

First discovery of *Stegodon* (Proboscidea) in Malaysia

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Abstract: A cheek tooth of *Stegodon*, an extinct genus of Proboscidea, had been discovered in a cave in Gopeng, Perak. The discovery represents the first fossil of *Stegodon* ever found in Malaysia. Embedded in lithified cave infillings are the associated dental remains from at least three or four other different taxa of fossil mammals commonly found among Southeast Asian Pleistocene-Holocene faunas. The finding provides a unique chance for investigations into the evolution dynamics of *Stegodon* in this part of Southeast Asia and the species diversity of Proboscidea in prehistoric Peninsular Malaysia. Fossil mammal assemblages from different phases of Pleistocene-Holocene period collected from karstic caves in Peninsular Malaysia, when considered with similar assemblages from other parts of Southeast Asia, have the potential to contribute to our understanding of prehistoric faunal migrations and species compositional changes among the biogeographic (sub)divisions in Southeast Asia. This may ultimately lead to a better knowledge of the possible paleoenvironmental and paleoclimatic fluctuations that influenced patterns of migration and adaptive responses of mammalian faunas in Quaternary Southeast Asia.

Keywords: *Stegodon*, cave paleontology, Quaternary mammals, Southeast Asia, prehistoric migrations

INTRODUCTION

There has been a wide gap in Quaternary vertebrate paleontological studies since the first major publication in the 1960s (Hooijer, 1962). As a consequent of which, Malaysia is lagging far behind in this important aspect of Quaternary science investigation among the Southeast Asian countries. However, this knowledge gap had been partially filled relatively recent with the report of the first discovery of orangutan (*Pongo* sp.) fossils in Peninsular Malaysia (Yasamin *et al.*, 2013), an overview on the elephant fossils and distribution (Lim, 2013) in prehistoric Peninsular Malaysia and a number of new geographic records of prehistoric rat (murinae) species by Sahak *et al.* in 2019 and Sahak (2020) from sites dating back from

500-33 Ky (thousand years). Caves with exceptionally high potential had also been reported from Merapoh (Pahang) which represented the first *Pongo* fossil site in central Peninsular Malaysia (Muhammad *et al.*, 2019). Associated fauna includes fossils of the regionally extinct Asian Black Bear (*Ursus thibetanus*) (Muhammad *et al.*, 2019) and possibly other higher primates.

To date, about 1000 isolated teeth remains had been collected from several fossil-bearing caves, with globally and regionally extinct taxa: *Pongo*, *Ursus thibetanus*, Hog Badger (*Arctonyx*), Javan Rhinoceros (*Rhinoceros sondaicus*), Sumatran Rhinoceros (*Dicerorhinus sumatrensis*), Lesser Giant Rat (*Leopoldamys minutus*). The rest consists of diversified faunas of Porcupines

(Hystricids), Bamboo Rats (*Rhizomys* spp.), Malayan Sun Bear (*Helarctos malayanus*), Clouded Leopard (*Neofelis nebulosa*), Tiger/Leopard (*Panthera* spp.), Dog/Dhole (Canids), Asian Elephant (*Elephas maximus*), Wild Boar (*Sus* spp.), Sambar Deer (*Cervus unicolor*), medium-sized deer (Cervids), Mousedeer (*Tragulus* spp.), Southern Serow (*Capricornis sumatraensis*), large-sized wild cattle (Bovids), monkeys (Cercopithecines), various murine species and possibly other higher primates.

A routine exploration of caves in Gopeng by a group of cave enthusiasts from the Kinta Valley Watch group on July 26, 2020 had uncovered a peculiar object. Upon initial observation of photos and the actual object in situ within its encasing sediments in the field and consultation with various experts, it had been identified as a cheek tooth of *Stegodon*, a globally extinct genus of Proboscidea. Fossils of *Stegodon* or related forms had been recorded from central and east Africa in Chad, Democratic Republic of Congo, Uganda, Ethiopia, Kenya and Tanzania. Within Asia, species of the genus had been reported from China (both mainland and Taiwan), Japan, India, Pakistan, Nepal, Myanmar, Thailand, Laos, Vietnam, Indonesia (Java, Sulawesi, Sangehe, Sumba, Flores and Timor) and the Philippines (Luzon and Mindanao) but not from Malaysia.

THE CAVE/LOCATION OF THE FOSSIL SITE

The specific location of the discovery site is kept embargoed until the necessary procedures are taken for protection and preservation. An updated publication with complete information of the location and more data after various analyses will be published. The cave is located in a relatively small karst hill (unmarked in any regional topographical maps consulted) with a small stream flowing along the periphery of its cliff. Multi-level notches can be seen along a wall, with some parts forming shelter caves. The height of the notches is at about 2 m high, and extend into the cave. The cave forms two distinct layers that trend towards the southwest and cut through the hill. The upper passage is elevated about 6 m above the ground and forms a narrow cave trending towards

the southwest. Fossil-bearing remnants of 0.8 m-thick lithified cave infillings are cemented on both sides of the passage walls. The clastic cave sediment consists of mostly fine sands with some muds, and intercalation of streaky crystalline carbonate, with some subangular rock pebbles. The tooth of the *Stegodon* was embedded approximately in the middle of the passage, about 70 cm from the cave floor. Dental remains of mammals were also found in the soft sediments in the lower passage.

THE FIELDWORK, EXTRACTION AND ONGOING WORK

Metrical data of the exposed section of the tooth were collected as accurately as field conditions allowed using a hand-held vernier caliper. Results from visual observation of the external morphological characters were documented. To ensure the morphological details of the exposed surface of the *Stegodon* fossil can be accurately captured and recorded prior to extraction, dentists used special dental materials to prepare the tooth impression and cast of the fossil. This procedure is essential as any mishandling during extraction might damage the fossil. Before applying to the *Stegodon* tooth, the moulding process had been experimented and improved upon using similar fossil-bearing matrix (collected from other cave sites) in the lab and on an exposed bovid tooth fossil (while still embedded in its encasing matrix) in the field. Extraction had been carried out after the moulding process by using battery-powered drills, hammers and chisels. Extraction was targeted at both the tooth and the encasing matrix immediately surrounding and protecting the fossil tooth. The whole process of moulding and extraction was video and pictorially recorded.

The complete cave passages were mapped for geomorphology and taphonomy description, with information on other features such as the streams and other karst hills in the surrounding gathered. The data give us clues on the depositional environment of the cave infilling and probably can be used for age estimation of the cave. Carbonate grains in the encasing sediment were separated and handpicked for U series age determination



Figure 1: A cheek tooth of *Stegodon* found embedded in lithified cave sediment in Gopeng, Perak.



Figure 2: Morphological details of the exposed surface of the *Stegodon* is captured by moulding prior to extraction.



Figure 3: Extracted tooth in encasing matrix.

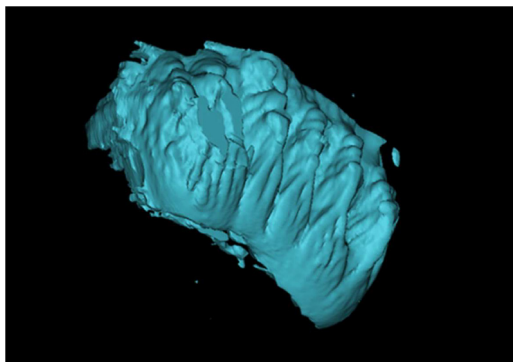


Figure 4: 3D reconstruction image of *Stegodon* tooth fossil using a high precision cone beam computed tomography (CBCT).

and are being tested in National Taiwan University. This initial analysis will be followed by other techniques to be decided in the future.

Detailed morphological studies on the fossil and high-precision imaging using micro-computed tomography (MicroCT) and cone beam computed tomography (CBCT) are being conducted and will be followed by comparison with museum collections to determine the serial position of the tooth and possible species.

ASSOCIATED FAUNA

Associated fauna had been observed and to date, *Pongo*, *Sus* spp., modern elephant (*Elephas* or related form) and a large-sized bovid were found in both of the passages in the potentially rich sediments. Early field observation indicates the lower passage may be of younger age compared to the upper passage. Both passages are likely to give a long record of various taxa that may span tens of thousands of years during the Late Pleistocene or earlier.

CONCLUSIONS

Caves in Peninsular Malaysia have proved to be sites for scientifically important Quaternary fossil materials.

These fossil and geological findings can provide answers to some pertinent research questions, such as the evolution and migrations of mammals and their adaptations to habitat changes in this part of Southeast Asia during the Quaternary. Peninsular Malaysia, with its strategic location between continental and island Southeast Asia, very likely acted as one of the key corridors for prehistoric migrations of land mammals and humans. This study is the first step towards developing a niche area for natural history and heritage studies with region-wide implications.

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