

Historical, exceptionally large skulls of saltwater crocodiles discovered at the Lee Kong Chian Natural History Museum in Singapore

Yusuke Fukuda^{1*}, Choon Beng How², Bernard Seah³, Shufen Yang², Kate Pocklington⁴ and Lim Kok Peng⁴

Abstract. Crocodylians show a wide range of maximum Total Length (TL) and *Crocodylus porosus* is considered one of the largest crocodilian species with some individuals attaining more than 6 m in length. Remains of such exceptionally large crocodiles are sometimes found in different countries although details of these individuals such as TL, origin, or date of acquisition have been lost in many cases. Here we measured two exceptionally large but little known skulls found at the Lee Kong Chian Natural History Museum in Singapore and compared their morphological measurements to other large skulls reported from different countries. We found out in literature that one of the skulls, named “Edgar”, had been from one of the largest crocodiles ever reported (6.7 m TL) and brought from Java to the museum in 1887. Details of the other skull, named “Giryu”, still remain unknown. Based on the morphological measurements we presented here, it is likely both these crocodiles were *C. porosus* larger than at least 6 m TL. Given that such large individuals are hardly seen today due to previous hunting and habitat loss, these skulls have significant, biological and cultural values.

Key words. crocodile, *Crocodylus porosus*, skull, Java, Raffles

INTRODUCTION

The 24 extant species of crocodilian currently recognised show a wide range of maximum Total Lengths (TL), including some members exceeding 5 m in the wild. *Crocodylus porosus* Schneider, 1801, commonly called the saltwater, estuarine, or Indo-Pacific crocodile, is considered to be the largest crocodilian species, with some individuals known to reach more than 6 m in length (Whitaker & Whitaker, 2008; Britton et al., 2012; Grigg & Kirshner, 2015). Biological remains of such giants are sometimes found in the form of preserved skulls or tanned skins in private and/or public collections in different countries, which are often outside the current or historical range of the species in question (Whitaker & Whitaker, 2008). It is not unusual that such remains are aged as these historical specimens often come from animals that had lived before many crocodilian populations were depleted due to uncontrolled hunting or excessive habitat loss in the last century. It is also not unusual to lack details on the provenance and morphometric characteristics of specimens, which have high biological and cultural values. Here we report on two large, little known skulls of crocodiles discovered in the collection at Lee Kong Chian Natural

History Museum (LKCNCNHM) in Singapore, and provide detailed morphological measurements and estimates of TL of the individuals from which they were derived.

MATERIAL & METHODS

Cranium (upper jaw) and mandible (lower jaw) named “Edgar” and another cranium named “Giryu” (義龍) are included in the Zoological Reference Collection (accession numbers ZRC 2.7300 for Edgar and ZRC 2.7301 for Giryu, Fig. 1) at the LKCNCNHM (formerly Raffles Museum of Biodiversity Research), National University of Singapore, Singapore. No details such as the species, origin, size and age of these specimens were available until this study was conducted.

We measured the two skulls at LKCNCNHM on 17 April 2018, using two 100 cm rulers and a 500 cm tape measure, both made of stainless steel. We followed the standardised methods for measuring crocodilian skulls, including those used by Britton et al. (2012). First we measured the Dorsal Cranial Length (DCL) A (Fig. 2) on both craniums, which is the length between the tip of the snout and the rear of the cranial platform (parietal in the occipital part) along the mid-line of a skull. DCL A is the head length measurement most commonly referred to for a crocodilian skull or head. We also measured DCL B which is DCL but at a horizontal level (Fig. 2). Because DCL B ignores the slope on the cranium, it is shorter than DCL A and is used only in a supplementary manner for estimating the size of an animal. We measured DCL B of Edgar, but not Giryu, as the absence of the lower jaw in the latter would affect the DCL B angle. We then measured Maximum Cranial Width (MCW), which is the

¹Northern Territory Department of Environment and Natural Resources, Australia; Email: yusuke.fukuda@nt.gov.au (*corresponding author)

²Sungei Buloh Wetland Reserve, National Parks Board, Singapore

³Bernard Photojournals, Singapore

⁴Lee Kong Chian Natural History Museum, National University of Singapore, Singapore

Table 1. Measurements of the two skulls (Edgar and Giryu) found at LKCNHM, Singapore. See text for the abbreviations. The measurements for other crocodiles in a similar size (Lolong, Corroboree, and Old Charlie) were included for comparative purposes.

Skull	DCL A (mm)	DCL B (mm)	MHW (mm)	MCW (mm)	IOW (mm)	TL (cm)
Edgar	701	682	520	240	80	670 ^{&^}
Giryu	706	n/a	n/a	205	67	n/a
Lolong*	700	694	450	228	84	617.0
Corroboree [†]	728	n/a	458	230	71	670 [^]
Old Charlie [†]	666	n/a	480	235	75	615.0

[&]From Hanitsch (1908). ^{*}From Britton et al. (2012). [†] From Manolis (2006). This skull is also reported by Whitaker and Whitaker (2008), but measurements in Manolis (2006) are considered more accurate since the skull was bleached and damaged after 2006. [†]From Webb & Messel (1978). [^]Not measured but estimated.



Fig. 1. Exceptionally large skulls of *Crocodylus porosus* Schneider, 1801 discovered at the Lee Kong Chian Natural History Museum (LKCNHM). Edgar on left and Giryu on right.

maximum width of the cranial plate between squamosals, and Inter-Orbital Width (IOW), which is the minimum width between orbits (eyes) (Fig. 3). We also measured the Maximum Head Width (MHW), which is the width at the widest part (usually mandible) of a head (Fig. 3) for Edgar, but not Giryu as it did not have the lower jaw.

RESULTS

Although Edgar (with lower jaw) was slightly shorter (0.7%) than Giryu (upper jaw only), it was considerably wider than the latter (17.1%; Table 1). Edgar had two teeth left (one on the right side of the upper jaw and the other on the left side of the lower jaw) while Giryu had none.

During the measurement of Edgar, we found handwriting that read “5/4/1887” on the inner side of the left, retroarticular process of the articular (Fig. 4). We later discovered that Hanitsch (1908) had reported that a large skull of *C. porosus* was presented to the museum by Mr. G. Edgar in 1887. He described that the skull length, which is considered equivalent

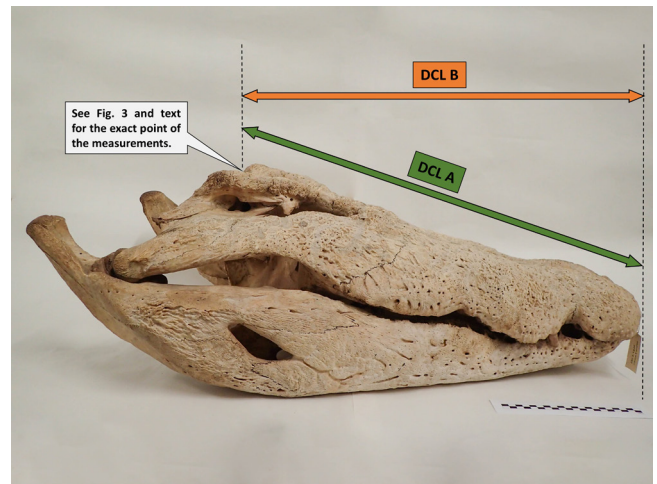


Fig. 2. Measurement of Dorsal Cranial Length (DCL) A and B of Edgar, *Crocodylus porosus* Schneider, 1801.

to DCL A, was 27.5 inches (699 mm). He also noted that the skull “must have belonged to a monster quite 22 feet in length” (equivalent to 670.5 cm) and “it probably came from Java”. Although details of the smaller skull remained unknown, the morphological characteristics such as the two elevated ridges running between the openings of the eyes and nostril (Fig. 1).

DISCUSSION

Within large crocodiles, the head could cease increasing in its length although width may continue to grow, thus a combination of morphological measurements for the head width may be a more accurate index for predicting TL (Webb & Messel, 1978). For example, a large skull located in Darwin of the Northern Territory, Australia known as Old Charlie is shorter than that of Lolong, another large *C. porosus* captured in Philippines in 2011, but this does not mean that Old Charlie was smaller than Lolong. In fact, Old Charlie’s skull was wider than Lolong and both crocodiles were in similar TL (Table 1). Likewise, Edgar is shorter but considerably wider than Corroboree, the largest skull in Australia, and both crocodiles may have been in a similar size (6.7 m TL). Corroboree was originally caught at the Point Sturt in the Northern Territory (NT) in the 1970s and now on display at the Corroboree Tavern in the NT. If these crocodiles were in a similar size, Corroboree’s TL reported

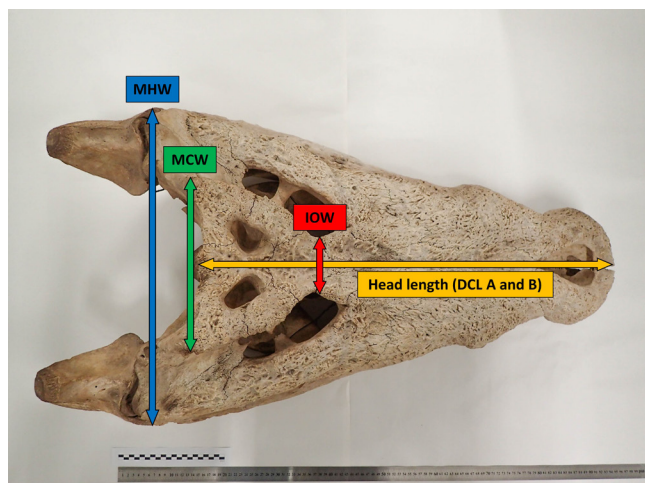


Fig. 3. Measurement of head length (DCL A and B, see Fig. 2), Inter-Orbital Width (IOW), Maximum Cranial Width (MCW) and Maximum Head Width (MHW) of Edgar, *Crocodylus porosus* Schneider, 1801.

by the owner who observed the animal when captured is likely to be a reasonable estimate as it is consistent with Hanitsch (1908) reporting that Edgar came from a 22 ft (approximately 6.7 m) crocodile. Edgar is actually the widest skull ever recorded (Whitaker & Whitaker, 2008; Britton et al., 2012). In contrast, Giryu had the narrowest skull of the four, but with a slightly longer head than Lolong, which indicates that the crocodile might have been smaller than Lolong (6.17 m TL).

To the best of our knowledge and available literature (e.g., Webb & Messel, 1978; Kar, 2006; Manolis, 2006; Whitaker & Whitaker, 2008; Britton et al., 2012; Grigg & Kirshner, 2015), there are only 12 *C. porosus* skulls known to be longer than 700 mm DCL, two of which are Edgar and Giryu. The largest skull, reported to be 760 mm, is at the Paris Museum, and was collected from Cambodia in the 1800s, but TL is unknown (Whitaker & Whitaker, 2008; Grigg & Kirshner, 2015). HL or DCL alone has been widely used to estimate TL of crocodilians although many datasets are biased towards smaller individuals and there is known to be a significant variation in their HL:TL ratios (Webb & Messel, 1978). Fukuda et al. (2013) calculated HL : TL ratios for *C. porosus* from 2,755 individuals ranging from 38 to 503 cm long and showed that 1 : 7 ratio can be used to predict TL with reasonable accuracy. Moreover, a few reliable records suggested that the ratio increasingly becomes higher as a crocodile grows exceptionally large (e.g., 1 : 8.81 for Lolong with 6.17 m TL). Accounting these observations, all these 12 skulls are most likely from crocodiles longer than 600 cm TL and some may have been close to 700 cm. Given that *C. porosus* with such large TL are rarely seen today because of previous hunting and habitat loss, the biological and cultural values of these historical skulls cannot be over-stated. LKCNHM is considering incorporating both of the skulls in its educational displays within the Biodiversity Gallery.

In Singapore, historical data for some individuals measuring 609 cm (recorded as 20 feet in length) have been found



Fig. 4. Handwritten date on the mandible of Edgar, *Crocodylus porosus* Schneider, 1801. It is unknown whether this date refers to a day when the skull was obtained in the field or presented to the museum by Mr. G. Edgar.

recorded in digitised newspapers. These measurements were taken from captured or shot individuals at 20 ft length in 1863 (The Straits Times, 1863) and 1904 (The Straits Times, 1904). Other measurements exceeding these, such as 762 cm, recorded as 25 ft length (The Straits Times, 1960) and 914 cm recorded as 30 ft length (The Straits Times, 1878) were taken from sightings only and are most likely to be utterly overestimated or exaggerated.

ACKNOWLEDGEMENTS

We thank Tony Pine who helped us measure the skulls and Shimpei Ochi at Herpetological Society of Japan who encouraged us to publish this article. We are thankful to Charlie Manolis, Rom Whitaker and anonymous reviewers for their constructive inputs. Charlie Manolis re-measured the skull “Corroboree” for this study. Funding for Y. Fukuda was provided by National Geographic Society – Asia (grant number 51-16).

LITERATURE CITED

- Britton ARC, Whitaker R & Whitaker N (2012) Here be a dragon: Exceptional size in a saltwater crocodile (*Crocodylus porosus*) from the Philippines. *Herpetological Review*, 43: 541–546.
- Fukuda Y, Saalfeld K, Lindner G & Nichols T (2013) Estimation of total length from head length of saltwater crocodiles (*Crocodylus porosus*) in the Northern Territory, Australia. *Journal of Herpetology*, 47: 34–40.
- Grigg G & Kirshner D (2015) *Biology and Evolution of Crocodylians*. Cornell University Press, New York, 649 pp.
- Hanitsch R (1908) *Guide to the Zoological Collections of the Raffles Museum, Singapore*. Straits Times Press, Singapore, 112 pp.
- Kar S (2006) Record of a large saltwater crocodile from Orissa, India. *Crocodile Specialist Group Newsletter*, 25(3): 27.
- Manolis C (2006) Record of a large saltwater crocodile from the Northern Territory, Australia. *Crocodile Specialist Group Newsletter*, 25(3): 27–28.
- Schneider JG (1801) *Historiae Amphibiorum naturalis et literariae. Fasciculus secundus continens Crocodilos, Scincos, Chamaesauras, Boas. Pseudoboas, Elapes, Angues. Amphisbaenas et Caecilias*. Frommanni, Jena, Germany, 374 pp.
- The Straits Times (1863) Wednesday, 10th June. The Straits Times 13 June 1863. <http://eresources.nlb.gov.sg/newspapers/>

- Digitised/Article/straitstimes18630613-1.2.9.2.aspx. (Accessed 22 November 2015).
- The Straits Times (1878) Wednesday, 3rd July. The Straits Times 6 July 1878. <http://eresources.nlb.gov.sg/newspapers/Digitised/Article/straitstimes18780706-1.2.16.2.aspx>. (Accessed 22 November 2015).
- The Straits Times (1904) Catching a crocodile. The Straits Times 31 May 1904. <http://eresources.nlb.gov.sg/newspapers/Digitised/Article/straitstimes19040531-1.2.25.aspx> (Accessed 12 September 2015).
- The Straits Times (1960) Croc scares fishermen. The Straits Times 18 March 1960. <http://eresources.nlb.gov.sg/newspapers/Digitised/Article/straitstimes19600318-1.2.154.aspx> (Accessed 12 September 2015).
- Webb GJW & Messel H (1978) Morphometric analysis of *Crocodylus porosus* from the north coast of Arnhem Land, northern Australia. Australian Journal of Zoology, 26: 1–27.
- Whitaker R & Whitaker N (2008) Who's got the biggest? Crocodile Specialist Group Newsletter, 27(4): 26–30.