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## **Sexual Dimorphism of Shell Turtles (*Cuora amboinensis*) in the Ex-situ Conservation Area, Bengkulu University, Sumatra**

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**Abstract.** This research aims to determine the physical differences between male and female turtles based on the secondary morphological characteristics of *Cuora amboinensis*. The method used in this research is a visual method with metric data presented in photos and measurement data, with a sample size of 20 individuals consisting of 12 females and 8 males. The research was carried out in September–December 2023 at the biodiversity study center at Bengkulu University. Observation results identified male *C. amboinensis* turtles with larger heads and brighter chins than female turtles. The carapace is oval with small bumps on vertebral 5 and wider marginal edges than in female turtles; the male's plastron displays a distinctive concave while the females have a flatter plastron. Male turtles have longer and thicker tails than female turtles. There are differences in the morphological characteristics of male and female *C. amboinensis* turtles, specifically in the head, carapace, plastron, and tail morphology.

**Keywords:** Bengkulu University; *Cuora amboinensis*; Conservation; Dimorphism; Turtle

### I. INTRODUCTION

*Cuora amboinensis* is a reptile that spends most of its time in water or is called a semiaquatic animal. In IUCN data, *C. amboinensis* is currently "Endangered" (EN). The population has declined by 50-80% over the last three generations due to widespread intensive exploitation that has not stopped. The species *C. amboinensis* is found throughout Southeast Asia, including in several regions of Indonesia. According to [1], states that the distribution of subspecies is as follows: *C.a. amboinensis* (Maluku, Sulawesi, and the Philippines), *C.a. cuoro* (Sumatra, Java, and nearby islands), *C.a. kamaroma* (Thailand, Philippines), *C.a. lineata* (Myanmar).

Conservation needs to be done to maintain and protect flora and fauna ecosystems [2][3]. Bengkulu University (UNIB) is the only campus in Bengkulu that has a turtle conservation program called the "UNIB Campus Safe

Home for Turtles" program to make the UNIB campus a green campus and a safe place for the development of turtles. This conservation area was formed in 2016 through collaboration between the University of Bengkulu and the University of Carolina Greensboro [4]. Knowing the sex of a turtle also has a big impact on conservation efforts. Several important aspects are: 1) identifying numbers and proportions can help design management to prevent imbalances. 2) biological differences between males and females may provide additional insights for designing more effective conservation strategies.

Sexual dimorphism is a term used to describe the morphological differences between male and female animals. Some differences in sexual behavior in animals are: 1) males are larger than females, and the aim is to fight with other males in terms of competing for mates and territory. 2) females are much larger than males, so

making a profit can increase the number of offspring. 3) males are smaller, allowing them to be more flexible in crossing various obstacles in complex habitats to find a female mate. 4) males have contrasting colors to attract females [5]. Morphological differences between males and females arise due to natural selection that focuses on different behaviors in the context of the same traits [6]. One of the main aspects of sexual dimorphism is related to reproduction, and the extent of the differences can often be explained by factors that influence the reproductive success of each sex. For example, males in many species face limitations in their reproductive success due to their ability to acquire mates through intrasexual or intersexual competition.

Research result [7], described the *C. amboinensis* turtle in the Asian region with a sample of 691 individuals. Observations on the turtle *C. amboinensis* were carried out by observing 5 patterns and 33 morphological characteristics. Completed the taxonomy of the species *C. amboinensis* and determined the only two recognized subspecies, namely *C.a. amboinensis* and *C.a. kamaroma*, *C.a. cuora* is synonymous with *C.a. amboinensis* while *C.a. lineata* is synonymized with *C.a. kamaroma*. According to [8], dimorphism is a secondary or primary sexual morphological characteristic to differentiates male and female *Heosemys spinosa* turtles. This study shows the male's relatively flat carapace, deep plastral depressions, a relatively longer tail, and a swollen base.

This study identified that male and female *C. amboinensis* turtles have significant differences in the size of the head, 5th vertebra (V5), and marginal sides, these aspects have not been observed by previous researchers. By revealing these differences, this research opens the door to a deeper understanding of sexual dimorphism. The research focuses on turtles spread across Sumatra, especially in Bengkulu province, to determine the physical differences between males and females based on secondary morphological characteristics. Distinguishing between males and females is important to identify sex variations to help in conservation efforts for the *C. amboinensis* species.

## II. METHODS

### *Time and Place of Research*

This research was carried out in September-December 2023 at the ex-situ conservation area of Bengkulu University.

### *Tools and Materials*

The tools used in this research were a caliper (Digital Sketmat Sigmat Vernier Caliper), an Android cellphone,

a ruler, and coins. The material used in this research was the turtle *C. amboinensis*

### *Research Procedures*

Prepare an adult *C. amboinensis* turtle, according to [7] adult turtles are characterized by turtles that have already reproduced, with a carapace length of 97.4-195 mm for male turtles and 98-198 mm for female turtles, identifying male and female turtles so that we get 20 turtles consisting of 12 female turtles and 8 male turtles.

### *Data Analysis*

This research was conducted using visual and metric methods, namely by using images, visualizations, or visual elements as the main data or important components of the research [9][10]. All parts of the turtle's body morphology were identified, including head morphology, eye patterns, shape and color of the chin, feet, hands, carapace, plastron, and tail, observed to produce several differences that could distinguish between male and female individuals. Differences were found in the morphology of the head, carapace, plastron, and tail. Metric data was carried out using calipers to see size differences in head and tail morphology. Technical measurements can be seen in Figure 1.



Figure 1. Measuring the tail length of *C. amboinensis*.

## III. RESULTS AND DISCUSSION

From the observations and measurements, several differences in secondary morphological characteristics of *C. amboinensis* were obtained, including head morphology, carapace morphology, plastron morphology, and tail morphology.

### *Head Morphology*

*Cuora amboinensis* has a triangular head with three circular yellow lines from the top of the nose to the tip of the head. Several characteristic features that can differentiate male and female turtles in terms of head morphology, namely head width and chin color, can be

seen in Figure 2. Head width was measured using a caliper from the widest point in the head area. The head width of male turtles varies between 28.1 mm to 33.2 mm, while the head width of female turtles is the smallest, 25.4 mm to the largest, 28.9 mm. The head of the male turtle *C. amboinensis* is larger compared to the female turtle (Figure 2a). A large head provides an advantage in fighting, fighting for food, and competition for female mates through direct competition or displaying dashing visuals to attract the female's attention. Female turtles tend to have smaller heads because their reproductive role is more focused on egg development and nest maintenance. The smaller head makes nest-keeping movements easier. These differences reflect

different evolutionary strategies between the sexes to increase their reproductive success in their natural environment. According to [11], males of *C. amboinensis* tend to have larger heads and sturdier legs and arms than females. Male turtles have striking color characteristics, whereas female turtles choose suitable males based on expression; for example, the male turtle's chin shows a bright yellow color, in contrast to female turtles, whose chin color tends to be softer/paler yellow (Figure 2b). Sexual selection is evidenced by differences in brightness between the two sexes, such as in turtle necks, which function in species recognition or evaluation in mate selection [12] [13].

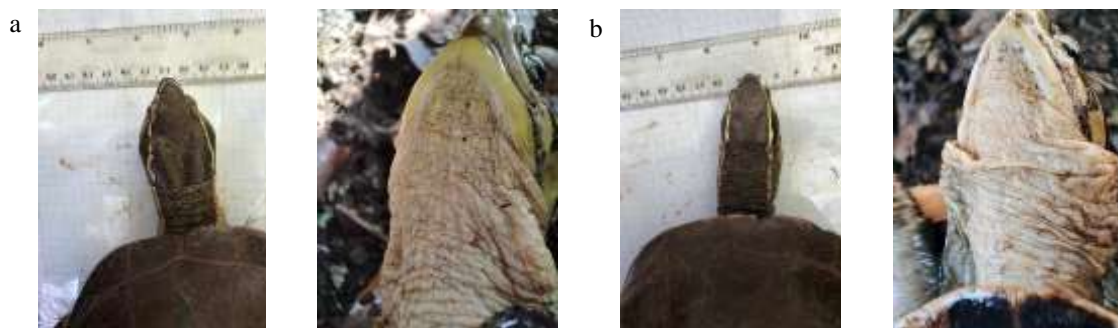


Figure 2. Head width and chin color of the turtle *C. amboinensis*; a) Male, b) Female.

### Carapace Morphology

The carapace or shell of a turtle is generally hard and immovable, having a hexagonal shape with vertical symmetry. The hard carapace acts as a home for the turtle, the carapace also functions as a shelter from predator attacks. The parts of the carapace consist of the

cervix which is located in the middle of the top part of the carapace, the marginal located on the side of the turtle consisting of 24 marginal pieces, the vertebral located in the middle of the carapace which consists of 5 vertebral pieces, the right and left pleural located on the side of the vertebrae totaling 8 pieces can be seen in (Figure 3c).

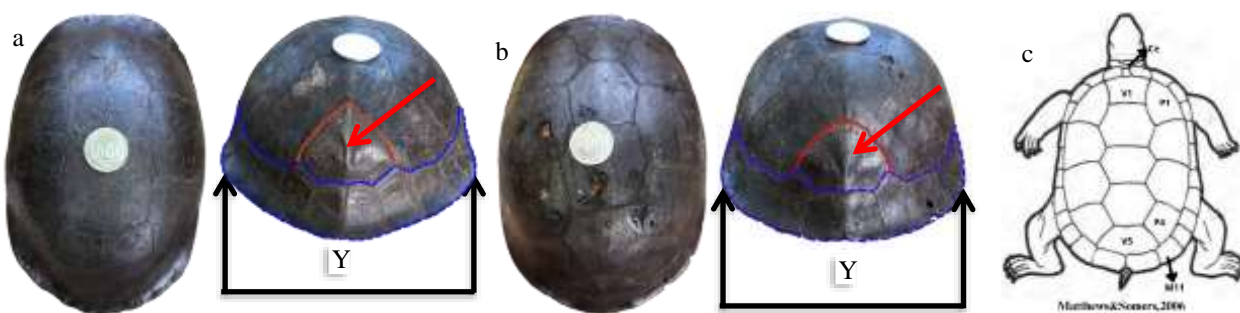


Figure 3. Carapace shape, vertebral area 5, and marginal sides of the turtle *C. amboinensis*; a) Male, b) Female, c) Visualization of carapace parts.

Male turtles have an oval carapace, while female turtles tend to have a round carapace. The carapace of males tends to be flat compared to females, this agrees with [14]. The rounded carapace on female turtles helps provide a larger space to accommodate eggs during the egg-laying process. This difference is one of the characteristics of sexual dimorphism in turtles, where

carapace structure can be a clue to distinguishing the sex. The carapace of male turtles is characterized by small bumps located in the vertebral area 5 (V5) shown in the arrow (Figure 3b). This small lump is due to the morphological structure of the plastron which bends inward, making the vertebral area of the male turtle protrude outward. Male turtles have marginal sides that

tend to be wider than female turtles, which can be seen in (Figure 3a). The marginal part of the carapace of this male turtle shows marginals that are slightly curved upwards, giving the impression of being wider and slightly sloping compared to female turtles which have slimmer shells and lighter marginal curves. Curved marginals are found at marginals 8-12 on the right side and marginals 13-17 on the left side (Y). Female turtles show a wider carapace and a taller carapace allows the female to produce many eggs, and male turtles have a smaller hydrodynamic [15]. This part of the carapace plays a role in anti-predator behavior during the mating season [16]. Male turtles have a dark black carapace compared to female turtles, which have black; the striking color of male turtles indicates sexual selection, whereas females choose suitable males based on their striking color [12] [17].

#### Plastron Morphology

The plastron consists of gular, humeral, pectoral, abdominal, femoral, and anal shown in (Figure 4b). The parts of the plastron are also connected by sutures between the parts, which are called sutures. The plastron structure is one of the distinctive characteristics of *C. amboinensis*, with horizontal sutures separating the

pectoral and abdominal plates, so this turtle is also called the broken-chested turtle. Apart from the carapace, the plastron also functions as a place to hide/protect, with suture stitching on the 12 plastral pieces making it easier for the turtle to open and close the plastron so that it can insert its head and tail if it feels threatened. The plastron of male turtles has a different shape from that of female turtles, and male turtles have distinctive depressions in the pectoral, abdominal, and femoral areas. The function of the basin is to provide additional space for male turtles to ride female turtles to make the mating process easier [18]. Female turtles have a flatter plastron, providing the excess space needed to accommodate eggs during egg-laying (Figure 4a). The difference in this part in the shape of the plastron is one of the characteristics of sexual dimorphism that identifies the sexes turtles by looking at their lower protective structures. In general, the color of the plastron of male and female turtles is not different, but the male turtle has black spots that are smaller and denser, while the female turtle has black spots that are wide and irregular. In male turtles, a distinctive brownish color was also found in certain parts, namely the pectoral, abdominal, and femoral parts. These stains were thought to be due to mounting activity during copulation.

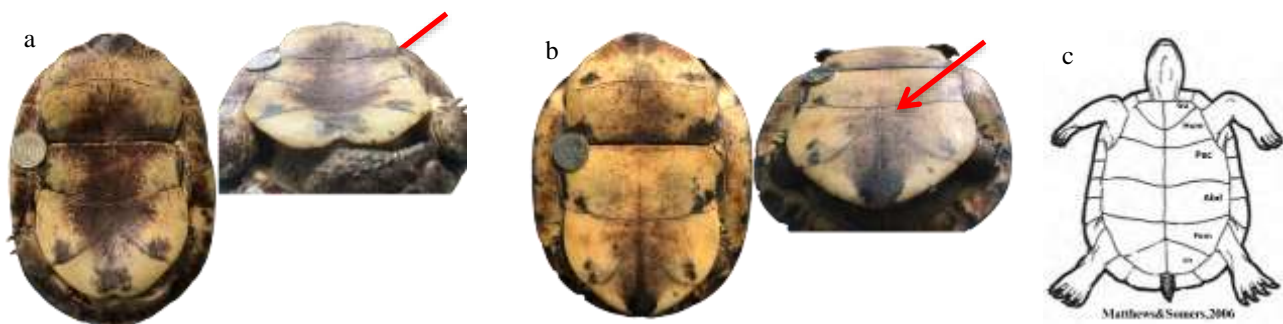


Figure 4. Plastron of the turtle *C. amboinensis*; a) Male, b) Female, c) Visualization of plastron parts

#### Tail Morphology

The tail of *C. amboinensis* is a striking characteristic when distinguishing the physical characteristics of males and females. The tail of male turtles tends to be longer and thicker than female turtles. Differences in the morphology of male and female turtles can be identified by looking at the male's tail, which is longer and thicker, and the location of the cloaca, which is further from the base of the tail, compared to female turtles. Tail length was measured using a caliper from the base of the tail to the tip of the tail [19].

The shortest length of a male turtle is 23.4 mm; the largest is 29.5 mm; the shortest length of a female turtle is 16.5 mm, and the largest is 19.7 mm. The thickness of the turtle's tail is measured at the base point before the cloaca opening. It was identified that the smallest thickness of a male turtle's tail was 7.4 mm to the largest 8.9 mm, while the smallest thickness of a female turtle was 5.2 mm to the largest 6.3 mm. The location of the male turtle's cloaca, which is much more outward than that of female turtles, is one aspect that differentiates its morphology, which plays an important role in the reproductive process, as shown in (Figure 5).

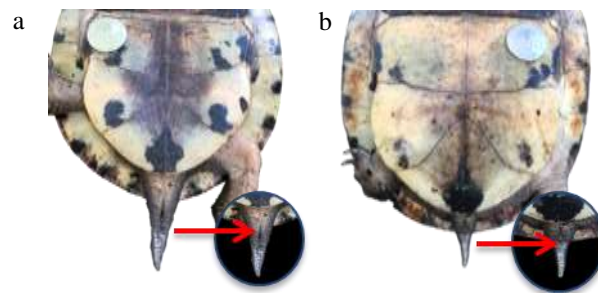


Figure 5. Tail and cloacal opening of the turtle *C. amboinensis*; a) Male, b) Female.

#### IV. CONCLUSION

Morphological studies of *C. amboinensis* show differences between male and female turtles. Differences in secondary sexual dimorphism in male and female *C. amboinensis* turtles are found in the head, carapace, plastron and tail. One of the characteristics of secondary sexual dimorphism from morphological studies shows that the male's plastron has a distinctive depression, a larger head, more contrasting color, the carapace is oval with a small bump on V5, and the marginal sides are wider.

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TABLE 1  
 DIMORPHISM BASED ON MORPHOLOGICAL CHARACTERISTICS OF *C. AMBOINENSIS*

| No. | Aspect                    | Male   | Female   |
|-----|---------------------------|--|--|
| 1.  | Head                      |  |  |
|     | a. Head Width Size        | 28. 1 mm-33. 2 mm  | 25. 4 mm-28. 9 mm  |
|     | b. Chin Color             | Bright Yellow  | Pale Yellow  |
| 2.  | Carapace                  |  |  |
|     | a. Shape                  | The Oval has small bumps, and the posterior marginal plate (M8-M17) is wider and curved. | Round does not have a similar lump; the posterior marginal is small and straight down. |
|     | b. Color                  | Deep black and more contrast   | Black color and no contrast  |
| 3.  | Plastron                  |  |  |
|     | a. Shape                  | Has a depression   | Flat   |
|     | b. Color                  | Smaller, more regular black spots  | Large, irregular black spots   |
| 4.  | Tail                      |  |  |
|     | a. Long                   | 23. 4 mm-29. 5 mm  | 16. 5 mm-19. 7 mm  |
|     | b. Thickness              | 7. 4 mm-8. 9 mm  | 5. 2 mm-6. 3 mm  |
|     | c. Color                  | Brownish black   | Brownish black   |
|     | d. Location of the cloaca | Far  | Inside   |