Gross Anatomical and Morphometrical Studies on Scapula, Humerus, Radius and Ulna of Tiger (*Panthera tigris*)

A clinical report submitted by

.....

MD. Kabir Hossain

Intern ID: 27

Roll No : 15/29

Reg No : 01444

Report Presented in Partial Fulfillment for the Degree of

Doctor of Veterinary Medicine

Faculty of Veterinary Medicine

Chattogram Veterinary and Animal Sciences University

Gross Anatomical and Morphometrical Studies on Scapula, Humerus, Radius and Ulna of Tiger

(Panthera tigris)

Approved By-

…….

Professor Dr. Mohammad Lutfur Rahman

Department of Anatomy and Histology

Chattogram Veterinary and Animal Sciences University

Faculty of Veterinary Medicine

CHATTOGRAM VETERINARY AND ANIMAL SCIENCES UNIVERSITY

Khulshi, Chattogram.

Contents

Titles Page No

1. Abstract 04

2. Introduction..... 05

3. Materials & Methods..... 07

4. Results & Discussions.....

4.1. Scapula 08

4.2. Humerus 11

4.3. Radius and Ulna 14

5. Conclusion 17

6.Limitation..... 18

7.Future plan..... 19

8.Acknowledgement 20

9. References..... 21

ABSTRACT

The study was carried out to know the gross anatomy and morphometry of scapula, humerus, radius and ulnar bone of forelimb of adult Royal Bengal tiger skeleton to explore their characteristics features. The bones were collected from Bangladesh National Zoo, Dhaka and processed scientifically in the laboratory of Anatomy, CVASU. The scapula was quadrangular shape with two surfaces, three borders and three angles. Its lateral surface was unequally divided into supraspinous and infraspinous fossa by a well-developed spine which gradually decreased towards the proximal extremity. The acromian process was subdivided into thick triangular shaped suprahamate process and hamate process which was over hanged the glenoid cavity. The humerus of tiger was a long bone with a spirally twisted shaped. The body of humerus was somewhat compressed laterally. The radius was slightly twisted bone with an anteroposteriorly flattened shaft and two extremities. The proximal extremity had a concave facet and the distal extremity was expanded and was about twice the size of proximal extremity. The ulna was longer than radius and was flattened mediolaterally. The proximal extremity had olecranon process, anconeus process and facet for humerus. The olecranon process possessed three tubercles. In Tiger, some osteomorphometrical features in the bones of forelimb indicated unique discrepancies which were the key factors for interpretation in radiology and forensic studies.

Keywords: Glenoid Cavity, Hamate and Suprahamate Process, Radius Ulna, Olecranon Process.

INTRODUCTION

The Bengal tiger's coat is yellow to light orange, with stripes ranging from dark brown to black; the belly and the interior parts of the limbs are white, and the tail is orange with black rings.Males have an average total length of 270 to 310 cm (110 to 120 in) including the tail, while females measure 240 to 265 cm (94 to 104 in) on average (Mazak et al.1981). The tail is typically 85 to 110 cm (33 to 43 in) long, and on average, tigers are 90 to 110 cm (35 to 43 in) in height at the shoulder (Karanth et al.2003). The weight of males ranges from 180 to 258 kg (397 to 569 lb), while that of the females ranges from 100 to 160 kg (220 to 350 lb (Mazak et al.1981). The smallest recorded weights for Bengal tigers are from the Sundarbans, Bangladesh where adult females are 75 to 80 kg (165 to 176 lb (Barlow et al.2010). The tiger has exceptionally stout teeth. Its canines are 7.5 to 10 cm (3.0 to 3.9 in) long and thus the longest among all cats (Sunquist et al.2002). The greatest length of its skull is 332 to 376 mm (13.1 to 14.8 in). The number of Bengal tigers in Bangladesh part of the Sundarbans has increased slightly, according to a latest tiger census. The number rose up to 114 in 2018, from 106 recorded during the previous survey in 2015. The census on the critically endangered species was conducted dividing the Sundarbans into three areas-Khulna, Bagerhat and Satkhira. The census in Satkhira was conducted in 2017. The following year, the census was carried out in Khulna and Bagerhat. Forest officials said they conducted the camera trap census in 1,659 sq km of core tiger population areas in the Sundarbans. Of the total area, 1,208 square kilometres is in Satkhira, 165 square kilometres in Khulna and 286 square kilometres in Shoronkhola, Bagerhat. Forest officials installed 491 cameras on trees at 239 points of the Sundarbans and collected 2,500 images of tigers during a 249-day survey. Analysing the images of tigers, experts projected that the total number of Bengal tigers is 114. Indian tiger experts helped the forest department officials to conduct the census. According to the Tiger Census 2015, the tiger population was only 106 in the Bangladesh part of the Sundarbans. In recent years the number of tigers are continuously decreasing due to poaching, diseases and destruction of habitat. The poaching is considered as one of the most important cause for reduction of their population and bringing them at the verge of extinction. The tiger is a member of the felidae family and carnivorous in habit. Previously some anatomical studies on domestic felines and canines have been conducted and some informations are available on few bones of leopard, Panther

and Asiatic lion (Nzalak et al.2018). There is paucity of the literature on systematic information of characteristic anatomical features of bones of tiger. Many scientists have been studied on the skeletal systems of large animals, for example horse, cattle, small ruminants such as sheep, goat (Sisson et al.1975) carnivores such as dog (Evans et al.2013) wild carnivores such as leopard(Podhade et al.2007), Asiatic cheetah (Nazem et al.2017) and Indian wild cat (Palanisamy et al.2018). Only some literatures are available on few bones of the Asiatic lion (Nzalak et al.2018) but the morphometrical study of the skeletal system of the tiger has not been studied in details. Besides, in the field of radiology and forensic studies, the osteomorphometrical features of the scapula, humerus, radius and ulna are very important for the diagnostic and clinical approach.

So the purposes of the studies are as follows:

1. to know the gross anatomy and morphometry of the bones of forelimb.
2. to interpret the bones of tiger in radiographic and foreignsic studies.

MATERIALS AND METHODS

The bones (scapula, humerus, radius and ulna) of forelimb of adult tiger were examined at the Anatomy Museum of Chittagong Veterinary and Animal Sciences University, Bangladesh. Recently this tiger was died in the Bangladesh National Zoo, Dhaka and buried in an isolated place of the zoo with aseptic measures. Subsequently the bones were collected, processed by removing the mud and boiled with water and hydrogen peroxide (H_2O_2) for one hour to remove the remaining muscular structures from the bones. After removing the muscular structures through knife all the bones were properly washed with fresh water and finally all the bones were dried under sunlight for a week. Whole processing was done carefully to keep the anatomical structures unchanged. To get the gross anatomical parameters different views of the scapula, humerus, radius and ulna were observed. For the gross morphometric study, the length, width, height and circumference were measured by using a calibrated scale and were recorded in centimeter (cm). The weight was also measured by using a digital balance and recorded in gram (gm). The morphometrical measurements of scapula, humerus, radius and ulna of the tiger compared with previous findings with other animals like ruminant, canine, feline, etc.

RESULT AND DISCUSSION

Scapula:

The scapula of tiger was quadrangular in shaped which was similar with Indian wild cat (Palanisamy et al.2018)and in Civet cat (Sarma et al.2017).The scapula of tiger possessed two surfaces, three borders and three angles which were found to be analogus to those of the horse, cattle, sheep dog (Sisson et al.1975). The lateral surface of scapula was divided by a well developed spine into two unequal fossae, i.e. supraspinous fossa and infraspinous fossa were similar in lion. However, equal fossae were found in dog and Indian wild cat (Palanisamy et al.2018).The height of the spine gradually decreased towards the proximal extremity which was similar with the findings of lion (Pandey et al.2004). The distal continuation of the spine was known as acromian process, composed of hamate process and suprahamate process; however, they also called as acromian and metacromian process. The hamate process was triangular with thick blunted ends that over-hanged the glenoid cavity. The findings were consistent within lion (Nzalak et al.2010)although it was not over hanged to the glenoid cavity in cattle, sheep and goat (Sisson et al.1975).

Figure1. Lateral view of left scapula of lion: 1) Cranial angle 2) Caudal angle 3) Cranial border 4) Caudal border 5) Supraspinous fossa 6) Infraspinous fossa 7) Scapular spine 8) Tuberosity of spine 9) Suprahamate process 10) Hamate process 11) Scapular notch 12) Coracoids process and 13) Glenoid cavity.

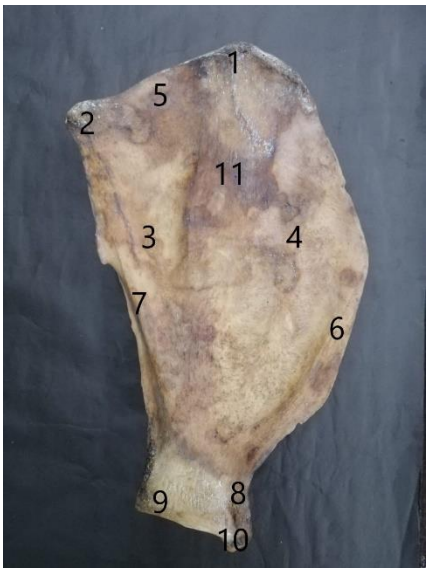

Figure 2. Medial view of left scapula of lion: 1) Cranial angle 2) Caudal angle 3) Supraspinous fossa 4) Infraspinous fossa 5) Dorsal border 6) Cranial border 7) Caudal border 8) Scapular notch 9) Glenoid cavity and 10) Coracoid process.

Figure 3. Ventral view of left scapula of tiger: 1) Glenoid cavity 2) Hamate process and 3) Suprahamate process 4) Coracoid process.

The dorsal border was measured 26.5 cm both in right and left scapula. The cranial border was slightly convex which extended from scapular notch to cranial angle. The outline of border was circular and smooth as mentioned previously in lion. It's length was 22.5 cm (right) and 21.4 cm (left). The caudal border was straight with thick and smooth outline and extended from the caudal angle to glenoid cavity which was studied previously in Indian lion (Nzalak et al.2010) leopard and Indian wild cat (Palanisamy et al.2018).The length of this border in right and left scapula was measured 18.3 cm and 18 cm respectively. The glenoid

cavity was oval to quadrangular in shaped which was similar to tiger (Tomer et al.2018)and elongated oval in shaped, observed in Indian lion (Nzalak et al.2010)but found elongated in elephant (Ahasan et al.2016). Its length was 5.2 cm and 5.4 cm in right and left, respectively and the width was 3.7 cm and 3.6 cm, respectively.

Table 1: The morphometrical data of different parameters of scapula.

Serial no	**Parameters**	**Right**	**Left**
1	Weight (gm)	181	180
2	Maximum length (Dorsal border to glenoid cavity) (cm)	26.5	26.5
3	Maximum width (Cranial border to caudal angle) (cm)	20	17.2
4	Length of cranial border (cm)	22.5	21.4
5	Length of caudal border (cm)	18.3	18
6	Length of dorsal border (cm)	20	19.9
7	Length of scapular spine (cm)	22.7	22.4
8	Height of scapula spine from supraspinous fossa (cm)	3.8	3.9
9	Height of scapula spine from infraspinous fossa (cm)	4	4
10	Maximum width of supraspinous fossa (cm)	6.9	6.8
11	Maximum width of infraspinous fossa (cm)	7.4	7.5
12	Length of glenoid cavity (cm)	5.2	5.4
13	Width of glenoid cavity (cm)	3.7	3.6
14	Distance between glenoid cavity and acromion process (cm)	3.6	3.9

Humerus:

The humerus was one of the major bones in the appendicular skeleton of tiger to bear the total body weight. It was a long bone with a spirally twisted shaft, which was located obliquely downward and backward directed. It formed shoulder joint above by its head with the glenoid cavity of scapula and elbow joint below by its

condyles with the proximal extremities of radius and ulna. The morphometrical data for different parameters of humerus of tiger presented in table below:

Table 2: The morphometrical data for different parameters of humerus.

Serial no	**Parameters**	**Right**	**Left**
1	Weight (g)	381.2	381.4
2	Total length (cm)	28	27.9
3	Shaft Length (cm) Circumference of upper part (cm) Circumference of middle part (cm) Circumference of lower part (cm)	 20 12.1 10.5 10.6	 20.1 12 10.3 10.4
4	Circumference of head (cm)	19.4	19.6
5	Proximal extremity Circumference (cm) Width (cm)	 22 8	 21.8 7.9
6	Distal extremity Circumference (cm) Width (cm)	 20 4.7	 19.8 4.5
7	Depth of olecranon fossa (cm)	17.5	17.6

It possessed a cylindrical shaft (diaphysis or body) and two enlarged extremities (epiphysis) such as proximal extremity and distal extremity. The head was rounded. The greater tubercle was large and prominent on the cranial and lateral surface of proximal end of bone, whereas the later one was smaller, dorsally extended, non-articulated just under the head on the medial surface. Similar findings were observed in Asiatic cheetah (Nazem et al.2017)but mostly prominent major tubercle was found in dog (Ahasan et al.2016). The shaft was compressed craniocaudally in proximal part, rounded to oval in middle part and compressed mediolaterally in distal part as described in lion (Kirberger et al.2005). The bones had four surfaces- the lateral, medial, cranial and caudal

surface, but only two surfaces- lateral and medial were observed in Asiatic cheetah (Nazem et al.2017).The lateral surface was spirally twisted and smooth, whereas the medial one was compressed in the proximal part and almost rounded in the distal part. A shallow, convex musculospiral groove (also known as brachial groove) was present on the lateral surface, which continued until the proximal half of this bone. The less developed deltoid tuberosity was noticed at the edge between the lateral and medial surfaces, whereas well developed deltoid tuberosity was noticed in dog(Sarma et al.2017). On the lateral surface, there was another obliquely crest like structure known as tricipital line or deltoid crest, which ended in the deltoid tuberosity. On the cranio-lateral aspect of humerus, another crest like structure was started from the distal part of lateral (greater) tuberosity, continued as slightly oblique line and finally terminated at teres major tuberosity. On the distal part of the shaft, a supracondyloid ridge started just above the lateral epicondyle, continued obliquely and then ended on its caudal surface. The nutrient foramen were bserved on the caudal surface of the proximal to the middle of the shaft but (Nzalak et al. 2018)observed this foramen on the distal half of the shaft. In contrast, two nutrient foramen were observed in Asiatic cheetah (Nazem et al.2017).The distal extremity of the humerus had two condyles, two epicondyles, one supracondyloid foramen, radial and olecranon fossae. A long, narrow supracondyloid foramen was found on the medial surface of the distal extremity just above the medial epicondyle. This foramen didn’t connect the radial fossa with the olecranon fossa as found in dog (Sarma et al.2017).

Figure 4. Caudal view of left humerus of tiger: 1) Head 2) Greater tubercle 3) Neck 4) Deltoid tuberosity 5) Olecranon fossa 6) Lateral epicondyle, and 7) Medial epicondyle.

Figure 5. Medial view of left humerus of tiger: 1) Lesser tubercle 2) Head 3) Neck 4) Crest of lesser tubercle 5) Shaft, 6) Supracondyloid foramen, and 7) Medial epicondyle.

Radius and Ulna:

The radius had a long shaft or body and two extremities- the proximal one was smaller and distal one was larger and expanded. The head of the radius was very well defined. On the proximal surface of head, the concave fovea capitis radii- a triangular articular surface was seen which articulated with the lateral condyle of humerus. This was in agreement with the previous report of (Nzalak et al.2018). Immediately below the head, the neck had an irregular surface for the articulation with ulna in its caudal part. A rough, prominent eminence- the radial tuberosity was present on the medial surface of the proximal extremity. The shaft of radius was craniocaudally compressed, which was similar with Asatic cheetah (Nazem et al.2017)but dissimilar with Asian elephant (Ahasan et al.2016). It had four surfaces- anterior, posterior, lateral and medial. The anterior surface was rough for the attachment of tendons of muscles, while the posterior surface was somewhat concave as reported in dog and cat (Sisson et al.1975). The lateral and medial surfaces were a bit rounded and comparatively smooth. The distal extremity was the largest part of this bone. It had a medial elongated projection called medial

(radial) styloid process. An articular surface-ulnar notch for the attachment of radius with ulna was also present.

Table 3: The morphometrical data for different parameters of radius.

Serial no	**Parameters**	**Right**	**Left**
1	Total length (cm)	28	27
2	Proximal extremity Circumference (cm) Width (cm)	 11.4 3.5	 11.5 3.7
3	Distal extremity Circumference (cm) Width (cm)	 15.9 4.9	 15.4 4.8
4	Circumference at mid shaft (cm) Circumference of upper part (cm) Circumference of middle part (cm) Circumference of lower part (cm)	 7.6 8.6 9.2	 7.8 8.5 9.1

The ulna was the longest bone in the forelimb of tiger. The olecranon of ulna was projected further than the radius at the proximal extremity, which was similar with the cattle (Budras et al.2011) and sheep (Sisson et al.1975) but not similar with the horse (Sisson et al.1975). The free end of this olecranon was extended caudolaterally to form olecranon tuberosity as observed in dog (Sisson et al.1975)and Asiatic cheetah (Nazem et al.2017). It had three prominences- two were cranial and the caudal one was large and rounded as reported in dog (Sisson et al.1975). The trochlear (semilunar) notch was large and articulated with the trochlea of humerus. It was continued distally by the medial and lateral coronoid

processes to form a concave surface for articulation, whereas proximally it was continued with the anconeal process. As like as radius, the shaft of ulna was triangular in section and slightly convex cranially. These similar findings were also observed in Asiatic cheetah (Nazem et al.2017). The proximal half of the shaft was thick as resembling to the distal part of caudal view. At the distal extremity, a distally projected lateral styloid process was seen which articulated with the carpal bones as observed previously by (Nzalak et al. 2018). Medially it had a convex facet that articulated with the radius bone.

Table 4: The morphometrical data for different parameters of ulna.

Serial no	**Parameters**	**Right**	**Left**
1	Total length (cm)	35	35
2	Proximal extremity Circumference (cm) Width (cm)	 13.2 4	 13.1 5
3	Distal extremity Circumference (cm) Width (cm)	 8.2 4.2	 8.8 4.5
4	Circumference at mid shaft (cm) Circumference of upper part (cm) Circumference of middle part (cm) Circumference of lower part (cm)	 11.3 7.5 6.1	 11.2 7.9 5.7

Figure 6. Craniomedial view of right radius and ulna of tiger: 1) Olecranon tuber 2) Olecranon process 3) Anconeal process 4) Trochlear notch 5) Capitular fovea of radius 6) Interosseous space, and 7) Medial styloid process of radius.

CONCLUTION

The scapula of tiger was quadrangular shape with two surfaces, three borders and three angles. Its lateral surface was unequally divided into supraspinous and infraspinous fossa by a well-developed spine which gradually decreased towards the proximal extremity. The acromian process was subdivided into thick triangular shape suprahamate process and hamate process which was over hanged the glenoid cavity. The humerus of tiger was a long bone with a spirally twisted shaped. The body of humerus was somewhat compressed laterally. Radius was slightly twisted bone with an anteroposteriorly flattened shaft and two extremities. The proximal extremity had concave facet and distal extremity was expanded and was about twice the size of proximal extremity. The ulnar bone was longer than radius and was flattened mediolaterally. The proximal extremity had olecranon process, anconeus process and facet for humerus. The gross anatomical features and morphometric parameters of different bones of forelimb will be indicating tools for comparative studies and radiographic interpretations.

LIMITATION

1. There were no sufficient samples due to shortage of animals. Collection of bones of wild animals like tiger was very difficult in our country.

2. The information of the bones of tiger was not available due to lack of osteological research in our country as well as in abroad.

3. The comparisons with closely similar type of species were not possible due to insufficient references.

FUTURE PLAN

My future plan is to achieve the depth knowledge on form and structure of wild animals for developing my career in the field of veterinary science specifically for being a competent veterinary surgeon. I am also interested to explore the comprehensive knowledge on animal locomotion (osteology associated with myology, tendon, ligaments, blood and nerve supply) for radiographic research, wildlife conservation research and eco-health approach.

ACKNOWLEDGEMENT

First of all, I would like to thank the **Almighty Allah** for being able to complete this clinical report.

I am thankful to the authorities of **Bangladesh National Zoo**, Dhaka, Bangladesh for giving permission to collect the bones of Tiger in the Anatomy museum of CVASU and allowed me for this study. I would like to express my gratitude and thanks to **Dr. Mohammad Lutfur Rahman**, Professor, Department of Anatomy and Histology, Faculty of Veterinary Medicine, CVASU for his skillful supervision and guidance to make this report successfully.

I am also thankful to **Dr. Shahariar Hasan Sohel and other members** of Anatomy laboratory for their supports and help during conducting this study. I am grateful to my classmate and friend **Sadia Jahan** for her kind co-operation and help specially during taking morphometric parameters of bones to complete this research work.

REFERENCES

1. Sisson S, Grossman JD, Getty R. Sisson and Grossman's The Anatomy of the Domestic Animals. Vol. 1 & 2, 5th ed. Philadelphia, USA: W.B. Saunders Press; 1975.

2. Evans HE, De Lahunta A. Miller's anatomy of the dog-E-Book. Elsevier Health Sciences; 2013.

3. Podhade D. Studies on characteristic features of appendicular skeleton of leopard as an aid in wildlife forensic. PhD, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, India; 2007.

4. Nazem MN, Sajjadian SM, Nakhaei A. Anatomy, functional anatomy and morphometrical study of forelimb column in Asiatic cheetah (*Acinonyx jubatus venaticus*). Italian Journal of Anatomy and Embryology 2017; 122 (3): 157-172. doi:10.13128/IJAE-22975.

5. Palanisamy D, Tomar MPS, Ankem PB, Ullakula RS, Jonnalagadda N, Korampalli V. Gross morphology of scapula in Indian wild cat (*Felis silvestris ornate*: Gray, 1830). International Journal of Current Microbiology and Applied Sciences 2018; 7 (4): 2473-2477. doi.org/10.20546/ijcmas.2018.704.283.

6. Nzalak JO, Eki MM, Sulaiman MH, Umosen AD, Salami SO, Maidawa SM, Ibe CS (2018). Gross anatomical studies of the bones of the thoracic limbs of the lion (*Panthera leo*). Journal of Veterinary Anatomy 2010; 3 (2): 65-71. doi:10.21608/JVA.2010.44901.

7. Pandey S, Bhayani DM, Vyas YL. Gross anatomical study on the scapula of Asiatic lion (*Panthera persica*). Indian Journal of Veterinary Anatomy 2004; 16: 53-56.

8. Tomar, M. P. S., Taluja, J. S., Vaish, R., Shrivastav, A. B., Shahi, A., & Sumbria, D. (2018). Gross anatomy of scapula in Tiger (Panthera tigris). *Indian Journal of Animal Research*, *52*(4), 547-550.

9. Palanisamy, D., Tomar, M. P. S., Ankem, P. B., Ullakula, R. S., Jonnalagadda, N., & Korampalli, V. (2018). Gross Morphology of Scapula in Indian Wild Cat (Felis silvestris ornate: Gray, 1830). *Int. J. Curr. Microbiol. App. Sci*, *7*(4), 2473-2477.

10. Sarma, K., Sasan, J. S., & Suri, S. (2017). Gross and Morphometrical Studies on Scapula of Civet Cat (Viverricula indica). *Int J Pure App Biosci*, *5*(6), 80-85.

11. Kirberger RM, du Plessis WM, Turner PH. Radiologic anatomy of the normal appendicular skeleton of the lion (*Panthera leo*). Part 1: thoracic limb. Journal of Zoo and Wildlife Medicine 2005; 36 (1): 21-29. doi.org/10.1638/03-013.

12. Ahasan ASM, Quasem M, Rahman ML, Hasan RB, Kibria ASM, Shil SK. Macroanatomy of the bones of thoracic limb of an Asian elephant (*Elephas maximus*). International Journal of Morphology 2016; 34 (3): 909-917. doi.org/10.4067/S0717-95022016000300016.

13. Budras KD, Habel RE. Bovine anatomy. Germany: Schlütersche; 2011.

14. Nowak RM, Walker EP. Walker's primates of the world. 6th ed. Baltimore, USA: Johns Hopkins University Press; 1999.

15. Hildebrand, M., & Hurley, J. P. (1985). Energy of the oscillating legs of a fast-moving cheetah, pronghorn, jackrabbit, and elephant. *Journal of morphology*, *184*(1), 23-31.

16. Mazák,V.(1981).*Pantheratigris*.Mammalian species. **152** (152):18. doi:10.2307/3504004. JSTOR 3504004.

17. Karanth, K. U. (2003). "Tiger ecology and conservation in the Indian subcontinent". *Journal of the Bombay Natural History Society*. **100** (2–3): 169–189. Archived from the original on 10 March 2012.

18. Barlow, A.; Mazák, J.; Ahmad, I. U.; Smith, J. L. D. (2010). "A preliminary investigation of Sundarbans tiger morphology". *Mammalia*. **74** (3): 329–331. doi:10.1515/mamm.2010.040.

19. Sunquist, M.; Sunquist, F. (2002). *"Tiger Panthera tigris (Linnaeus, 1758)"*. *Wild Cats of the World*. University of Chicago Press. pp. 343–372. ISBN 978-0-22-677999-7.