cloaca diameter of *S. crassicollis*; (a) Male (b) Female

The data obtained showed that male *S. crassicollis* had longer and thicker tails compared to female *S. crassicollis*, which were shorter and slimmer table 3.1. Based on previous research conducted by Dayeni et al. (2020), it shows that the tail *S. crassicollis* the male tail is longer than the female tail. From the data obtained from the measurement of tail length measured from the cloaca to the tip of the tail, a significant value of less than 0.05 was obtained, which is 0.00, and the diameter of the cloaca obtained a significant value of 0.04. Male turtles have longer tails and have a larger cloaca diameter, and the location of the cloaca is further from the base of the tail compared to females. The diameter of the cloaca of male turtles is larger than that of females due to differences in biological function and reproductive adaptation. In male turtles, the cloaca functions to release the reproductive organs (penis) during mating. In addition, a larger cloaca also helps males in directing the reproductive organs to the female during copulation, especially since the turtle's mating position often requires additional flexibility. In females, the cloaca is smaller because it primarily functions for laying eggs, and its shape is simpler without requiring adaptation for copulation. The location of the cloaca is far from the tail of male turtles because the function of the cloaca is not only as a digestive organ but also as a reproductive organ. The longer and thicker tail of male turtles will make it easier for them to accelerate during the mating process. Baizurah & Das (2021), which identifies that male turtles can be seen by their longer tails and the distant location of their cloaca to aid the mating process.

e. Heavy

The body weight of S. crassicollis obtained a significant value of more than 0.005, so that the data was stated as not statistically significant. However, if seen from the data, the weight of the male turtle is lighter, compared to the female, although not statistically. This is related to the living environment. *S. crassicollis* The research was conducted in the TLC area of Bengkulu University. *S. crassicollis* did not search for food independently as in nature, resulting in the comparison of male and female weights being statistically insignificant. This generally causes male turtles to be lighter than females, according to Karyadi et al. (2023), which states that female turtles have a relatively heavier weight because their mobility is not like that of the relatively active male turtles. This active behavior carried out by male turtles is usually to attract the attention of female turtles.when you want to get married, according to Bonnet (2001), which stated that the light body weight of males would benefit mobility during mating and foraging.

4. CONCLUSION

The results of the study on morphometrics and sexual dimorphism in white-cheeked turtles (Siebenrockiella crassicollis) in the Turtle Learning Center conservation area of Bengkulu University showed that there were significant differences in the length of the humeral scale midline and tail length between male and female turtles. Males have larger sizes in the length of the humeral scale midline and tail length, which supports sex identification for conservation purposes. These results are consistent with the objectives stated in the introduction, namely to identify differences in sexual dimorphism as part of conservation efforts for this species.

Future developments from this research could include further exploration of other morphometric adaptations related to the ecology of the species in conservation settings. Further research could also focus on the effectiveness of sexual dimorphism-based conservation strategies at the Turtle Learning Center or in other habitats to strengthen the white-cheeked turtle population in the wild.

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