THE RAFFLES BULLETIN OF ZOOLOGY 2013 Supplement No. **29**: 139–153
http://zoobank.org/urn:lsid:zoobank.org:pub:2E00FB5A-CE52-4B57-95A8-21105BC678F2
Date of Publication: 30 Nov.2013

QUATERNARY *ELEPHAS* FOSSILS FROM PENINSULAR MALAYSIA: HISTORICAL OVERVIEW AND NEW MATERIAL

Lim Tze Tshen
Zoological Museum, Institute of Biological Sciences, University of Malaya, 50603 Kuala Lumpur, Malaysia
Email: limtzetshen@yahoo.com

ABSTRACT. — Elephant fossils have rarely been reported from Peninsular Malaysia. The present study represents the first attempt at compiling all currently known historical reports about elephant fossil discoveries, over a time span of more than 100 years, supplemented by previously unreported specimens from museum collections and recently found materials. A total of 19 specimens, all isolated dental materials of presumed Late Pleistocene and Holocene age are recorded. Most of these materials represent opportunistic finds from past tin-mining operations and mineral resources surveys; only a few are associated with archaeological artefacts. Fossils have been recorded in all states in Peninsular Malaysia except Kedah, Penang, Melaka and Terengganu. Historical and taphonomic backgrounds of these finds are examined, and it is suggested that rodents (porcupines) have played only a minor role for the accumulation of large fossils (elephant molars) found in caves. Critical morphological and metrical evaluations of the fossils indicate that they all belong to *Elephas maximus*. Present evidence does not support the original identification of some of the fossils as *Palaeoloxodon namadicus*. Confirmation of *Palaeoloxodon namadicus* occurrence in prehistoric Peninsular Malaysia demands the find of better fossils, especially of cranial material.

KEY WORDS. — *Elephas*, Quaternary, fossil, Peninsular Malaysia, *Palaeoloxodon*, Borneo, Southeast Asia

INTRODUCTION

The genus *Elephas* has only one surviving species, the Asian Elephant (*Elephas maximus*) today. The history of the genus, however, is more diverse, containing many extinct species during past geological times (Osborn, 1942; Hooijer, 1955; Maglio, 1973). In prehistoric times, the species was recorded from Java (van den Bergh et al., 1992; van den Bergh, 1999) and Borneo (Hooijer 1972; Cranbrook et al., 2007), and beyond its current distributional range west to the Tigris-Euphrates Basin in Iraq (Sukumar & Santiapillai, 1996) and north to China (Zhang, 1979; Tong, 2002) beyond the Yangtze River Valley (Han & Xu, 1985). Its range, however, has constricted dramatically since historical times (Oliver, 1978; Shoshani & Eisenberg, 1982) with present distribution limited to certain areas within the Indomalayan biogeographic region (Corbet & Hill, 1992). It is currently present in 13 nations: Bangladesh, Bhutan, India (including feral populations on some of the Andaman Islands), Nepal, Sri Lanka in South Asia; Cambodia, China, Indonesia (Sumatra and Kalimantan), Laos, Malaysia (Peninsular Malaysia and Sabah), Myanmar, Thailand and Vietnam in Southeast Asia (Choudhury et al., 2012). Within Peninsular Malaysia, it is still present in Kelantan, Perak, Johor, Pahang, Terengganu, Kedah and Negeri Sembilan (Salman et al., 2011), and often comes into conflict with people in certain states, e.g., Johor (Salman & Nasharuddin, 2003).

Subspecific relationships among the living and extinct populations of *Elephas maximus* were discussed by Deraniyagala (1955: 116–125). However, only three living subspecies are recognised by Shoshani & Eisenberg (1982: 1): the Sri Lankan Asian Elephant (*E. m. maximus*); the Mainland Asian Elephant (*E. m. indicus*) and the Sumatran Asian Elephant (*E. m. sumatranus*). Based on various characters, Shoshani & Tassy (2005: 8, 10) suggested that *E. m. sumatranus* is the most primitive among the three subspecies, *E. m. maximus* the most derived, and *E. m. indicus* an intermediate form. They left opened the question regarding the affinity and nomenclature for the population living in north Borneo.

In 1973, Maglio (1973: 50) noted the curious fact that even though it is potentially the best known species of *Elephas*, the Asian Elephant was hardly represented in the fossil record. This resounding statement still carries a certain amount of truth because, as a matter of fact, fossilised remains of *Elephas maximus* or **Palaeoloxodon namadicus* have rarely been discovered in either an archaeological or a palaeontological context in Peninsular Malaysia. Reports on elephant fossils are sporadic and these fossils were usually opportunistic discoveries not directly associated with palaeontological surveys. The paucity of fossils has rendered it difficult to study and reconstruct the evolutionary history of the genus in Peninsular Malaysia. Since the first report, in the early 20th century, of an elephant fossil from Peninsular Malaysia (see below), only two very brief reviews were given in 1966 and 1973 (Jones et al., 1966; Stauffer, 1973). In this paper, a compilation of published records from mostly out-of-print publications is presented together with detailed descriptions of previously unreported museum specimens and newly discovered materials. Their morphology and possible taxonomic relationships are examined, especially in connection with recent finds from other parts of Southeast Asia.

MATERIAL AND METHODS

Literature review and historical records. — As the early discoveries of mammal fossils including those of elephant in Peninsular Malaysia are directly associated with mineral prospecting and surveys, the series of memoirs and reports published by the Geological Survey Department (now the Minerals and Geoscience Department Malaysia) remains an invaluable source of historical records. All the memoirs and reports, starting from the first issue (1937) until the latest available issue (1986) were thoroughly searched for any possible record of fossil finds.

Anatomical and sequential positions of isolated molars. — Determination of the anatomical position (maxillary or mandibular; left or right) of isolated cheek tooth follows the criteria suggested by Deraniyagala (1955: 51), supplemented by Zhou & Zhang (1974: 42):

Upper molars – occlusal surface relatively flat or convex; grinding surface relatively broad and short, almost perpendicular to the long axis of tooth; concave along lingual margin; higher degree of abrasion on lingual side of grinding surface.

Lower molar – occlusal surface concave, especially on mid-section; grinding surface relatively long, almost parallel to the long axis of tooth; convex along lingual margin; higher degree of abrasion on buccal side of grinding surface.

Zoologists sometimes designate the six cheek teeth of elephants with the roman numerals, I to VI. However, in the current paper the conventional scheme used by most modern palaeontologists is followed, i.e., DM2-DM3-DM4-M1-M2-M3, in order of succession from the back to the front of each jaw quadrant, as though on a conveyor belt. Serial position of an isolated tooth is determined by the number of plates present, if it is a complete specimen, and size (i.e., width); if it is incomplete, using the modern *Elephas maximus* data recorded and published in Roth & Shoshani (1988: 578, 580).

Dimensions of measurement and parameters. — All measurements were taken using hand-held vernier caliper. Morphological terms for cheek teeth and methods of measuring and tabulating biometrical parameters are largely based on those used by Maglio (1973: 8–13), Roth & Shoshani (1988: 572–574) and van den Bergh (1999: 28–30). Dimensions used in the current paper include:

Length (L) – Maximum length of a cheek tooth, measured along the longitudinal axis of the tooth parallel to crown base.

Width (W) – Maximum width of a cheek tooth, measured across the widest plate (including the covering cementum layer, if any), with the jaws of the caliper parallel to the anterior and posterior plates.

Height (H) – Maximum height of the highest plate, measured from crown base (not including root mass) to the top of the plate.

Height/Width Index (H/W Index) – Also known as Hypsodonty Index (HI) or Relative Crown Height (RCH), in which the maximum height (H) of a tooth is expressed as a percentage of its maximum width (W), and calculated by multiplying the height-width ratio by 100.

Plate number – The total number of plates or lamella present or preserved as viewed from the side of a tooth which include the small half-plate at the front end of a tooth and also plates partially covered within cementum.

Lamellar Frequency (LF) – The number of plates that occur in a standard distance of 100 mm along the antero-posterior axis of a tooth, calculated using the following formula:

LF = (Total number of plates × 100) / Maximum Length

Palaeoloxodon *or* Elephas namadicus. — The validity of the taxon *Palaeoloxodon*, as a distinct genus or representing merely a subgenus of *Elephas*, may be questionable (Shoshani & Eisenberg, 1982; Shoshani & Tassy, 2005). Because of the uncertainty regarding its taxonomic placement, the name *Palaeoloxodon* is marked with an asterisk (*) throughout the text.

Abbreviations. — Abbreviations for institution mentioned in the text and tables:

MZIBD – Zoology Museum (Institute of Biodiversity, Wildlife & National Parks Department Malaysia)
RMBR – Raffles Museum of Biodiversity Research (National University of Singapore)
UKM – Universiti Kebangsaan Malaysia
UMZM – Zoological Museum (University of Malaya)
ZRC – Zoological Reference Collection numbers used by the Raffles Museum of Biodiversity Research (National University of Singapore)

RESULTS

The palaeontological material. — Fossils of *Elephas* and related forms so far found and reported from Peninsular Malaysia comprise the following (in order of sequence identical to the list in Table 1):

1. Salak Specimen
   Andrews (1905/06: 18) in an anonymous note reported

Table 1. List of elephant fossils from Peninsular Malaysia. See Material and Methods for abbreviations.

Item	Primary Reference	Identification (tooth; species)	Current Repository	Catalogue No.
1	Andrews (1905)	Probable upper molar; *Elephas namadicus*	? Taiping Museum	
2	Savage (1937)	Teeth; *Elephas maximus*	Unknown	
3	Richardson (1939)	Tooth; Probably *Elephas namadicus*	Unknown	
4	Roe (1951)	Upper 3rd molar; *Elephas maximus*	Unknown	
5	Ingham & Bradford (1960)	Tooth; *Elephas maximus*	Unknown	
6	Ingham & Bradford (1960)	Teeth; elephant	Unknown	
7	Jones et al. (1966)	Right upper 3rd molar; *Elephas maximus*	Unknown	
8	Peacock & Dunn (1968)	Right upper 2nd /3rd molar; tentatively *Elephas maximus* or *Elephas namadicus*	Unknown	
9	Peacock & Dunn (1968)	Right upper milk tooth or 1st molar; *Elephas maximus*	Unknown	
10	Peacock & Dunn (1968)	Left upper milk tooth or 1st molar; *Elephas maximus*	Unknown	
11	Davison (1991)	Section of tusk; *Elephas maximus*	? UKM	
12	Present study	Upper 2nd molar; elephant	Geology Museum (Ipoh)	16021
13	Present study	Left lower 2nd molar; *Elephas maximus*	Private collection	
14	Present study	Right lower molar; *Elephas maximus*	RMBR	ZRC.4.7883
15	Present study	Lower molar; *Elephas maximus*	RMBR	ZRC.4.7882
16	Present study	Upper molar; *Elephas maximus*	RMBR	ZRC.4.7881
17	Present study	Lower molar; *Elephas maximus*	RMBR	ZRC.4.7884
18		Specimen not seen; *Elephas maximus*	RMBR	ZRC.4.7885
19	Present study	Two associated plates of a lower molar; *Elephas maximus*	UMZM	

that this isolated tooth (probably upper molar) was found in a tin mine of a Mr. Tan Ong Peng (opposite the old Police Station at Salak, Kuala Kangsar, Perak), at a depth of 12 feet (~3.7 m) from the surface, and later presented to the Perak State Museum (now the Taiping Museum). It was identified as belonging to *Elephas namadicus* (**Palaeoloxodon namadicus*), following similar finds in Myanmar (near Mandalay) and Bukit Besar in Pattani (Andrews, 1903). No morphological description or measurements of the specimen were given in the original report, and Andrews' identification was doubted by others in subsequent years (see Peacock & Dunn, 1968).

2. Chemor Specimens
   It is apparent that more than one specimen from Chemor (Perak) were being referred to in the report by Savage (1937: 25). These were stated to come from grey sandy clay at the bottom of a limestone cup 60 feet (~18.3 m) below the surface. The exact number of finds was not given, neither was any morphological observation or measurements provided in support of his allocation of the material to *Elephas maximus*.

3. Tersang Specimen
   This tooth was found by F. G. W. Dunsford in the Tersang Gold Mine (Raub, Pahang) from the auriferous alluvium near bedrock about 16 feet (~4.9 m) below the surface, and at 350 feet (~106.7 m) above mean sea level (Richardson, 1939, 1950). The specimen was forwarded to R. H. von Koenigswald for identification who remarked that it is a poorly preserved tooth and assigned it to *Elephas namadicus* (**Palaeoloxodon namadicus*) provisionally. This was the second specimen from Peninsular Malaysia identified as belonging to **P. namadicus*.

4. Batu Specimen
   Roe (1951: 74) noted that a tooth was found at the Lian Hin Tin Mine (lot 215) in Batu valley, Selangor, in 1949. The deposit in which the specimen had been found was stated to be under about 20 feet (~6.1 m) of tin-bearing alluvium, resting on the granite bedrock. A. T. Hopwood identified it as the upper 3rd molar of *Elephas maximus*.

5. Kuala Dipang Specimen
   A tooth of *Elephas maximus* was reported from Kampung Kuala Dipang, Perak (Ingham & Bradford, 1960). No further information was provided in the report.

6. Sungai Siput South Specimen(s)
   An unspecified number of elephant teeth found in alluvium was also noted in the report of Ingham & Bradford (1960: 81).

7. Wang Tangga Specimen
   This isolated tooth was found, together with other vertebrate remains, in the valley alluvium of Wang Tangga in Kaki Bukit (Perlis) at a depth of 15 feet (~4.6 m) (Jones et al., 1966). D. A. Hooijer identified the tooth as the right upper last molar (i.e., 3rd molar) of *Elephas maximus*, and mentioned that it had a narrow crown and was similar to fossils from the cave deposits of Sumatra (Padang Highland caves in central Sumatra).

8. Kuala Bering Specimen
Peacock & Dunn (1968: 171) noted that this strongly mineralised, yellowish-grey and brown heavy fossil was found resting on a ledge in a small limestone cave west of Kuala Bering (Sungai Jenera) in Ulu Kelantan. It was thought to be a right upper molar (2nd or 3rd molar), with 13 plates preserved. They remarked that it resembles a tooth of **Palaeoloxodon* cf. *namadicus* from Borneo and an upper 2nd molar of **Palaeoloxodon namadicus* from Myanmar. Some features mentioned include strongly wrinkled enamel, fairly well stepped occlusal surface and certain plates exhibiting rudimentary median expansions in the enamel figures. Measurements of the specimen were given as follow: Maximum breadth at the 10th plate from the posterior end (83 mm); Maximum anterior-posterior length (186 mm); Maximum height at the fourth plate from posterior end (180 mm). Based on these measurements and morphological grounds, they tentatively assigned it to *Elephas namadicus* (**Palaeoloxodon namadicus*). A different view was, however, expressed by D. A. Hooijer who thought it belonged to *Elephas maximus* (Peacock & Dunn, 1968) after studying the drawings, measurements and photographs of the specimen. Pictures of the specimen were featured in two views in pls. 1 and 2 of the paper.

9. Lukut Specimen A (Left)
Also reported in Peacock & Dunn (1968: 171) was a pair (left and right) of upper milk (deciduous) teeth or 1st molars found by tin miners in alluvium deposit near Lukut (Negeri Sembilan). Both teeth appeared to be only lightly fossilised, less heavy in weight and less mineralised that the Kuala Bering specimen. They concluded that these two were *Elephas maximus*, a conclusion also maintained by D. A. Hooijer. It was noted that these two teeth were then kept by their finders but D. J. Gobbett (Geology Department, University of Malaya) was able to borrow the specimens for photographing and measurement. However, no picture or measurement of either specimen was included in the original report, and it is not known if D. J. Gobbett has published any additional information regarding these specimens.

10. Lukut Specimen B (Right)
See description for Lukut Specimen A above.

11. Kuala Selinsing Specimen
A section of tusk (diameter: 66–74 mm) of *Elephas maximus* was found among the animal remains excavated from a protohistoric coastal community site at Kuala Selinsing, Perak (Davison, 1991). This item is different from all the material examined in the present paper in that it was found in an archaeological context and reported as an artefact carved into a shape like a spindle or bee-hive (Davison, 1991). It was speculated that it could be from an animal hunted or found locally, or even an item of trade. The specimen should exist in the collection of the History Department, Universiti Kebangsaan Malaysia, Bangi (Davison, personal communication, 2013).

12. Geology Museum (Ipoh) Specimen [Specimen No.: 16021]
This specimen is on display in the exhibition hall of the Geology Museum in Ipoh (Perak). About 18 plates which diverge apically are visible from side view. Based on the number of plates and a slightly convex occlusal outline it is most probably an upper 2nd molar. None of the plates seems to be covered with cementum and many of them have their enamel flanks eroded. Its state of preservation (texture and colour) closely resembles those specimens housed in the RMBR (see below). No specific information regarding the provenance is available from the display label.

13. Grik Specimen. (Figs. 1, 2)
This is a relatively complete left lower 2nd molar with the crown and the root mass preserved. There are about 18 plates attached to one another through the cementum of the transverse valleys of adjoining plates. These plates, especially those towards the posterior appear to be arranged in an S-shaped curvature and converge apically towards the crown. The occlusal surface is slightly concave with the front seven plates (including the frontmost half-plate) already in use exposing the dentine within each worn plate. The enamel borders seem to be single-layered in profile and delicately wrinkled. There is no clear and large median expansion (loxodont

Fig. 1. Grik Specimen in lingual view; occlusal surface and anterior section of the tooth to the top and right sides of the figure, respectively, beside a 15-cm ruler as scale.

Fig. 2. Grik Specimen in occlusal view; anterior section of the tooth to the right side of the figure, beside a 15-cm ruler as scale.

Table 2. Measurements (in mm) and biometric parameters for lower 2nd molar of *Elephas maximus* and related forms. Values for maximum length in incomplete specimens are followed by a '+' sign. H/W Index = Height/Width Index; LF = Lamellar Frequency; n = sample size.

	Max. Length	**Max. Width**	**Max. Height**	**H/W Index**	**LF**
Grik Specimen	264.9	65.1	133.9	206	~ 6.8
Elephas maximus (modern)[a]	194–235 (n = 5)	58–73 (n = 6)	120–140 (n = 2)	197–207 (n = 2)	5–8 (n = 6)
Elephas maximus (fossil; Tonkin)[a]	180–265 (n = 5)	63–70 (n = 5)	115–125 (n = 5)	182–192 (n = 4)	5.5–7 (n = 5)
Elephas maximus (fossil; Cipeundeuy, Java)[b]	181+	71	127		6.5
Elephas maximus (fossil; Cipeundeuy, Java)[b]	290	75.5	~ 149	~ 200	5.4
Elephas hysudricus (Haripoor, Punjab)[a]		73	~ 95		6.5
Elephas hysudrindicus (Java)[a]		65–69 (n = 3)	124–145 (n = 2)		~ 5–7.5 (n = 4)
Palaeoloxodon namadicus (Siwalik Hills)[a]	259	84			
Palaeoloxodon namadicus sinhaleyus (Sri Lanka)[c]	165+	72	123	171	4.5
cf. *Palaeoloxodon* aff. *namadicus* (Vietnam)[d]		85.4			
Palaeoloxodon namadicus[e]	242–292 (n = 5)	66–99 (n = 10)	119–126 (n = 2)	180.4–188.4 (n = 2)	4.3–6.8 (n = 10)

[a] Hooijer, 1955; [b] van den Bergh, 1999; [c] Deraniyagala, 1955; [d] de Vos & Vu, 1993; [e] Maglio, 1973

sinus) shown among the worn enamel figures, except for the second, third and fourth plates. The anterior median expansion of the second plate seems to converge with the posterior median expansion of the anterior half-plate, thereby connecting the two worn enamel figures. The three plates immediately behind the seventh are only minimally worn with two longitudinal grooves passing through the occlusal surface of the plate creating a trifold pattern of worn enamel loops. The remaining plates are either almost completely or partially covered within cementum layer. This specimen is highly mineralised and is believed to have originated from an opencast site in the Grik area (Perak). Measurements are given in Table 2.

14. Kampar Specimen A [Catalogue No.: ZRC. 4.7883]
According to the specimen label, it was found in Kampar (Perak) in association with a Neolithic adze, and was presented to the museum by G. H. Seddon. It was identified as a lower right molar of *Elephas maximus* by S. H. Zheng. The specimen is slightly bulging towards the lingual margin in occlusal view. Only the crown parts of 14 plates are preserved. All the plates converge apically and none is covered within cementum; parts of the cementum within transverse valleys had been eroded. Five of the foremost plates are worn exposing dentine within enamel loops, none of which shows any median expansion; enamel borders single-layered and wrinkled. The remaining plates are all trifold in occlusal wear pattern with three distinct median digitations (not yet fused together) and one lateral digitation at buccal and lingual sides, respectively.

15. Kampar Specimen B [Catalogue No.: ZRC. 4.7882]
Found together with the preceding specimen in association with a Neolithic adze from Kampar, it seems to have been presented to the museum under similar circumstances. It was identified as a molar of *Elephas maximus* by S. H. Zheng. Only nine plates are preserved which appears to be folded in an S-shaped curvature and converge apically. The crown surface is slightly convex along the lingual margin and therefore the tooth may be a left lower molar. The three frontmost plates are worn but the worn surface of the lateral digitation from the buccal side has not converged with that of the conjoined median+lingual digitations as to form a single enamel loop. Enamel borders wrinkled and single-layered, without median expansion. The two plates immediately behind the third have three median digitations and one digitation at each lateral side; but only two median digitations are seen for the remaining posterior plates, the number of lateral digitation on these plates remains the same.

16. Chenor Specimen [Catalogue No.: ZRC.4.7881]
This specimen is stated to have been found on the property of the Wannli Hydraulic Tin mines in Chenor (Perak), and presented to the museum by F. W. Liew in 1936. The place name, 'Chenor' is most probably a spelling error of 'Chemor', and it remains unclear if this tooth is among the few specimens, also from Chemor, reported in Savage (1937: 25) (see above). It was determined as a molar of *Elephas maximus* by S. H. Zheng. No root mass but only the crown of about 20 plates are preserved. Each of these plates runs almost parallel to one another and there is no

sign of convergence towards the apex. This feature, in combination with the convex occlusal surface, suggests that it is an upper molar. None of the plates is covered within cementum and most of this substance has also been eroded from the lateral and occlusal surfaces of the transverse valleys. The plates are close-set and leaving only narrow valleys between two adjoining plates. The five foremost plates are worn and each has a single worn enamel figure with single-layered and coarsely wrinkled enamel border; the immediate two plates behind the fifth display a trifold worn pattern. None of the worn enamel figures or loops shows any median expansion. Most of the remaining plates have three separate median digitations and one lateral digitation at each side.

17. Muar Specimen A [Catalogue No.: ZRC.4.7884]
Information from the original label shows that this molar (together with the next specimen) was dug out near the Muar River in Johor, and presented to the museum by R. D. Hudson in 1908 bearing the original number 'S. 78'. Only the crown of about 12 plates is preserved and all the plates converge apically, thus suggesting this may be part of a lower molar. Most of the plates are completely covered within cementum and those that are only partially covered (the frontmost four plates) show four or three median digitations.

18. Muar Specimen B [Catalogue No.: ZRC.4.7885]
The specimen was not seen but according to the label of the preceding specimen this tooth was found from the same spot and presented to the museum under similar circumstances. A note written in pencil on the label suggests that the specimen in question may still be on display in the museum of the National University of Singapore. Morphological observations therefore are not available at present for this specimen.

19. UMZM Specimen. (Figs. 3, 4)
No specimen label is associated with this tooth fragment but it was found among a collection of vertebrate fossils with a note 'from cave mining deposits, ? Tambun, Perak' and 'ex Geological Dept., Ipoh'. It consists of only two adjoining plates from a molar. The smaller plate has an unworn median pillar and although all digitations are damaged apically it is still possible to discern that both plates have three digitations in the centre and one on each side. Enamel border appears to be single-layered and no wrinkles are seen. In lateral view, the plates run slightly in an S-shaped curvature and the two appear to converge apically with the crown of the larger plate partially shelters that of the other plate, suggesting that these two plates may be from a lower molar. Measurements for the smaller plate: Maximum height (99.6 mm), Maximum width (48.7 mm). Measurements for the larger plate: Maximum height (107.7 mm), Maximum width (56.0 mm).

DISCUSSION

Temporal and spatial distributions of elephant fossils. — So far, at least 19 fossil specimens derived from elephants have been found in Peninsular Malaysia. These undated but presumably Late Pleistocene or Holocene materials were allocated to the living Asian Elephant, *Elephas maximus* and the extinct genus (or subgenus) **Palaeoloxodon* by their respective original investigators.

Remains of **Palaeoloxodon* have been found in Middle Pleistocene deposits elsewhere in Asia: China (Zhou & Zhang, 1974), Myanmar (Louys et al., 2007), Vietnam (Tougard, 2001) and Laos (Arambourg & Fromaget, 1938). It appears

Fig. 3. UMZM Specimen, showing the smaller plate and the unworn median pillar; occlusal surface of the tooth fragment to the left side of the figure. Scale bar in cm.

Fig. 4. UMZM Specimen, showing digitations on the two plates; occlusal surface of the tooth fragment to the bottom side of the figure. Scale bar in cm.

to have existed into the Late Pleistocene, as a number of Late Pleistocene sites in China (Han & Xu, 1985) have also yielded records of **Palaeoloxodon* but its presence in the Late Pleistocene deposits of Vietnam is questionable, for example at Lang Trang and Ma U'Oi, because the specific identity of the fossils from these sites is still debatable or uncertain (de Vos & Vu, 1993; Bacon et al., 2006). Given that the temporal distribution of **Palaeoloxodon* in mainland South-east Asia is still far from certain, and in particular, since the identifications and subsequent allocations of the few specimens from Peninsular Malaysia (Salak Specimen, Tersang Specimen and Kuala Bering Specimen) to this extinct taxon are still open to question (see below), it remains unwise at the present state of our knowledge to assign a Middle Pleistocene age to these problematic materials.

Stegodont species common to the Middle Pleistocene *Stegodon-Ailuropoda* Fauna have yet to be found in Peninsular Malaysia, even though representatives of the genus *Stegodon* are regularly found at Pleistocene fossil sites in the Sundaic biogeographic subregion, notably in Java (Hooijer, 1955; Medway, 1972; van den Bergh et al., 1992, 1996), Wallacean biogeographic subregion (Hooijer, 1955, 1970; Medway, 1972; van den Bergh et al., 1992, 1996) and in the Indochinese biogeographic subregion (Tougard, 2001; Han & Xu, 1985).

The fossils reported here are distributed across seven of the 11 states in Peninsular Malaysia (from north to south): Perlis (n = 1), Perak (n = 11), Kelantan (n = 1), Selangor (n = 1), Negeri Sembilan (n = 2), Pahang (n = 1) and Johor (n = 2). All these states still have resident *Elephas maximus* of varying population sizes, except Perlis and Selangor with no elephants recorded in a recent population survey (Salman et al., 2011). Within its current range (Salman et al., 2011) only Terengganu and Kedah are without any report of elephant fossils. This apparent lack of fossil discoveries from these two states and the many finds from Perak (11 out of a total of 19) are highly likely the results of sampling biases. It can be seen from the individual description of the specimens given above that a great majority of the finds are directly related to past tin mining activities, for which Perak played a more important role that the other two states. Melaka and Penang (including Seberang Perai) likewise are without any reports of fossils, and neither supports any living wild elephants today (Salman et al., 2011). It may be worth noting that elephants are believed to have roamed throughout most of the suitable habitats in Peninsular Malaysia during the 19th century, except Penang Island (Salman et al., 2011). However, it is doubtful if the small stretch of water body (~4 km across the narrowest stretch) between Penang Island and mainland Peninsular Malaysia would be an effective barrier to elephants, a species known for its swimming ability and has been roughly estimated to be able to swim up to 160 km (Meijaard, 2001, cited in Tong, 2002) to colonise nearby lands. The lack of fossil evidence from Melaka and Penang may likely be due partly to inadequate prospecting in the past and a general absence of fossil-bearing sites (for example, caves and eroded terraces along large rivers).

Historical and Taphonomic backgrounds of elephant fossil finds. — Rarity of *Elephas maximus* or other mammal fossils from Peninsular Malaysia may be in part owing to the fact that its fossiliferous Quaternary deposits have not yet been thoroughly identified and explored in a systematic manner, and perhaps also because survey efforts in the past were mainly focused on geologically younger deposits (for example, terminal Late Pleistocene-Holocene context).

The most recent finds are the Kuala Selinsing Specimen and the Grik Specimen, discovered around 1991 and 2009, respectively. Most of the other fossils were found as isolated by-products during a period when tin mining and prospecting was active and contributed greatly to the economic progress of the country. With the near or almost termination of tin mining operations in Peninsular Malaysia it is understandable that fossils of elephant are now no longer discovered under such circumstances. Furthermore, the use of elephant or other mammal fossils as an age indicator for the deposits which contain them and hence the professional need to look specifically for them during mineral resource surveys have diminished greatly with the advent of more direct dating methods (for example, radiometric and luminescence datings) which provide the absolute age, as opposed to relative age of a deposit.

Only the Kuala Selinsing Specimen and perhaps the Kampar Specimens A and B were found under archaeological context with associate artefacts. Extensive archaeological and palaeontological investigations since the 1990s in a number of sites in Peninsular Malaysia had, however, failed to reveal further material and it remains unclear what taphonomic factors may have contributed to such an apparent lack of elephant fossils. Ros Fatihah & Yeap (2000: 194) in a preliminary report on a fossil cave (Badak Cave C) from the Lenggong Valley in Perak tentatively identified a tooth that was then embedded in the surrounding matrix as that from a young elephant. Subsequent extraction and identification of the specimen revealed that it is a left lower 1st molar of a rhinoceros (Yasamin Ibrahim, 2013). However, since the fossil cave is yet to be excavated systematically and the exposed fossil bones not fully identified, it is reasonable to expect that more local species may eventually be found in these fossil-rich sediments following in-depth studies.

Apart from the factors discussed above, the near lack of active geological uplifting and subsequent erosion of terrestrial Pleistocene deposits in nowadays tectonically stable Peninsular Malaysia may account for the infrequent and small amount of fossil finds from non-cave sites in the area. Under such conditions, it is not surprising to find that fossils were in most cases encountered when the alluvial landscape was subjected to large scale modifications (for example, mining and irrigation operations). Relatively stable geological conditions have also been proposed for the general paucity of early Quaternary mammal fossils on Borneo (van den Bergh, 1999), except in cases when fossils or subfossils that were only lightly mineralised are associated with Late Pleistocene archaeological sites.

Only two of the materials reported in the present paper, the Kuala Bering and the UMZM Specimens are undisputedly stated to have come from cave sediments. The UMZM Specimen is smaller than the Kuala Bering Specimen and it is therefore not difficult to postulate what possible means by which it can be brought into the cave. Clearly, without any specific background information regarding its depositional condition it is highly conjectural in any attempt at reconstructing the sequence of events that led to its final deposition inside a cave. However, an interesting insight can be gained through a comparison of the state of preservation of elephant fossils from other sites in the region, notably from the fossil caves in Java.

At present, there are eight fossil sites from Java which were found to have undoubted records of the Asian Elephant or of remains allocated to the species by their original investigators but later regarded as inconclusive because of the fragmentary nature of the materials. Four are cave or rock shelter sites, Sampung (Dammerman, 1932–1934), Punung A & B (Badoux, 1959; Storm et al., 2005), Panumbangan (Erdbrink, 1954, cited in Badoux, 1959) and Song Gupuh (Morwood et al., 2008); the other four are either open-air sites, Cipeundeuy (van den Bergh, 1999) and Rancamalang (information gathered from an exhibition poster in the Geology Museum of Bandung), or with background setting unknown, Sentang Kedung Klampo, near Kuwung, residency Rembang (van der Maarel, 1932, cited in Badoux, 1959) and Mauk (Rokus Awe Due, personal communication, cited in Morwood et al., 2008). Cave specimens, at least those from Sampung and Punung, are highly fragmentary and badly preserved, consist of isolated plates (Sampung) and associated plates of cheek tooth fragments (Punung), and in no way approach the greater number of specimens or the better state of preservation as exhibited by materials from Cipeundeuy (dental and post-cranial elements) and Rancamalang (a complete lower jaw with attached molars), but are comparable to the state of preservation of the UMZM Specimen.

It is generally believed that rodents, porcupines in particular, play a key role as major bone accumulation agents in the Punung fossiliferous fissures (Storm et al., 2005) because in most cases the fossil teeth are without roots and bear unmistakable traces of gnawing marks (a series of elongated and parallel sided double grooves converging to a single point) from these rodents. Similar taphonomic interpretation has been suggested for a number of fossil caves outside Java, for example the Late Pleistocene sites of Padang Highland caves in central Sumatra (de Vos, 1983), Duoi U'Oi in Vietnam (Bacon et al., 2008) and Ban Fa Suai in Thailand (Zeitoun et al., 2010). Animal remains from the Sampung rock shelter, also fragmentary among most of the materials collected were, however, thought to represent prehistoric kitchen refuse since some of them show sign of fire scorching, and prehistoric implements and human remains were found from the site (Dammerman, 1932–1934). No gnawing marks by rodents on the fossils were noted in the original report but remains of porcupine (*Hystrix javanica*) were found in all layers, except the uppermost (0–1 m) layer. Song Gupuh from the Gunung Sewu Limestones area of east Java is also thought to be a prehistoric human occupation site and it has been suggested that humans were at least partially responsible for the earliest bone accumulation at the site which also included remains of *E. maximus* (Morwood et al., 2008). It should be mentioned that no chewing marks of rodents on the bone materials or remains of porcupine were reported from the site.

Findings from these fossil sites suggest that the UMZM Specimen may also have undergone such biogenic processes before its deposition inside the cave, with porcupines, of which three species are present in the forests of Peninsular Malaysia (Medway, 1983), or prehistoric humans as the key collecting agent. Close examination of the fossils of other mammal species associated with the UMZM Specimen, however, does not rule out other possibilities. Firstly, there are bones of some large mammals that do not show any signs of chewing by rodents or bear any indication suggesting human-made modifications (smashing, percussion, burning and cutting marks). In fact, the whole collection has not been stated as coming from an archaeological site and based on our current knowledge no artefact or human remain is associated with these fossils. The fossils are therefore clearly not from the kitchen refuse of prehistoric humans or accumulated through the gnawing activities by rodents; on the contrary, there is indication, in the form of clusters of coarse sand lodged in small crevices at the base of the plates in the UMZM Specimen and also inside the root parts of an upper cheek tooth of a rhinoceros which suggests that underground water may be responsible for carrying these material inside the cave.

The Kuala Bering Specimen (186 mm long, 83 mm wide, 180 mm high) is a sizeable tooth when compared with the UMZM Specimen (only two plates remaining, 22 mm long, 57 mm wide, 108 mm high). Weight of the Kuala Bering Specimen, thought to be either an upper 2nd or 3rd molar is not provided in the original report but a study of masses of complete and nearly complete isolated teeth of modern *Elephas maximus* by Roth & Shoshani (1988: 583) indicates that the weights for maxillary 2nd (V) and 3rd (VI) molars generally exceed 1000 g. It has been found that most bone materials sampled in a lair of an African Porcupine (*Hystrix africaeaustralis*) in South Africa (Brain, 1981) weighed 0–50 g, though objects of up to 750 g did occur. Adult African porcupines weigh 10.0–24.1 kg (Barthelmess, 2006), but adult Malayan porcupines weigh only about 8 kg (Medway, 1983). Thus, a single Malayan porcupine might not be able to remove the larger items, such as the Kuala Bering Specimen, from the sites where elephants or other large animals died into a cave.

It would seem more plausible to suggest that larger fossils were brought in through the actions of subterranean water bodies and, to a lesser extent, perhaps by large scavengers and carnivores (e.g., hyenas, felids, etc.) through their feeding activities (White, 1975; Brain, 1981). If these are the prevailing modes of deposition, it seems reasonable to suggest that any chewing marks observed on large bones may merely be a sign of secondary working by rodents after these larger items had been brought in the caves by other means. This explanation does not exclude the role played by porcupines and other rodents or raptors, notably owls (Andrews, 1990), in the accumulation of many medium to small sized bone and dental materials within a cave fossil assemblage.

In short, for cave sites which have yielded fossils of small and large or very large species (such as proboscideans), for example the caves in Padang Highland with its *Elephas maximus* fossils (some specimens as much as 167 mm long and 76 mm wide) (Hooijer, 1955) and the Liucheng *Gigantopithecus* Cave in Guangxi Province, southern China with its stegodonts remains (Pei, 1987), one needs to be careful not to attach too much importance to a single preferred explanation. The agent active in gnawing bones is not necessarily the main agent responsible for the accumulation of the animal remains recovered from a cave, as shown in a comprehensive analysis of animal fossils found in different layers of the Sterkfontein cave in South Africa (Brain, 1981).

Species diversity of elephants in prehistoric Peninsular Malaysia. — The occurrence of the extinct species **Palaeoloxodon namadicus*, apart from the extant Asian Elephant in prehistoric Peninsular Malaysia had been cited widely in studies on local and Southeast Asian Pleistocene faunas (Hooijer, 1962; Jones et al., 1966; Medway, 1972; Sartono, 1973; Harrisson, 1975; Ros Fatihah & Yeap, 2000; Louys et al., 2007), especially with reference to the Salak Specimen reported by Andrews (1905/06: 18). The greater number of elephantid fossils reviewed in the present paper allows a re-examination of this point, but only 10 of the reported 19 specimens are useful for this discussion, the others having been described with insufficient details, no illustrations other than for the Kuala Bering Specimen, and with their current repositories unknown.

Among the 10 useful fossils, four are maxillary teeth, five are mandibular, and one is of indeterminate position. The sequential positions of many of these teeth are unclear; most of them are not complete, and it remains a tricky task to assign the exact sequential position of an isolated tooth (detached, as they were, from the trough of the jaws and also from the associated teeth in front and behind), with parts of their plates missing (either through use and wear or post-mortem alteration). Estimating the number of missing plates is not always possible or straightforward because the specimens in many instances lack much of the root mass. Despite these limitations, it is fairly safe to conclude that none of the 19 specimens represents milk dentition, except perhaps the Lukut Specimens A and B.

Morphological observations (for the Kuala Bering Specimen, only indirect comparison through published measurements and photographs is possible) show that all are too high-crowned for stegodonts, and despite the fact that some stegodonts did show a tendency towards increased hypsodonty of their molars and thereby superficially resemble the cheek teeth of *Elephas*, this phenomenon is mainly confined to insular stegodonts (van den Bergh, 1999). Secondly, the worn enamel in the specimens reported here does not exhibit the two well differentiated layers of approximately equal thickness that is a character distinguishing molars of *Stegodon* and Elephantidae (van den Bergh, 1999). A third character, the shape of the valleys between transverse lophs, however, is not used in the current assessment as it is meant to be viewed on the longitudinally cut tooth (van den Bergh et al., 1992), and has to be used in combination with other criteria (van den Bergh, 1999).

The Geology Museum (Ipoh) and Chenor Specimens, both with their parallel-sided plates, are undisputedly from the upper jaw dentition, the former with about 18 plates and the latter about 20 plates. The maximum number of plates reported for the upper 2nd and 3rd molars of **Palaeoloxodon namadicus* is 13 and 17, respectively (Table 3). Even though a higher number of 18 to 20 plates was mentioned for the 3rd molar of **Palaeoloxodon namadicus* by Colbert (1943: 418) it is not clearly stated which 3rd molar from the jaws (maxillary or mandibular or combined) this plate number represents. A complete upper left 1st molar of *E. maximus* from Sarawak (the Niah Specimen) was reported to have 13 plates (Cranbrook et al., 2007). Thus, based on the higher number of plates presents in both of the specimens in question, they are unlikely to be **Palaeoloxodon namadicus*; on the contrary, the number of plates observed falls within the ranges of variation recorded for the upper 2nd and 3rd molars of the modern species, *Elephas maximus* (Table 3).

It seems from the published photographs of the Kuala Bering Specimen that the posterior part of the tooth is not complete. If this is the case, the true number of plates must exceed the 13 reported in the original description. Peacock & Dunn (1968: 171) commented that the Kuala Bering Specimen resembles a tooth (left upper 2nd or 3rd molar) of **Palaeoloxodon* cf. *namadicus* reported from Samarinda, east Borneo (Hooijer, 1952, cited in Hooijer, 1955) and compared it with an upper 2nd molar from Myanmar (ANSP No. 14627) assigned to **Palaeoloxodon namadicus* by Colbert (1943: 418). The resemblance among these three molar specimens appears to apply only to their crown morphology and certain absolute measurements because a comparison of their respective parameters clearly does not hold out such a relationship. The calculated values for the H/W Index and LF of the Kuala Bering Specimen is 217 and ~7, respectively. But, the Samarinda specimen has both a lower H/W Index (~214) and LF (5.5) (Hooijer, 1955) than the Kuala Bering Specimen. Similarly, ANSP No. 14627 has an even lower calculated H/W Index (190) and the LF (5.5) reported is also lower (Colbert, 1943). Apart from that the Kuala Bering Specimen also shows a higher values for the two parameters under consideration when compared with those published for *Elephas hysudricus* (H/W Index: upper 3rd molar 112.5–147.2, n = 5; LF: upper 2nd molar 4.5, upper 3rd molar 3.9–6.5, n = 6) (Maglio, 1973), a low-crowned species recorded from the Early to Middle Pleistocene deposits of India (Hooijer, 1955), Myanmar (Colbert, 1943) and possibly south China (Zhou & Zhang, 1974). Thus, based on these comparative parameters the

Table 3. Characteristic dental features of *Palaeoloxodon namadicus* and *Elephas maximus* according to different authors.

Palaeoloxodon namadicus	***Elephas maximus***	**Reference**
Molars with thicker worn dentine surface, presenting no curve towards the apex. Enamel thicker. Crimping of enamel plates very much like *Elephas maximus*.		Lydekker, 1880, cited in Hooijer, 1955
Some teeth from Myanmar, China and Japan show excessive plication (folding) of the enamel, thereby approximate *E. maximus*, although with a lower plate formula.		Lydekker, 1886, cited in Osborn, 1942
Upper 3rd molar with an estimated total of 15 plates, estimated LF 8, maximum width 101 mm. Width of lower 2nd molar 84 mm, estimated length 264 mm. Plates broad, close-set, entirely lacking loxodont sinus (median expansion on worn enamel figure), enamel borders thin. **Plate formula**: DM4 (lower) 10 ½ ; M1 (lower) ½-13-½; M2 (lower) ?15; M3 (lower) 15–16, (upper) 14–15		Osborn, 1942
Cheek teeth hypsodont, with wrinkled enamel. Loxodont sinus rudimentary or absent. About 18–20 plates in 3rd molar.		Colbert, 1943
Upper and lower molars tend to be wider and have lower LF than their homologues in *E. maximus*.		Hooijer, 1955
Worn enamel figures with patterns similar to those in *E. maximus* but rhomboid-shaped	Crown of molar broader, closely appressed plates. LF 7 to 10 or more. Valley between plates rather narrow. Enamel layer rather thick with distinct and compact plications. (o — o) or (o o o o o) pattern for worn enamel figures.	Chang, 1964
Narrow molars; crown height generally 50 to 150% greater than the width; worn enamel figures usually with pointed median expansions, but sometimes lacking; wear figures with central portion and lateral rings in early stages of abrasion; enamel thickness 1.0 to 3.5 mm with strong, close but even folds; plates closely spaced with small cement intervals between them; LF 4.4 to 7.7 for M3. **Plate formula**: DM2 (upper) ?, (lower) 3; DM3 (upper) 6–7, (lower) 5–7; DM4 (upper) 10, (lower) 9–10; M1 (upper) 10–11, (lower) 9–11; M2 (upper) 11–13, (lower) 11–15; M3 (upper) 12–17, (lower) 13–18	Narrow molars; crown height 50 to 150% greater than width; worn enamel figures irregular in outline; median folds and expansions lacking; enamel moderately thick, 2.5 to 3.0 mm, coarsely folded with small, open loops; plates thin and closely spaced; LF 5.0 to 9.0. **Plate formula**: DM2 (upper) 4–5, (lower) 5; DM3 (upper) 7–8+, (lower) 6–9; DM4 (upper) 11–15, (lower) 11–14; M1 (upper) 14–17, (lower) 14–17; M2 (upper) 17–21+, (lower) 16–21; M3 (upper) 20–26, (lower) 21–29	Maglio, 1973; Roth & Shoshani, 1988, for *E. maximus* plate formula
Plates moderately broad, rhomboid-shaped at base, upper part shows (o — o) pattern at initial stages of wear, middle circle becomes oblong in shape. Enamel thickness 2 to 3 mm; LF 5 to 5.5 **Plate formula**: M3 (upper) 14–15, (lower) 15–16	Molars moderate in size, grinding surface of crown oblong, relatively broad. Plates close-set, patterns of worn enamel figures (o — o) or (o o o o), oblong in shape in advanced stages of wear with expanded middle part but not differentiate into an enlarged middle and lateral sections. Valley between plates narrow. Distinct and compact foldings on enamel layer. LF 6 to 8 **Plate formula**: DM2 (upper) 4, (lower) 4; DM3 (upper) 8, (lower) 8; DM4 (upper) 12, (lower) 12; M1 (upper) 12, (lower) 12; M2 (upper) 16, (lower) 16; M3 (upper) 20–24, (lower) 20–24	Zhou & Zhang, 1974

Kuala Bering Specimen is not similar to **Palaeoloxodon namadicus* or *Elephas hysudricus*, but falls within the lower limits of observed ranges of variation for fossil and modern *E. maximus* recorded by Hooijer (1955: 118, 123).

The lower molars from the RMBR material (Kampar Specimens A, B and Muar Specimen A) are all incomplete, lacking plates from either the front or back or from both ends. The worn enamel figures show fine to coarse folding and none shows any sign of median expansion. It is admittedly difficult to assign a specific identity to the UMZM Specimen (Figs. 3, 4), because it is too fragmentary and the sequential position of the tooth to which the two attached plates belonged is far from certain. The smaller plate has a calculated H/W Index of 205 and the larger one, 192. The H/W Index for **Palaeoloxodon namadicus*, as calculated based on two lower 2nd molar specimens, MCZ No. 6255 and MCZ No. 6256 from Myanmar (Colbert, 1943) is 153 and 192, respectively. It is clear from Table 2 and from the data published by Hooijer (1955: 126, 127) and Maglio (1973: 41) that there is considerable overlap for the H/W Index values between homologous lower molars of *E. maximus* and **Palaeoloxodon namadicus*; the former, however, generally has higher values than the latter. Based on this rather slim evidence, one tends to associate the UMZM Specimen closer to *E. maximus* than to the other species. Another aspect of the UMZM Specimen worth mentioning is the occurrence of a median pillar on the smaller plate which would give rise to a median expansion on a worn enamel figure upon advanced abrasion of the plate.

The Grik Specimen seems like a complete lower molar as indicated by its root mass and the presence of an anterior half-plate (Figs. 1, 2). The apical convergence of the posterior plates in the last lower molar (3rd molar) of modern *E. maximus* is so pronounced that they radiate like the slats of a hand-held fan and they are recurved backwards basally, rendering an upturned profile to the hinder part of the tooth (Hooijer, 1955; van den Bergh, 1999). Such a distinctive curvature is not seen in the Grik Specimen suggesting that the current specimen more likely represents a 2nd rather than the 3rd molar. The number of plates (about 18) corresponds with the range given for the 2nd molar of the Asian Elephant (Table 3), whereas the maximum plate number reported for **Palaeoloxodon namadicus* is only 15. It is clear from Table 2 that the current specimen is narrower at the crown and has a higher H/W Index and LF than its homologue in **Palaeoloxodon namadicus*; all dimensions of measurements and the parameters do not in any way suggest it being *E. hysudricus* either (Maglio, 1973). This specimen can safely be assigned to *E. maximus*, and it fits well within the range of variation recorded for the modern species (Table 2).

There is no strong evidence that any of the specimens represents **Palaeoloxodon namadicus*. They all appear to be metrically more similar to the living species, *E. maximus*. As for dental morphology, the Kuala Bering Specimen is again crucial to our evaluation. Three features in particular were stated by Peacock & Dunn (1968: 171) to support their allocation of the specimen to **Palaeoloxodon namadicus*: strongly wrinkled enamel; fairly well stepped occlusal surface; and rudimentary median expansions in the enamel figures of certain plates. No doubt their observation of these features is valid as far as the specimen is concerned; however, what is more important is the usefulness of these features in determining its species. A folded enamel border seems to be a common feature for both taxa (see Table 3; Maglio, 1973) but it remains to be explored, in a quantitative way if there is any significant difference in the degree of enamel folding which is taxonomically meaningful, and how to use this parameter to separate the many taxa previously described under the genus/subgenus **Palaeoloxodon* (Chang, 1964; Zhou & Zhang, 1974). The second feature about the well stepped profile of the grinding surface is difficult to assess as it has not been considered by other authors as a diagnostic feature for the taxon (see Table 3). Chemical erosion of the cementum substance in the inter-plate valleys by acidic water is a possible explanation for creating such a stepped profile, as suggested by Deraniyagala (1955: 52) for some of the fossil teeth from Sri Lanka. There is a great deal of discussion and confusion (see Pei, 1987: 82) about the taxonomic significance of the presence or absence of the median expansion (loxodont sinus); it is stated to be entirely lacking (Osborn, 1942) or rudimentary (Colbert, 1943) in **Palaeoloxodon namadicus*. Hooijer (1955: 110) concluded that such a feature is not invariably present in **Palaeoloxodon namadicus* after citing the observations of Patte (1931) made on materials collected by Falconer and Cautley, and he provided evidence that such a feature can also be found in the worn plates of a left lower 3rd molar of fossil *E. maximus* (Collection Dubois No. 802) from the Sibrambang Cave in the Padang Highland of Sumatra (Hooijer, 1955: 136, pl. XVII, fig. 3). Deraniyagala (1955: 51–53, pl. 24, fig. 3, pl. 25, fig. 3) concluded that modern material of *Elephas maximus* from Sri Lanka occasionally possesses a similar structure. That the occurrence of the median expansions on worn enamel figures is not restricted to a particular population of the Asian Elephant is supported by pictures of modern specimens from Peninsular Malaysia published by Momin Khan (1977: pl. 1, figs. F, H). Such structures are also clearly shown in two of the specimens in the MZIBD examined (MZIBD 0042 and MZIBD 0043) (Lim, pers. obs., 2011). It seems, therefore, that Peacock & Dunn's original identification of the Kuala Bering Specimen (as **Palaeoloxodon*) is not supported either by a metrical or by a morphological re-evaluation of the specimen, and the results shown here tend to agree with Hooijer's re-identification of the specimen as being from the modern species (in Peacock & Dunn, 1968: 172). It is, indeed unfortunate that similar evaluation cannot be extended to the other two specimens originally allocated to **Palaeoloxodon namadicus* (the Salak and Tersang Specimens) since no morphological description or metrical data of the fossils are recorded in the literature, and it is highly likely that both are no longer available now for examination.

It is interesting from a zoogeographical point of view if some of the elephantid remains recovered from continental Southeast Asia can be unequivocally assigned to **Palaeoloxodon namdicus* as it seems that this species has only been recorded from two other localities within the Sundaic biogeographic subregion—Bukit Besar in the Pattani area of Thailand (Andrews, 1903) and Samarinda, east Borneo (Hooijer, 1952, cited in Hooijer, 1955). However, results from the current analysis do not seem to suggest any tangible and unambiguous evidence for a former occurrence of the species in Peninsular Malaysia. The disjunct and patchy distribution of the species still remains a biogeographical riddle yet to be satisfactorily solved. In view of the fact that the molars of **Palaeoloxodon* and *Elephas* may be "deceivingly similar", as rightly remarked by Hooijer (1955: 110), it would appear that "… only the find of a good skull (always a bit of serendipity) would give us a firmer base for identification…" (Hooijer, 1968 in a letter to Dunn, Peacock & Dunn, 1968: 172).

POSTSCRIPT

The results of a DNA study published in 2003 seem to have settled, from a molecular point of view, the issue about the origins of the *Elephas maximus* now living in northern Borneo, noting that these animals are genetically distinct and indigenous to the island (Fernando et al., 2003). This would be a stronger argument if it were supported by morphological study, especially given that the genetic differences observed were suggested to indicate a 300,000 years separation history between the Bornean stock and its closest relative from a common ancestor (Fernando et al., 2003: 111). Preliminary results from a morphometric study on a small sample of Bornean elephants (six individuals from Sabah), however, failed to reveal any significant differences in the morphological measurements examined between the animals from Borneo and Peninsular Malaysia (Nurzhafarina et al., 2008), a finding which is in general agreement with the result obtained through a comparison of skull measurements reported in Cranbrook et al. (2007: 119). Cranbrook et al. (2007: 111) re-opened the debate by suggesting that results from the genetic analysis are also compatible with the notion that the living elephants in Borneo may derive, after a period of naturalisation in Sulu, ultimately from the now extinct Javan stock. Some interesting information highly relevant to a few points raised in Cranbrook et al. (2007) had been gathered through the current study, and it may be worth recording:

1. Shelford (1899: 218, 219) in a short note recorded the discovery of a fossil tooth from the Bau limestone area of Sarawak, and identified it as a molar of *Elephas indicus* (now *Elephas maximus*). It is noted in Cranbrook et al. (2007: 105) that this important specimen is no longer in the collections of the Sarawak Museum, and therefore only the morphological observations made by Banks (1931: 16) are presented in their 2007 paper. By choosing this specimen as the paratype for what he thought may be a distinct subgenus for the population on Borneo (*Elephas maximus borneensis*) Deraniyagala not only provided a detailed morphological and metrical record for the specimen (Deraniyagala, 1955: 124) but also included pictures of it in his 1955 monograph on extinct and living elephants (Deraniyagala, 1955: pl. 47). The morphological observations of Deraniyagala and the pictures agree well with those of Banks, but while Banks noted that the specimen is a fragment of "the first of the two premolars in the upper jaw" (Banks, 1931: 16), Deraniyagala identified it as "the anterior part of the permanent first upper left molar" (Deraniyagala, 1955: 124). This difference of opinions is unavoidable since the specimen in question is not a complete tooth, which would otherwise make the determination of its sequential position more straightforward. Some important measurements provided by Deraniyagala include: Length of the worn crown (60 mm), Width (50 mm), Lateral length of the tooth fragment (55 mm), Depth of the highest fold (65 mm), Lateral thickness of a fold (11 mm), Number of crenulations in 10 mm (4). Deraniyagala (1955: 124) clearly stated that the specimen was sent to him for examination by the then Acting Curator of Sarawak Museum, Tom Harrisson but it remains uncertain if the specimen has been returned to the Museum. The possibility that the specimen still remains in Colombo cannot be ruled out.

2. If it can be proved that the elephants of northern Borneo are the living descendants of the extinct Javan race, then its legitimate name should follow the one created by Deraniyagala in 1950 for the population on Java, *Elephas maximus sondaicus*. The specimens chosen as the type and paratype for this taxon would accordingly assume greater importance. Deraniyagala (1955: 124) chose the fossil molars reported by Dammerman (1932–34: 482) as the type for this subspecies, and it seems that the specimens under consideration are now housed in the Geological Research and Development Center in Bandung, Indonesia under the catalogue number 'GRDC 425' (van den Bergh, 1999: 53). For the paratype, Deraniyagala (1955: 124) chose a stone carving of an elephant at Borobudur, figured by Krom (1926: pl. 44). Since this publication by Krom may no longer be widely available, and especially given the fact that there are many depictions of elephants in Borobudur, it may seem a rather difficult task for one to track down that

Fig. 5. Bas-relief of a tusked elephant from Borobudur chosen as the paratype for the Javan subspecies of the Asian Elephant, *Elephas maximus sondaicus* by Deraniyagala in 1955.

particular stone carving chosen as the paratype. Aided by the figure in Krom (1926: pl. 44), however, one can still find the stone carving, and as it was not known to have been recorded in any recent publication, it would seem worthwhile to include it here (Fig. 5).

ACKNOWLEDGEMENTS

This paper is a contribution to Supplement No. 29 of the Raffles Bulletin of Zoology, marking the eightieth birthday of the Earl of Cranbrook (V). I am particularly grateful to the Earl of Cranbrook for his unfailing encouragement and inspiration in all my research work; thanks to Geoffrey Davison, David Wells, Yong Hoi Sen for their invitation to contribute to this special issue of the Raffles Bulletin of Zoology; to Kelvin Lim Kok Peng (Raffles Museum of Biodiversity Research) who kindly showed me the specimens under his care; A. Sasekumar (Zoological Museum, University of Malaya) for allowing me to study the fossils; Dato' Abd. Rasid Samsudin and Fakhrul Hatta Musa (Wildlife & National Parks Department, Malaysia), Md Zuki Abu Bakar (Department of Veterinary Preclinical Sciences, University Putra Malaysia) for permission to examine modern elephant remains in the Institute of Biodiversity (Bukit Rengit, Lanchang, Pahang) and the University Veterinary Laboratory & Museum, respectively; Rosli bin Hashim (Institute of Biological Sciences, University of Malaya) for supporting my research trip to Singapore; the private collector in Perak who prefers to be anonymous for permission to study and publish his fossils; Chin Sing Yun (Global Environment Centre), Lim Teckwyn (Resource Stewardship Consultants) for alerting me on new discoveries in Peninsular Malaysia and on the occasional reports of elephant fossils in the publications of the Geological Survey Department, respectively; assistance from Avango and Tsan for preparing the figures is very much appreciated.

LITERATURE CITED

Andrews, C. W., 1903. Note on a tooth of *Elephas namadicus*. In: Annandale, N. & H. C. Robinson (eds.), *Fasciculi Malayensis—Anthropological and Zoological Results of an Expedition to Perak and the Siamese Malay States, 1901–1902*. The University Press of Liverpool, Longmans, Green & Co., London. 307 pp.

Andrews, C. W. (in an anonymous note), 1905/06. Fossil tooth of *Elephas namadicus* from Perak. *Journal of the Federated Malay States Museums*, **1**: 81–82.

Andrews, P., 1990. *Owls, Caves and Fossils*. The University of Chicago Press, Chicago. 231 pp.

Arambourg, C. & J. Fromaget, 1938. Le gisement quaternaire de Tam Nang (Chaîne Annamitique septentrionale). Sa stratigraphique et ses faunes. *Comptes Rendus de l'Académie des Sciences*, **203**: 793–795.

Bacon, A.-M., F. Demeter, S. Roussé, T. L. Vu, P. Duringer, P.-O. Antoine, K. T. Nguyen, T. M. Bui, T. M. H. Nguyen, Y. Dodo, H. Matsumura, M. Schuster & T. Anezaki, 2006. New palaeontological assemblage, sedimentological and chronological data from the Pleistocene Ma U'Oi cave (northern Vietnam). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **230**: 280–298.

Bacon, A.-M., F. Demeter, P. Duringer, C. Helm, M. Bano, T. L. Vu, T. K. T. Nguyen, P.-O. Antoine, T. M. Bui, T. M. H. Nguyen, Y. Dodo, F. Chabaux & S. Rihs, 2008. The Late Pleistocene Duoi U'Oi cave in northern Vietnam: palaeontology, sedimentology, taphonomy and palaeoenvironments. *Quaternary Science Reviews*, **27**: 1627–1654.

Badoux, D. M., 1959. *Fossil Mammals from Two Fissure Deposits at Punung (Java)*. Kemink En Zoon N. V., Utrecht. 151 pp.

Banks, E., 1931. A popular account of the mammals of Borneo. *Journal of the Malayan Branch of the Royal Asiatic Society*, **9**: 1–139.

Barthelmess, E. L., 2006. *Hystrix africaeaustralis*. *Mammalian Species*, **788**: 1–7.

Brain, C. K., 1981. *The Hunters or the Hunted? An Introduction to African Cave Taphonomy*. The University of Chicago Press, Chicago. 365 pp.

Chang, H.-C., 1964. On new material of *Palaeoloxodon namadicus* of China, with discussion on the classification of some Pleistocene elephants of China. *Vertebrata PalAsiatica*, **8**: 269–280. (Text in Chinese, with English summary).

Choudhury, A., D. K. Lahiri Choudhury, A. Desai, J. W. Duckworth, P. S. Easa, A. J. T. Johnsingh, P. Fernando, S. Hedges, M. Gunawardena, F. Kurt, U. Karanth, A. Lister, V. Menon, H. Riddle, A. Rübel & E. Wikramanayake (IUCN SSC Asian Elephant Specialist Group) 2008, 2012. *Elephas maximus*. *IUCN Red List of Threatened Species. Version 2012.2*. IUCN. www.iucnredlist.org. (Accessed 27 Apr.2013).

Colbert, E. H., 1943. Pleistocene vertebrates collected in Burma by the American Southeast Asiatic Expedition. *Transactions of the American Philosophical Society*, New Series, **32**: 395–429.

Corbet, G. B. & J. E. Hill, 1992. *The Mammals of the Indomalayan Region: A Systematic Review*. Natural History Museum Publications, Oxford University Press, U.K. 488 pp.

Cranbrook, Earl of, J. Payne & C. M. U. Leh, 2007. Origins of the elephants *Elephas maximus* L. of Borneo. *Sarawak Museum Journal*, **63**: 95–125.

Dammerman, K. W., 1932–34. On prehistoric mammals from the Sampoeng Cave, central Java. *Treubia*, **14**: 477–486.

Davison, G. W. H., 1991. Animal remains from the protohistoric community at Kuala Selinsing, Perak. *Jurnal Arkeologi Malaysia*, **4**: 95–102.

Deraniyagala, P. E. P., 1955. *Some Extinct Elephants, Their Relatives and the Two Living Species*. Ceylon National Museums, Ceylon. 161 pp.

de Vos, J., 1983. The *Pongo* faunas from Java and Sumatra and their significance for biostratigraphical and paleo-ecological interpretations. *Proceedings of the Koninklijke Nederlandse Academie van Wetenschappen*, Series B, **86**: 417–425.

de Vos, J. & T. L. Vu, 1993. *Systematic discussion of the Lang Trang fauna (Vietnam)*. Unpublished report.

Erdbrink, D. P., 1954. Mesolithic remains of the Sampung stage in Java: some remarks and additions. *Southwestern Journal of Anthropology*, **10**, nr. 3. (Source not seen).

Fernando, P., T. N. C. Vidya, J. Payne, M. Stuewe, G. Davison, R. J. Alfred, P. Andau, E. Bosi, A. Kilbourn & D. J. Melnick, 2003. DNA analysis indicates that Asian elephants are native to Borneo and are therefore a high priority for conservation. *PLoS Biology*, **1**: 110–115.

Han, D. F. & C. H. Xu, 1985. Pleistocene mammalian faunas of China. In: Wu, R. K. & J. W. Olsen (eds.), *Palaeoanthropology and Palaeolithic Archaeology in the People's Republic of China*. Academic Press, New York. Pp. 267–289.

Harrisson, T., 1975. Perak fossils and Tampan. Appendix to Tampan: Malaysia's Palaeolithic reconsidered. *Modern Quaternary Research in Southeast Asia*, **1**: 53–70.

Hooijer, D. A., 1952. *Palaeoloxodon* cf. *namadicus* (Falconer et Cautley) from Borneo. *Proceedings of the Koninklijke Nederlandse Academie van Wetenschappen, Series B*, **55**: 395–398. (Source not seen).

Hooijer, D. A., 1955. Fossil Proboscidea from the Malay archipelago and the Punjab. *Zoologische Verhandelingen*, **28**: 1–146.

Hooijer, D. A., 1962. Report upon a collection of Pleistocene mammals from tin-bearing deposits in a limestone cave near Ipoh, Kinta Valley, Perak. *Federation Museums Journal*, **7**: 1–5.

Hooijer, D. A., 1970. Pleistocene South-east Asiatic pygmy stegodonts. *Nature*, **225**: 474–475.

Hooijer, D. A., 1972. Prehistoric evidence for *Elephas maximus* L. in Borneo. *Nature*, **239**: 238.

Ingham, F. T. & E. F. Bradford, 1960. *The Geology and Mineral Resources of the Kinta Valley, Perak*. District Memoir No. 9. Geological Survey, Federation of Malaya. 347 pp.

Jones, C. R., D. J. Gobbett & T. Kobayashi, 1966. Summary of fossil record in Malaya and Singapore 1900–1965. In: Jones, C. R., D. J. Gobbett & T. Kobayashi (eds.), *Geology and Palaeontology of Southeast Asia*. Volume 2. University of Tokyo Press (Japan). Pp. 309–355.

Krom, N. J., 1926. *The Life of Buddha on the Stupa of Borobudur: According to the Lalitavistara text*. M. Nijhoff, The Hague. 131 pp.

Louys, J., D. Curnoe & H. W. Tong, 2007. Characteristics of Pleistocene megafauna extinctions in Southeast Asia. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **243**: 152–173.

Lydekker, R., 1880. Siwalik and Narbada Proboscidia. *Memoirs of the Geological Survey of India. Palaeontologia Indica. Series 10*, **1**: 182–294. (Source not seen).

Lydekker, R., 1886. *Catalogue of the Fossil Mammalia in the British Musum (Natural History). Part IV, Containing the Order Ungulata, Suborder Proboscidea*. Taylor and Francis, London. 233 pp. (Source not seen).

Maglio, V. J., 1973. Origin and evolution of the Elephantidae. *Transactions of the American Philosophical Society*, **63**: 1–149.

Medway, Lord, 1972. The Quaternary mammals of Malesia: A review. In: Ashton, P. & M. Ashton (eds.), *Transactions of the Second Aberdeen-Hull Symposium on Malesian Ecology. Miscellaneous Series 13*. Department of Geography, University of Hull, Hull. Pp. 63–98.

Medway, Lord, 1983. *The Wild Mammals of Malaya (Peninsular Malaysia) and Singapore*. Oxford University Press, Petaling Jaya. 131 pp.

Meijaard, E., 2001. Successful sea-crossing by land mammals—A matter of luck, and big body: A preliminary and simplified model. *Geological Research and Development Centre (Bandung, Indonesia), Special publication*, **27**: 87–92. (Source not seen).

Momin Khan, M. K. B., 1977. Aging of elephants: Estimation by foot size in combination with tooth wear and body dimensions. *Malayan Nature Journal*, **30**: 15–23.

Morwood, M. J., T. Sutikna, E. W. Saptomo, K. E. Westaway, Jatmiko, R. Awe Due, M. W. Moore, Dwi Yani Yuniawati, P. Hadi, J-x. Zhao, C. S. M. Turney, K. Fifield, H. Allen & R. P. Soejono, 2008. Climate, people and faunal succession on Java, Indonesia: Evidence from Song Gupuh. *Journal of Archaeological Science*, **35**: 1776–1789.

Nurzhafarina, O., M. Maryati, A. H. Ahmad, S. Nathan, H. T. Pierson & B. Goossens, 2008. A preliminary study on the morphometrics of the Bornean elephant. *Journal of Tropical Biology and Conservation*, **4**: 109–113.

Oliver, R., 1978. Distribution and status of Asian elephant. *Oryx*, **14**: 380–424.

Osborn, H. F., 1942. *Proboscidea. A Monograph of the Discovery, Evolution, Migration and Extinction of the Mastodonts and Elephants of the World. Vol. II. Stegodontoidea, Elephantoidea*. American Museum Press, New York. Pp. 805–1675.

Patte, E., 1931. A propos d'un Elephas namadicus signalé en Annam. Quelques mots sur la fréquence laminaire. *Bulletin de la Société géologique de France*, **1**: 743–750. (Source not seen).

Peacock, B. A. V. & F. L. Dunn, 1968. Recent archaeological discoveries in Malaysia, 1967 (West Malaysia). *Journal of the Malaysia Branch of the Royal Asiatic Society*, **41**: 171–179.

Pei, W. Z., 1987. Carnivora, Proboscidea and Rodentia from Liucheng *Gigantopithecus* Cave and other caves in Guangxi. *Memoirs of the Institute of Vertebrate Palaeontology and Palaeoanthropology, Academia Sinica*, **18**: 1–134. (Text in Chinese, with English summary).

Richardson, J. A., 1939. *The Geology and Mineral Resources of the Neighbourhood of Raub, Pahang, Federated Malay States, with an Account of the Geology of the Raub Australian Gold Mine*. Geological Survey Department, Federated Malay States. 166 pp.

Richardson, J. A., 1950. *The Geology and Mineral Resources of the Neighbourhood of Chegar Perah and Merapoh, Pahang. Memoir No. 4 (New Series)*. Geological Survey Department, Federation of Malaya. 162 pp.

Roe, F. W., 1951. *The Geology and Mineral Resources of the Neighbourhood of Kuala Selangor and Rasa, Selangor, Federation of Malaya, with an Account of the Geology of Batu Arang Coal-field. Memoir No. 7 (New Series)*. Geological Survey Department, Federation of Malaya. 163 pp.

Ros Fatihah & E. B. Yeap, 2000. Proposed conservation of Badak Cave C, Lenggong as vertebrate fossil site extraordinary. *Proceedings of the Geological Society of Malaysia Annual Geological Conference*. Pp. 189–196.

Roth, V. L. & J. Shoshani, 1988. Dental identification and age determination in *Elephas maximus*. *Journal of Zoology (London)*, **214**: 567–588.

Salman, S. & O. Nasharuddin, 2003. A preliminary study on disturbance cases by elephants (*Elephas maximus*) in the state of Johor. *Journal of Wildlife and Parks*, **21**: 1–11.

Salma, S., B. O. Nasharuddin, B. Y. Mohd Nawayai, N. Burhanuddin Mohd, Z. Ahmad & A. Campos-Arceiz, 2011. Current status of Asian elephants in Peninsular Malaysia. *Gajah*, **35**: 67–75.

Sartono, S., 1973. On Pleistocene migration routes of vertebrate fauna in Southeast Asia. *Bulletin of the Geological Society of Malaysia*, **6**: 273–286.

Savage, H. E. F., 1937. *The Geology of the Neighbourhood of Sungei Siput, Perak, Federated Malay States, with an Account of the Mineral Deposits. Memoir No. 1 (New Series)*. Geological Survey Department, Federated Malay States. 46 pp.

Shelford, R. S., 1899. Notes from Sarawak Museum—On a fossil tooth found at Bau, Upper Sarawak. *Journal of the Straits Branch of the Royal Asiatic Society*, **32**: 218–219.

Shoshani, J. & J. F. Eisenberg, 1982. *Elephas maximus*. *Mammalian Species*, **182**: 1–8.

Shoshani, J. & P. Tassy, 2005. Advances in proboscidean taxonomy & classification, anatomy & physiology, and ecology & behaviour. *Quaternary International*, **126–128**: 5–20.

Stauffer, P. H., 1973. Cenozoic. In: Gobbett, D. J. & C. S. Hutchison (eds.), *Geology of the Malay Peninsula (West Malaysia and Singapore)*. Wiley-Interscience, New York. Pp. 143–176.

Storm, P., F. Aziz, J. de Vos, D. Kosasih, S. Baskoro, Ngaliman & L. W. van den Hoek Ostende, 2005. Late Pleistocene *Homo sapiens* in a tropical rainforest fauna in east Java. *Journal of Human Evolution*, **49**: 536–545.

Sukumar, R. & C. Santiapillai, 1996. *Elephas maximus*: Status and distribution. In: Shoshani, J. & P. Tassy (eds.), *The Proboscidea—Evolution and Palaeoecology of Elephants and their Relatives*. Oxford University Press, USA. Pp. 327–331.

Tong, H. W., 2002. Java fauna: Compared with that of Zhoukoudian area and south China. *Acta Anthropologica Sinica*, **21**: 325–336. (Text in Chinese, with English abstract).

Tougard, C., 2001. Biogeography and migration routes of large mammal faunas in South-east Asia during the Late Middle Pleistocene: Focus on the fossil ad extant faunas from Thailand. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **168**: 337–358.

van den Bergh, G. D., 1999. The Late Neogene elephantoid-bearing faunas of Indonesia and their palaeozoogeographic implications; a study of the terrestrial faunal succession of Sulawesi, Flores and Java, including evidence for early hominid dispersal east of Wallace's Line. *Scripta Geologica*, **117**: 1–419.

van den Bergh, G. D., F. Aziz, P. Y. Sondaar & S. T. Hussain, 1992. Taxonomy, stratigraphy and paleozoogeography of Plio-Pleistocene proboscideans from the Indonesian islands. *Publication of the Geological Research and Development Centre (Bandung), Paleontology Series*, **7**: 28–58.

van den Bergh, G. D., P. Y. Sondaar, J. de Vos & F. Aziz, 1996. The proboscideans of the South-east Asian islands. In: Shoshani, J. & P. Tassy (eds.), *The Proboscidea—Evolution and Palaeoecology of Elephants and their Relatives*. Oxford University Press, USA. Pp. 240–248.

van der Maarel, F. H., 1932. Contribution to the knowledge of the fossil mammalian fauna of Java. *Wetenschappelijke Mededeelingen Dienst Mijnbouw Nederlandsch-Indië*, No. **15**. (Source not seen).

White, T. D., 1975. Geomorphology to paleoecology: *Gigantopithecus* reappraised. *Journal of Human Evolution*, **4**: 219–233.

Yasamin, K. I., 2013. *Vertebrate Palaeontology from Selected Pleistocene Cave Sites in Perak and Selangor, Peninsular Malaysia*. Unpublished PhD thesis. Department of Geology, University of Malaya.

Zeitoun, V., A. Lenoble, F. Laudet, J. Thompson, W. J. Rink, J.-B. Mallye & W. Chinnawut, 2010. The cave of the monk (Ban Fa Suai, Chiang Dao Wildlife Sanctuary, northern Thailand). *Quaternary International*, **220**: 160–173.

Zhang, M. H., 1979. Note on a molar tooth of the Asian elephant from Ling Hu, Zhe Jiang. *Vertebrata PalAsiatica*, **17**: 175–176. (Text in Chinese).

Zhou, M. Z. & Y. P. Zhang, 1974. *Fossil Elephants of China*. Science Press, Beijing. 74 pp. (Text in Chinese).