

Morphometric Study of African Spurred Tortoise (*Centrochelys sulcata*) Based on Age Group

Tetty Barunawati Siagian(*)¹, Muhammad Firman Bayu Prayogo^{1,2},
Danuja Widigdaya², Pungki²

¹ College of Vocational Studies, IPB University, Jl. Kumbang No. 14 Bogor, Indonesia

² Gembira Loka Zoo, Jl. Kebun Raya No. 2 Kota Gede, Yogyakarta, Indonesia

*Corresponding Author: tettybarunawatisiagian@apps.ipb.ac.id

Submitted June 04th 2023 and Accepted July 03rd 2023


Abstract

Sulcata tortoises (*Centrochelys sulcata*) are kept and bred to prevent extinction. The *sulcata* tortoises were identified to determine their respective identities by measuring them morphometrically. Morphometric studies on *sulcata* tortoises are still minimal, so a morphometric study of the *sulcata* tortoises is needed. The purpose of this study was to identify and describe the morphometry of *sulcata* tortoises with three different age ranges kept in ex-situ conservation. The research sample used 15 *sulcata* turtles which were divided into 3 groups namely group A (1 year), Group B (2 years), and Group C (3 years). The morphometric parameters measured were body weight, head, carapace, plastron, forelimb, hindlimb and bridge. The results showed that the average body weight of group A, B and C turtles was 2,179 kg, 1,289 kg and 0,167 kg respectively. The average maximum carapace length in a row for groups A, B, C, namely 11.64, 23.18 and 16.72 cm. The average plastron lengths for groups A, B, C were 9.08, 6.44 and 9.24 cm respectively. The average forelimb length in groups A, B and C were 3.04, 6.28 and 7.78 cm respectively. The average hindlimb length for groups A, B, and C were 1.86, 3.5 and 4.04 cm, respectively. The average bridge width for groups A, B and C were 4.36, 8.94 and 10.1 cm respectively. Based on the results of morphometric measurements of the three groups of *sulcata* tortoises, it was shown that group C had a larger morphometric size than groups B and A, this was due to differences in age and growth factors. *Sulcata* tortoises group C is 3 years old and belongs to the juvenile group. *Sulcata* tortoise groups A and B aged 1 and 2 years are included in the yearly group.

Keywords: Carapace, Juvenile, Morfometri, Plastron, Yearly



Jurnal Pembelajaran dan Biologi Nukleus (JPBN) by LPPM Universitas Labuhanbatu is under a Creative Commons Attribution- NonCommercial-ShareAlike 4.0 International License (CC BY - NC - SA 4.0)

 <https://doi.org/10.36987/jpbn.v9i2.4344>

INTRODUCTION

Sulcata tortoises are in great demand by people to keep because they are unique, namely having a unique scute pattern, striking yellow color on their shell, fast growth, easy maintenance and high adaptability to weather. *Sulcata* tortoises are the second largest tortoise in the world, very strong and long lived (Petrozzi et al., 2018). *Sulcata* turtles can reach the age of 90 years in captivity, while in the wild they can live up to 150 years (Eshar et al., 2016). The *sulcata* tortoise, which has the Latin name *Centrochelys sulcata*, is known

as the African Spurred Tortoise, because this tortoise comes from the African Sahara Desert and has spurs on the hind thighs (Petrozzi, et al., 2018). The sulcata tortoise inhabits the southern edge of the Sahara Desert, in the Sahel region of West and Central Africa (Petrozzi et al., 2020). Sulcata tortoises can be found in Sub-Saharan habitats that stretch across the African continent, including the countries of Mauritania, Ethiopia, Sudan, Niger, Chad, Senegal and Mali (Brown, 2013). This statement is supported by Petrozzi et al., (2020) and (Radovanovic, 2019), stating that the distribution of sulcata tortoises is very wide on the African continent, including Saudi Arabia and Egypt. The habitat of the sulcata tortoise is in areas that have a longer dry season than the rainy season, with warm weather and low humidity throughout the year. Sulcata tortoises also live in a variety of habitat types such as semiarid grasslands, savannahs, and thorn shrublands (Vetter, 2005).

The sulcata tortoise (*C. sulcata*) population in nature has decreased and is in the *vulnerable* category according to the IUCN (International Union for the Conservation of Nature) and the Appendix II group according to CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora). Appendix II means that the animal is not yet endangered but will be endangered if it continues to be traded without any regulatio (Petrozzi et al., 2018). The decline in the sulcata tortoise population is due to habitat fragmentation, hunting and illegal trade. One of the efforts to prevent the decline in the sulcata tortoise population is by carrying out conservation outside its habitat or ex-situ conservation. Sulcata tortoises are maintained and bred to prevent extinction (Radovanovic, 2019). Sulcata tortoise conservation actions need to be supported by information about the identity of individual sulcata tortoises by measuring them morphometrically.

Morphometrics is a method of measuring external body shapes. Morphometrics can be used as a taxonomic feature for the identity of sulcata tortoise (Setiadi, 2018). Morphometrics is very important for animals kept in ex-situ conservation for individual identity, breeding and knowing animal growth patterns (Suryana et al., 2015). Morphometric studies on sulcata tortoises are still minimal both in nature and in ex situ conservation, so a morphometric study of the sulcata tortoise is needed. The purpose of this study was to identify and describe the morphometry of sulcata tortoises with three different age ranges kept in ex-situ conservation. It is hoped that this research will become basic information that supports efforts to conserve and manage sulcata tortoise species in ex-situ conservation.

METHOD

Time and Place of Research

The research was conducted from 27 June to 27 Mei 2023 at the Gembira Loka Zoo, Yogyakarta.

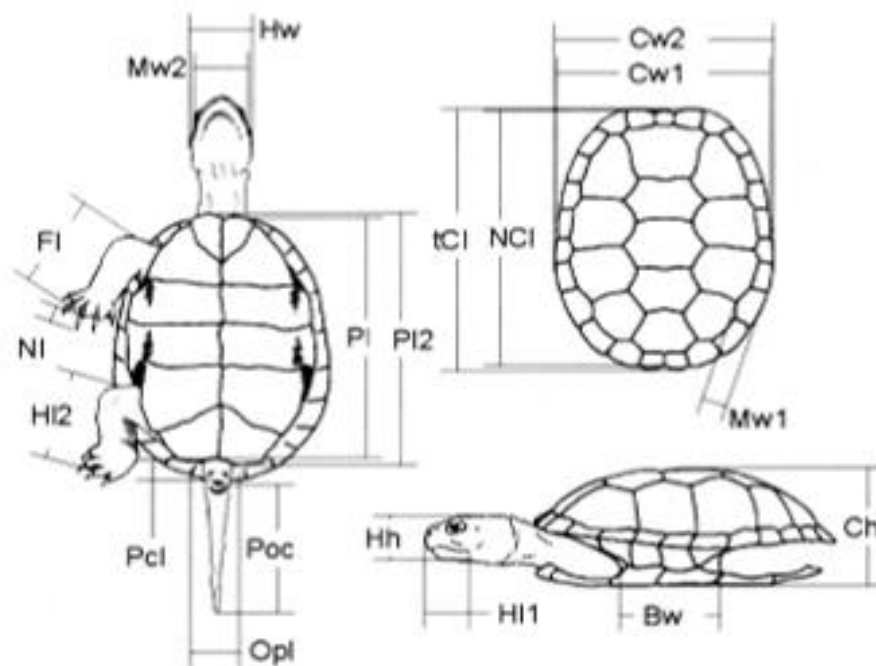
Tools and materials

The tools used in the morphometric measurements of Sulcata tortoises are a cloth meter, 2 rulers, scales, paper labels, ballpoint pens, morphometric form paper, and a road board. The materials used for morphometric measurements were 15 sulcata tortoises

which were divided into 3 groups namely group A (1 year old), Group B (2 years old), and Group C (3 years old). Information on the age of sulcata tortoises comes from individual medical records.

Sulcata Tortoise Morphometric Measurements

Sulcata tortoise were coded prior to weighing and morphometric measurements. Body weight was measured using a digital scale. The morphometric parameters of the sulcata tortoises measured were body weight, head length, head width, head height, maximal carapace length, nugal carapace length, carapace height, maximum carapace width, carapace width, Forelimb length, Forelimb nail length, hindlimb length, hindlimb nail length, plastron length, maximal plastron length, bridge width, and marginal width (Mahmoud, 2015; Ramos et al., 2009). Parameters of sulcata tortoises morphometric measurements according to (Ramos et al., 2009) are presented in Figure 1. Morphometric measurements used a meter and converted into a ruler. The measurement results are then recorded and averaged by age group.



Ket: head length (Hl); head width (Hw); head height (Hh); carapace height (Ch); carapace width (Cw1); maximal carapace length (Cw2); nugal carapace length (NCl); maximum carapace width (tCl); marginal width (Mw1); Forelimb length (Fl); Forelimb nail length (Nl); hindlimb length (Hl); hindlimb nail length (Nl2); plastron length (Pl); maximal plastron length (Pl2); dan bridge width (Bw)

Figure 1. Parameters of tortoises morphometric measurements according to (Ramos et al., 2009)

Data analysis

The morphometric data obtained were analyzed quantitatively with statistics in the form of an average. Morphometric description based on morphological variables is presented using a qualitative descriptive method.

RESULTS AND DISCUSSION

The tortoises age group is divided into hatchling, yearly, juvenile, sub adult and adult. Hatchlings start from hatching until they are less than 12 months old. Yearly is a tortoises aged 12-24 months. Juveniles are tortoises that are 24 months old and reach a carapace length of 14 centimeters. Sub adults are tortoises that have a carapace length of 14 cm to 18 cm. Adult is a tortoises that has a carapace length of more than 18 cm. Turtles have a shell which is divided into two parts, namely the carapace which covers the dorsal side and the plastron which covers the ventral part. The carapace and plastron are composed of several horny plates of varying shapes and sizes (Sari et al., 2021). The sulcata turtles measured were 1, 2 and 3 years old. The tortoise belongs to the yearling and juvenile groups. The average results of the sulcata tortoise morphometric values by age group are presented in Table 1.

Table 1. Mean Morphometric Value of *C. Sulcata* Group

Morphometric Parameters	Group Average		
	A	B	C
Body weight (kg)	0,167	1,289	2,179
Head length (cm)	1,64	2,94	2,84
Head width (cm)	1,8	3,04	2,74
Head height (cm)	1,56	2,96	3,1
Carapace height (cm)	4,62	11,04	11,4
Carapace width (cm)	6,82	13,36	15,76
Maximal carapace length (cm)	11,64	23,18	26,72
Nucal carapace length (cm)	8,96	18,62	20,8
Maximum carapace width (cm)	11,7	23,96	27,86
Marginal width (cm)	1,52	3,62	4,06
Forelimb length (cm)	3,04	6,28	7,78
Forelimb nail length (cm)	0,32	0,7	0,9
Hindlimb length (cm)	1,86	3,5	4,04
Hindlimb nail length (cm)	0,34	0,62	0,74
Plastron length (cm)	8,08	16,44	19,24
Maximal plastron length (cm)	8,72	17,8	21,16
Bridge width (cm)	4,36	8,94	10,1

Note: Group A: 1 year old; Group B: 2 years old; Group C : 3 years old.

Based on Table 1, the average body weight of group C tortoises is 2,179 kg, higher than that of B tortoises, which is 1,289 kg and A , which is 0,167 kg. The body weight of group C tortoises is higher than B and C due to the age difference. Group C tortoises are more mature than A and B tortoises. The older the sulcata tortoise, the more food volume and this affects weight gain. This statement is in accordance with (Willemsen & Hailey, 2003) which states that the factors that influence weight gain are volume of feed and regular feeding of Sulcata tortoises. Male and female turtles have different body weights, female tortoises are heavier than male because female tortoises have more muscle mass in the stomach to store eggs, have a wider and flat plastron to accommodate eggs , and has a volume on the back of the carapace that is larger than the male.

The results of measurements of the height, length and width of the head of the sulcata tortoises showed that the average head height of group C was 3.1 cm higher than that of group B, which was 2.96 cm and group A, which was 1.56 cm. The average head length of group A, B and C tortoises were 1.56 cm, 3.04 cm and 3.1 cm respectively. The average head width of group A, B, C tortoises was 1.8 cm, 2.96 cm and 2.74 cm respectively. The results of measuring the heads of sulcata tortoises are presented in Figure 2. The mean length and width of the heads of group C tortoises was lower than that of group B due to difficulties in measuring the heads of sulcata tortoises. When measuring sulcata tortoises, they often put their heads in because they are afraid, that the measurements will be inaccurate. According to (Rickyawan et al., 2020), the head of the sulcata tortoises can be seen clearly, but sometimes it is hidden inside the carapace. The scalp of the sulcata tortoise is yellowish brown. The head area consists of the face, eyes, mouth and neck. Sulcata tortoises have a short beak-like mouth with sharp edges and no teeth.

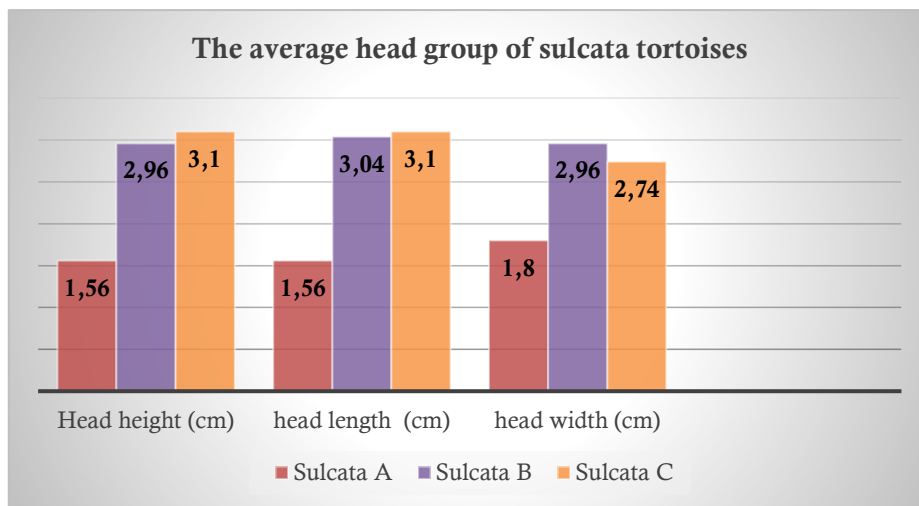


Figure 2. The average height, length and width of the turtle's head

The results of measurements of the turtle carapace including carapace height, carapace width, maximum carapace width, carapace length, and maximum carapace length are presented in Figure 3. The average carapace height for group A, B, C turtles were 4.62 cm, 11.04 cm respectively, and 11.4 cm. The average carapace width of group A, B, C turtles were 6.82 cm, 11.64 cm and 13.36 cm respectively, while the average maximum carapace width of groups A, B, C were 11.7 cm, 23.96 cm, and 27.86cm. The average carapace length of group A, B and C turtles were 8.96 cm, 18.62 cm and 20.8 cm respectively. The average maximum carapace length of groups A, B and C were 11.64 cm, 23.18 cm and 26.72 cm respectively. Based on these data, the results of morphometric measurements of the average length, height and width of the carapace in group C tortoises were higher than group B and A, due to the age growth factor. Group C tortoises were more mature than group A and B, so that the carapace growth is larger in size than group A and B.

The carapace is composed of symmetrical hexagonal plates. The carapace morphology consists of keratinized scales, dorsal cortex, cancellous interior, and ventral

cortex. The keratin scales on the outer surface are made of fibrous keratin protein (Jearanaisilawong et al., 2021). In the inner layer there are ribs (Achrai & Wagner, 2013). Sulcata tortoise carapace cannot be moved (Jongpairajcosit & Jearanaisilawong, 2017). The function of the carapace is to protect the soft tissue from predatory attacks and trauma from collisions with any object (Achrai & Wagner, 2013). Tortoises carapace can be affected by a disease, namely pyramiding. Pyramiding is a condition in which the keratinized plates of the carapace are raised in a conical manner, forming convex humps and corresponding grooves or valleys between the scales as the individual grows. Pyramiding is caused by humidity, ambient temperature, and food effects (Heinrich & Heinrich, 2016).

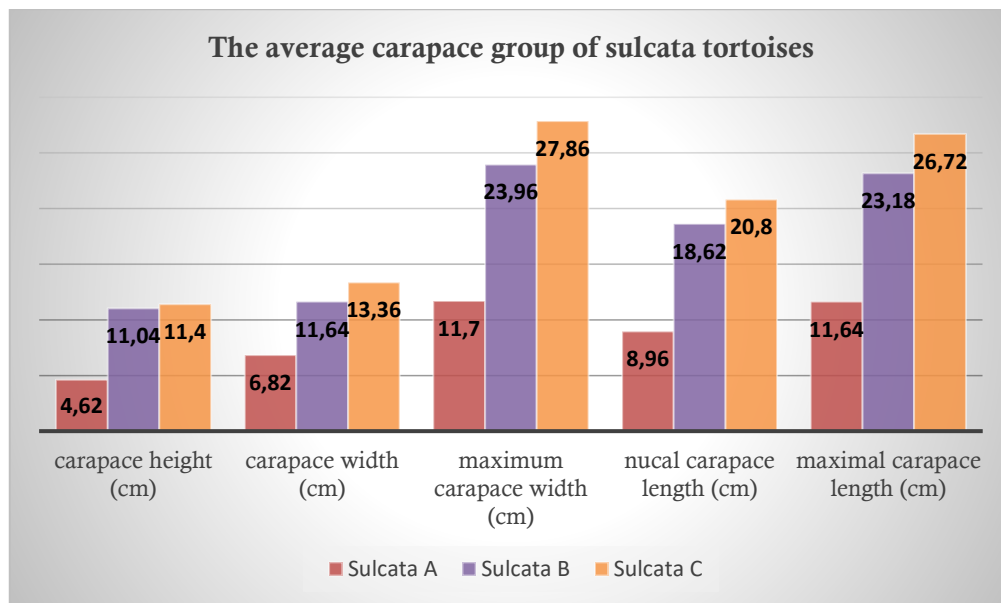


Figure 3. Results of measurements of average carapace in the sulcata tortoise group

The measurement results for a turtle's plastron include the plastron length and maximal plastron length (Figure 4). The mean plastron length of group A, B, C tortoises were 8.08 cm, 16.44 cm and 19.24 cm respectively. The maximum mean plastron length for group A, B and C tortoises were 8.72 cm, 17.8 cm and 21.16 cm, respectively. Based on these data, the average plastron length and maximum plastron length in group C were higher when compared to groups B and A. This was due to the age factor of group C tortoises being longer than group A and B. Rice et al. 2016 states that the plastron in sulcata tortoises is in the form of bony plates covered with keratinized scales. The function of the plastron is to protect the organs inside the turtle's body. The plastron has a brownish yellow color (Aristawati et al., 2022). The difference between the male and female plastrons in sulcata tortoises is that the male plastron will be concave, while the plastron of sulcata tortoises will be flat which functions as a space for egg development (Sari et al., 2021).

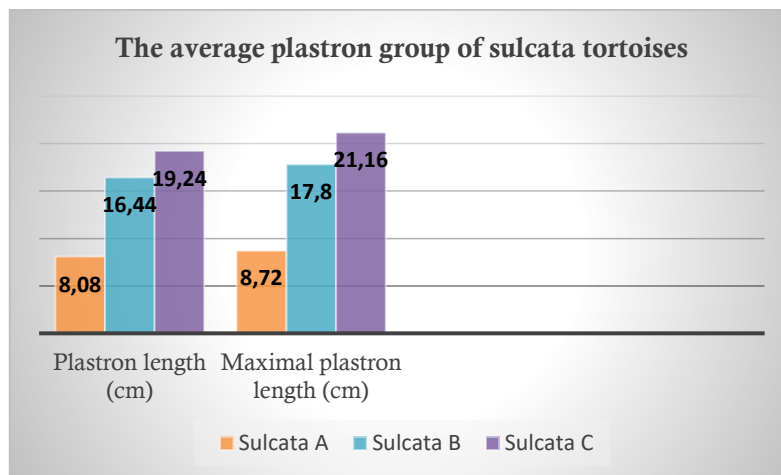


Figure 4. Results of plastron measurements of the sulcata tortoise group

Sulcata tortoises have a pair of forelimbs and hind legs. Measurement results for the forelegs and hindlimbs of sulcata tortoises include the forelimb length, forelimb nail length, hindlimb length and hindlimb nail length (Figure 5). The average forelimb length of group A, B and C turtles were 3.04 cm, 6.28 cm and 7.78 cm respectively. The average of the Forelimb nail length of group A, B, C were 0.32 cm, 0.7 cm and 0.9 cm respectively. Based on these data, it shows that the average of Forelimb length and Forelimb nail length of group C is longer than group B and A because they are influenced by growth factors where the age of group C tortoises is more mature than group A and B. The average hindlimb length of group A, B and C turtles were 1.86 cm, 3.5 cm and 4.04 cm respectively. The average of hindlimb nail length of group A, B and C tortoises were 0.34 cm, 0.62 cm and 0.74 cm respectively. Based on these data, it shows that the average hindlimb length and hindlimb nail length of group C tortoises is longer than B, and A is a factor of growth where C tortoises are more mature than A and B tortoises.

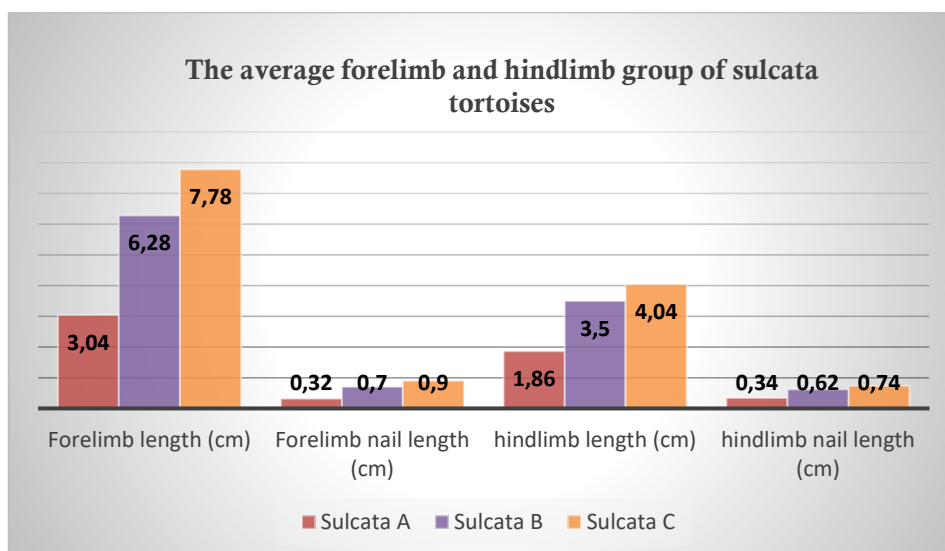


Figure 5. The average forelimb and hindlimb group of sulcata tortoises

Based on Figure 5, the average length of the turtle's forelimb is longer than the

hindlimb. This statement is in accordance with the opinion of (Petrozzi et al., 2018) which states that the forelimb of sulcata tortoises are longer than their hindlimb. The forelimbs of sulcata tortoises are movable and hidden inside the carapace. The forelimbs of the sulcata are dark yellow (Brown, 2013). The function of the forelimbs is as a tool for moving and digging the ground. The forelimbs of sulcata tortoises are in the form of an arrangement of large scales covered with keratin. The fore and hind toenails are composed of epidermal cells and keratin (Alibardi & Dipietrangelo, 2005). The hindlimb of the sulcata tortoises are blackish-brown and can be hidden under the carapace. The function of the hindlimbs is as a rear propulsion tool and as a support for the body. The hindlimbs are composed of an arrangement of scales covered with keratin ((Petrozzi et al., 2020; Brown, 2013). The morphology of the head, limbs, and the characteristics of the carapace and plastron of tortoises can be used as identification characteristics for tortoise species (Kendrick & Ades, 2009).

The results of measuring the average of bridge width (Figure 6) in group C tortoise, which is 10.01 cm longer when compared to group B and A turtles, which are 8.94 cm and 4.36 cm, this is due to the age growth factor. Group C tortoise are more mature. compared to group A and B turtles. Bridge is the link between the carapace and the plastron. The bridge is composed of two layers, namely the outer layer which has a structure of large and hard scales, while the inner layer has a structure in the form of tightly packed plates (Mochamad, 2021).

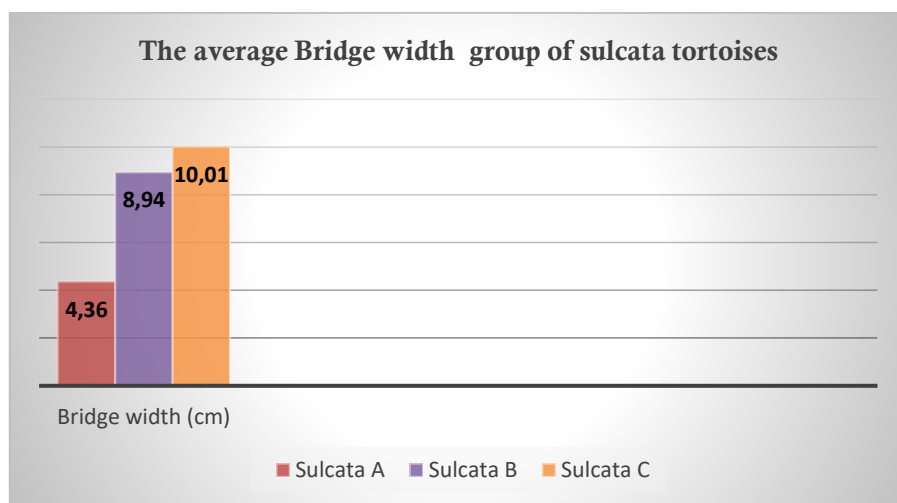


Figure 6. The average Bridge width group of sulcata tortoises

Based on the results of morphometric measurements of the sulcata tortoise group, it was shown that the C group had a larger morphometric size than the B and A turtles, this was due to age and growth factors. Turtle group C is 3 years old and belongs to the juvenile group. Sulcata tortoise groups A and B aged 1 and 2 years are included in the yearly group. The greater the age of the turtle, the greater the body size and morphological growth occurs. Factors that affect the growth of turtle morphology are the availability of food, environmental temperature, and humidity. Sulcata tortoises that live in ex-situ conservation are better cared for and have adequate food needs than those that live freely in nature. The main food for turtles in their natural habitat is grass, enriched with fruit,

leaves, bark and cactuses. The main food for turtles in captivity is lettuce, cabbage and allies (Raharjo et al., 2022). Turtles are given grass, straw, to wheat grass. Additional food for turtles in captivity such as pumpkin, mint leaves, grape leaves, and cactus. Giving this additional food aims to support the growth of the turtle carapace. Carapace growth requires a fairly high calcium. for its development such as giving mulberry leaves and grapes (Aristawati et al., 2022). The environmental temperature of the Sulcata tortoise that lives in ex situ conservation is regulated as needed, especially yearly so that it causes good growth. Yearly and juvenile placed in terrarium (Harahap & Nasution, 2021).

CONCLUSION

Based on the results of morphometric measurements of the three groups of sulcata tortoises, it was shown that group C had a larger morphometric size than groups B and A, this was due to differences in age and growth factors. Turtle group C is 3 years old and belongs to the juvenile group. Sulcata tortoise groups A and B aged 1 and 2 years are included in the yearly group.

ACKNOWLEDGEMENT

Thank you to the management of the Gembira Loka Zoo for helping and supporting the research.

REFERENCES

- Achrai, B., & Wagner, H. D. (2013). Micro-Structure And Mechanical Properties Of The Turtle Carapace As a Biological Composite Shield. *Acta Biomaterialia*, 9(4), 5890–5902. <https://doi.org/10.1016/j.actbio.2012.12.023>
- Alibardi, L., & Dipietrangelo, L. (2005). Differentiation Of The Epidermis Of Scutes In Embryos And Juveniles Of The Tortoise Testudo Hermanni With Emphasis On Beta-Keratinization. *Acta Zoologica (Stockholm)*, 86, 205–216.
- Aristawati, I. D. A. A. ., Sibang, I.N.A.N., I., Batan, W., & Anthara, M. (2022). Laporan Kasus: Penanganan Urolithiasis disertai Hematuria pada Kura-kura Sulcata. *Indonesia Medicus Veterinus*, 11(3), 424–436. <https://doi.org/10.19087/imv.2022.11.3.424>
- Brown, R. (2013). Caring for the Sulcata (*African spurred tortoise*) or the Leopard Tortoise (Care Sheet is the Same for Leopard Tortoise and Sulcata Tortoise). *USA: San Diego Turtle and Tortoise Society*, 1–7. <https://doi.org/10.3854/crm.5.110.sulcata.v1.2020>
- Eshar, D., Gancz, A. Y., Magen, N. A., Wagshal, E., Pohlman, L., & Mitchell, A. M. (2016). Selected Plasma Biochemistry Analytes Of Healthy Captive Sulcata (African Spurred) Tortoises (*Centrochelys sulcata*). *Journal of Zoo and Wildlife Medicine*, 47(4), 993–999.
- Harahap, P., & Nasution, K. R. (2021). Perancangan Terrarium with Automatic Controller Berbasis Arduino For Baby Tortoise Geochlone Sulcata. *Semin. Nas.*

TeknoL, 35(1), 34–44.

- Heinrich, M. L., & Heinrich, K. K. (2016). Effect Of Supplemental Heat In Captive African Leopard Tortoises (*Stigmochelys pardalis*) and Spurred Tortoises (*Centrochelys sulcata*) on Growth Rate and Carapacial Scute Pyramiding. *J. Exot. Pet Med*, 25(1), 18–25. <https://doi.org/10.1053/j.jepm.2015.12.005>
- Jearanaisilawong, P., Jongpairajcosit, N., & Glunrawd, C. (2021). Dynamic Behaviors and Protection Mechanisms of Sulcata Tortoise Carapace. *Comput. Methods Biomech. Biomed. Engin.*, 24(13), 1450–1462. <https://doi.org/10.1080/10255842.2021.1892661>
- Jongpairajcosit, N., & Jearanaisilawong, P. (2017). Mechanical Properties and Numerical Simulation of Sulcata Tortoise Carapace. *J. Mech. Behav. Biomed. Mater.*, 72, 261–267. <https://doi.org/10.1016/j.jmbbm.2017.04.012>
- Kendrick, R. C., & Ades, G. W. J. (2009). Taxonomic and Morphometric Analysis of a Trade Confiscation of Turtle Shells From Java, Indonesia. *Turtle*, 4, 1–5. <https://doi.org/10.3854/tln.004.2009>
- Mahmoud, M. A. (2015). Morphometry and Body Mass Index to Assess Health Condition in Captive Population of Greek Tortoise , *Tesudo Greaca*. *Alexandria Journal of Veterinary Sciences*, 45, 57–62. <https://doi.org/10.5455/ajvs.180480>
- Mochamad, R. A. (2021). Constant 12 And Reflexivity 472319 Hahslm on The Geography of The Earth in The Economic Era of Covid. *IOP Conf. Ser. Earth Environ. Sci*, 936(1), 183–195. <https://doi.org/10.1088/1755-1315/936/1/012018>
- Petrozzi, F., Eniang, E.A., Akani, G.C., Amadi, N., Hema, E.M., Diagne, T., Segniagbeto, G.H., Chirio, L., Amori, G., & Luiselli, L. (2018). Exploring The Main Threats To The Threatened African Spurred Tortoise *Centrochelys Sulcata* In The West African Sahel. *Oryx*, 52(3), 544–551. <https://doi.org/10.1017/S0030605316001125>
- Petrozzi, F., Hema, E., Demaya, G., Benansio, ., Eniang, E., Diagne, T., Segniagbeto, G., & Luiselli, L. (2020). *Centrochelys sulcata* (Miller 1779)- African Spurred Tortoise, Grooved Tortoise, Sahel Tortoise, Tortue Sillonnée. *Cheloniah Research Monographs*, 5(14), 110.1-110.16. <https://doi.org/10.1016/j.actao.2020.103581>
- Radovanovic, A. (2019). Husbandry and Reproduction of the African Spurred Tortoise , *Centrochelys sulcata*. *Testudo*, 9(1), 7–13.
- Raharjo, S., Widayarni, S., Indarjulianto, S., & Yanuartono. (2022). Surgical Removal of Bladder Stone in a Sulcata Tortoise (*Centrochelys sulcata*): A case study. *2nd International Conference on Tropical Wetland Biodiversity and Conservation*, 976, 1–6. <https://doi.org/10.1088/1755-1315/976/1/012010>
- Ramos, S., Franch, M., Montori, A., & Llorente, G. A. (2009). Morphometry and Biological Cycle of a European Pond Turtle (*Emys orbicularis*) Population from North-Eastern Spain. *Rev. Esp. Herp.*, 23, 117–128.
- Rickyawan, N., Ekhdiasmara, S., Karaman, Y., Kartika, R., & Hudriyah, U. (2020).

- Pengangkatan Benda Asing dengan Metode Coelio-Plastronotomi pada Kura-Kura Pardalis (*Stigmochelys pardalis*). *J. Med. Vet*, 3(2), 263–270.
<https://doi.org/10.20473/jmv.vol3.iss2.2020.263-270>
- Sari, J. P., Erlansari, A., & Purwandari, E. P. (2021). Identifikasi Citra Digital Kura-Kura Sumatera dengan Perbandingan Ekstraksi Fitur GLCM dan GLRLM Berbasis Web. *Jurnal Pseudocode*, 8(1), 66–75.
- Setiadi, A. E. (2018). Identifikasi Jenis Kura-Kura di Kalimantan Barat. *J. Pendidik. Biol*, 2(3), 493–497.
- Suryana, E., Elvyra, R., & Yusfiati. (2015).). Karakteristik Morfometrik dan Meristik Ikan Lais (*Kryptopterus limpok*, Bleeker 1852) di Sungai Tapung dan Sungai Kampar Kiri Propinsi Riau. *JOM FMIPA*, 2(1), 67–77.
- Vetter, H. (2005). Leopard and African spurred tortoise *stigmochelys pardalis* and *Centrochelys Sulcata*, in Chimaira (Ed). Am Main, Frankfurt, 189.
- Willemsen, R. E., & Hailey, A. (2003). Sexual Dimorphism of Body Size and Shell Shape in European Tortoises. *J. Zool. Lond*, 260, 353–365.
<https://doi.org/10.1017/S0952836903003820>

How To Cite This Article, with APA style :

Siagian T.B., Prayogo M.F.B., Widigdaya D., & Pungki. (2023). Morphometric Study of African Spurred Tortoise (*Centrochelys sulcata*) Based on Age Group. *Jurnal Pembelajaran dan Biologi Nukleus*, 9(2), 361-371.
<https://doi.org/10.36987/jpbn.v9i2.4344>