DIVERSITY AND DIET OF MIDDLE TO LATE PLEISTOCENE BOVID ASSEMBLAGES IN THAILAND

Athiwat Wattanapituksakul

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Palaeontology at Mahasarakham University

August 2016

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ชื่อเรื่อง ความหลากชนิดและอาหารของกลุ่มชีวินสัตว์วงศ์วัว-ควาย ยุคไพลสโตซีนตอนกลางและปลาย ในประเทศไทย
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บทคัดย่อ

เพิงผาถ้ำลอด จังหวัดแม่ฮ่องสอน ถ้ำประกายเพชร จังหวัดชัยภูมิ และถ้ำรากไทร จังหวัดเพชรบุรี เป็นแหล่งโบราณคดี และแหล่งบรรพชีวินวิทยา อายุช่วงปลายสมัยไพลสโตซีน ตอนกลาง ถึงตอนปลาย ปรากฏสัตว์เลี้ยงลูกด้วยนมร่วมสมัยกับกลุ่มสัตว์ หมีแพนด้ายักษ์ และช้างสเตโกดอน (*Ailuropoda-Stegodon* faunal complex) รวมถึงสัตว์วงศ์วัว-ควาย (Bovidae) จากการศึกษาทางบรรพชีวินวิทยาในแหล่งเหล่านี้ สามารถจำแนก สัตว์วงศ์วัว-ควาย ได้ 8 ชนิด ดังนี้ วัวกระทิง (*Bos gaurus*) วัวแดง (*B. javanicus*) กูปรี (*B.* cf. *sauveli*) ควายป่า (*Bubalus arnee*) เลียงผา (*Capricornis sumatraensis*) เลียงผาจีน (*C. milneedwardsii*) กวางผาจีนถิ่นใต้ (*Naemorhedus griseus*) และ กวางผาหิมาลัย (*N.* cf. *goral*)

จากการจำลองการกินอาหารของสัตว์วงศ์วัว-ควาย โดยการวิเคราะห์ ร่องรอยการสึกขนาดกลางบนผิวฟัน (mesowear) แสดงให้เห็นว่า กลุ่มประชากรซากดึกดำบรรพ์ในเพิงผาถ้ำลอด และถ้ำประกายเพชร มีความคล้ายคลึงกับประชากรสัตว์ในปัจจุบัน ส่วนการศึกษาร่องรอยการสึกขนาดเล็กบนผิวฟัน (microwear) แสดงให้เห็นถึง การกินอาหารที่มีความซับซ้อนมากขึ้นในสัตว์แต่ละชนิด ด้วยการเลือกกินอาหารที่แตกต่างกันระหว่าง 2 พื้นที่

การจำลองโครงสร้างอายุของกลุ่มประชากรวงศ์วัว-ควาย ในเพิงผาถ้ำลอด และถ้ำประกายเพชร แสดงให้เห็นว่า ทั้ง 2 พื้นที่มีความแตกต่าง ในความสัมพันธ์ระหว่างการตายของประชากรของวงศ์วัว-ควาย กับการกระทำของสัตว์ผู้ล่า และกิจกรรมการล่าของมนุษย์

คำสำคัญ: สัตว์ในวงศ์ย่อยวัว-ควาย สัตว์ในวงศ์ย่อยแพะ-แกะ สมัยไพลสโตซีนตอนกลางถึงปลาย การกินอาหารของสัตว์โบราณ สภาวะการตายของสัตว์ ประเทศไทย

TITLE Diversity and Diet of Middle to Late Pleistocene Bovid assemblages in Thailand

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ABSTRACT

Tham Lod Rockshelter (Mae Hong Son Province), Tham Prakai Phet(Chaiyaphum Province), and Tham Rak Sai (Phetchaburi Province) are archaeological and paleontological sites aged from Middle to Late Pleistocene who have yielded mammal associations related to the *Ailuropoda-Stegodon* faunal complex. The paleontological study of the dental specimens of bovidae allow to identified taxa that can be classified into 8 species: the gaur (*Bos gaurus*), the banteng (*B. javanicus*), the kouprey (*B.* cf. *sauveli*), the Asiatic water buffalo (*Bubalus arnee*), the Sumatran serow (*Capricornis sumatraensis*), the Chinese serow (*C. milneedwardsii*), the Chinese goral (*Naemorhedus griseus*), and the Himalayan goral (*N.* cf. *goral*).

The paleodiet reconstruction using mesowear analysis shows that the fossil populations (Tham Lod Rockshelter and Tham Prakai Phet) had similar behavior with the current populations. The microwear analysis reveals a more complex paleodiet for each species with a food selection different between the two sites.

The reconstruction of the age structure of the bovidae assemblages of Tham Lod and Tham Prakai Phet reveal different mortality profile corresponding to carnivore action and hunting activities on the bovid community.

Keyword: Bovidae, Caprinae, Middle/Late Pleistocene, Paleodiet, mortality profile, Thailand

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ABBREVIATIONS

Fossils: The any archaic living remains: random pieces of rock in the shape of bones, leaves or shells, and also trace was preserved or replaced in tissue with mineral by fossilization processes (Benton and Harper, 2013)

Subfossil: Organism remains which have not been complete fossils under insufficient condition and time.

Faunal remains: Elements left after the fauna death includes to bones, shells, hair, chitin, scales, hides, organic compound in sites (Yohe and Robert, 2006).

Ma: Million years ago

ka: Thousand years ago

BP: Years before present

TPKP: Tham Prakai Phet

TL: Tham Lod Rockshelter

TR: Tham Rak Sai

Dp2: Upper 2nd deciduous premolar

Dp3: Upper 3nd deciduous premolar

Dp4: Upper 4th deciduous premolar

P2: Upper 2nd premolar

P3: Upper 3nd premolar

P4: Upper 4th premolar

M1: Upper 1st molar

M2: Upper 2nd molar

M3: Upper 3nd molar

dp2: Lower 2nd deciduous premolar

dp3: Lower 3nd deciduous premolar

dp4: Lower 4th deciduous premolar

p2: Lower 2nd premolar

p3: Lower 3nd premolar

p4: Lower 4th premolar

m1: Lower 1st molar

m2: Lower 2nd molar

m3: Lower 3nd molar

CHAPTER 1

INTRODUCTION

1.1 Background

Bovids are an important part of the herbivores community in Thailand which during Pleistocene epoch. The first discovery of Early Pleistocene faunal assemblage in Thailand was made in 1949, a skull of *Bubalus*, was discovered at Nakhon Sawan Province (Lekagul, 1949; von Koenigswald, 1959). Bovids were often found in both Pleistocene archaeological and palaeontological sites as one of the importance prey for both carnivores and hunter-gatherers.

A specific mammalian association, call the *Ailuropoda-Stegodon* (Hooijer, 1958; Kahlke, 1961) is commonly found in Pleistocene archaeological and palaeontological sites. Bovid species represent as part of this fauna association, which compose of Ailuropodinae, Hyaenidae, Ponginae, Stegodontidae, Bovidae (Hooijer, 1958; Kahlke, 1961; Rink *et al.*, 2008). This faunal association was impacted by variation of climatic conditions and sea level changes, resulting on separation or connection of faunal habitat between two differents biogeographic regions. According to biostratigraphical record in Southeast Asia, at least two main episodes of faunal change (extinction or distribution shift) recogized into the late Middle-Pleistocene and the Late Pleistocene-Holocene transition (Tougard, 2001; Louys, 2007). While Bovidae have been one of mammalian families which can be adapt and survive until the recent.

Nowadays in Thailand, wild bovids are represented by six species, groups in two subfamilies: Bovinae comprises *Bos gaurus*, *B. javanicus*, and *Bubalus arnee*; Caprinae comprises *Capricornis milneedwardi*, *C. sumatraensis* and *Naemorhedus griseus*, following the IUCN in 2011 (Duengkae, 2011). Adjacent countries in Indochinese and Sundaic zoogeographic subregions are also habitat of other bovids such as *Pseudoryx nghetinhensis*, *Budorcas taxicolor*, *Naemorhedus goral*, and *N. baileyi* (Corbet and Hill, 1992; Wilson and Reeder, 2005).

In the previous work such as Tougard (2001), Zeitoun *et al.* (2005, 2010), the mammalian assemblage analysis as *Ailuropoda-Stegodon* complex were focusing on the palaeoenvironment and palaeoclimate reconstruction in Southeast Asia. Here, this study

applied other methodology to study mammals palaeodiet, and mortality profile in order to propose a more complete view of mammalian community from Pleistocene. Moreover, some Bovidae genera such as *Capricornis* and *Naemorhedus* is not often completely separeted (Tougard, 1998, 2001; Bacon *et al.*, 2008, 2011). Therefore, this study will be provided better understanding of the diversity and the distribution of bovid in Thailand during Middle to Late Pleistocene.

1.2 Objectives of the research

The analysis of the Bovidae assemblages of the Tham Lod Rockshelter and Tham Prakai Phet will be used to achieved three objectives.

1. Identified Bovidae species to reconstruct the Pleistocene bovid community in Thailand.

2. Reconstructed the paleodiet of the bovid specie using dental mesowear and microwear analysis in order to propose palaeoenvironmental reconstruction in Thailand during Middle to Late Pleistocene.

3. Reconstructed age profile and Interpreted mortality profile in anthropic and natural sites.

1.3 Scope of the research

The scope of the study is to describe the morphology of the bovids dental material from archaeoelogical and palaeontological sites using comparative anatomy associated with dental dimensions in order to characterized the differences between the Bovidae species. According to the diversity of the results in former studies, it helps to determine distribution changes of Bovidae from Middle to Late Pleistocene. The dental wear pattern will help to reconstruct the mortality profile of Bovidae in sites related to human activities and natural assemblages. Secondly, the microwear and mesowear analysis will allow proposing palaeoenviromental and palaeodiet reconstruction for Bovidae species at the end of Pleistocene.

1.4 Schedule of the research

The duration of the research ranges during 2012-2016 following Table 1.1.

Table 1.1 Schedule of the research.

Process	2012		2013		2014		2015		2016
	1-6	7-12	1-6	7-12	1-6	7-12	1-6	7-12	1-6
1. Previous work	←	→							
2. Survey and excavation			←	—	—	—	→		
3. Specimens preparation			←	—	—	—	→		
4. Identifications					←	—	—	→	
5. Comparison with recent and fossil specimens					←	—	—	→	
6. Aging and measurement determination					←	—	—	→	
7. Paleodiet analysis						←	—	—	→
8. Interpretation, analysis, and discusion						←	—	—	→
9. Conclusion									↔

1.5 Significance of the research

This palaeontological research is focused on Bovidae from Middle Pleistocene to Late Pleistocene in Southeast Asia. This research will serve as a reference for understanding the evolution and distribution of mammals at that time. The study will provide:

1. Better understanding on diversity and distribution of bovid species during Pleistocene in Thailand and in Southeast Asia. Moreover, the research will help to resolving taxonomic problem by the characterization of dental morphological features for each species. The reconstruction of the mortality profile for Bovidae species in archaeological and palaeontological assemblages will constitute a reference base for mammalian assemblages in tropical environment in Southeast Asia.

2. The information obtained by mesowear and microwear analysis on Bovidae teeth might be used to reconstruct palaeodiet and the palaeoenvironmental condition during Middle Pleistocene to Late Pleistocene in Thailand.

CHAPTER 2

LITERATURE REVIEW

During Middle to Late Pleistocene, Thailand was affected by the succession of glacial and interglacial periods. Theses fluctuations of climatic conditions affected the environment and the faunal associations. Firstly, this chapter introduces the environmental background of Middle and Late Pleistocene in Thailand and Southeast Asia. The last part of the chapter exhibits bovid assemblages in both recent and Pleistocene times in South East Asia.

2.1 Background of Middle and Late Pleistocene in Thailand and Southeast Asia

During Middle and Late Pleistocene dated back to 781,000-120,000 BP and 120,000-11,700 BP, respectively (Gibbard and Cohen, 2008; Cohen *et al.*, 2013)., 5 majors and 2 minors glaciations occurred (identifications based on the marine benthic foraminifera $\delta^{18}O$ analysis) (Tian *et al.*, 2002; Head and Gibbard, 2015), Figure 2.1. The global climate switches between glacial (with ice sheets in the Northern hemisphere and high mountain range associated to cooler climate than recent) and interglacial (with a similar climate or warmer than the recent) (Berger and Loutre, 2007). The sea level was 120 m lower than the recent mean sea level in the Last Glacial Maximum (Sathiamurthy and Voris, 2006; Hansen *et al*., 2013) which affect limit of the coastline (Clark *et al.*, 2009). These changing conditions had abeffect in Thailand and especially on the distribution of the *Ailuropoda-Stegodon* faunal complex in the region.

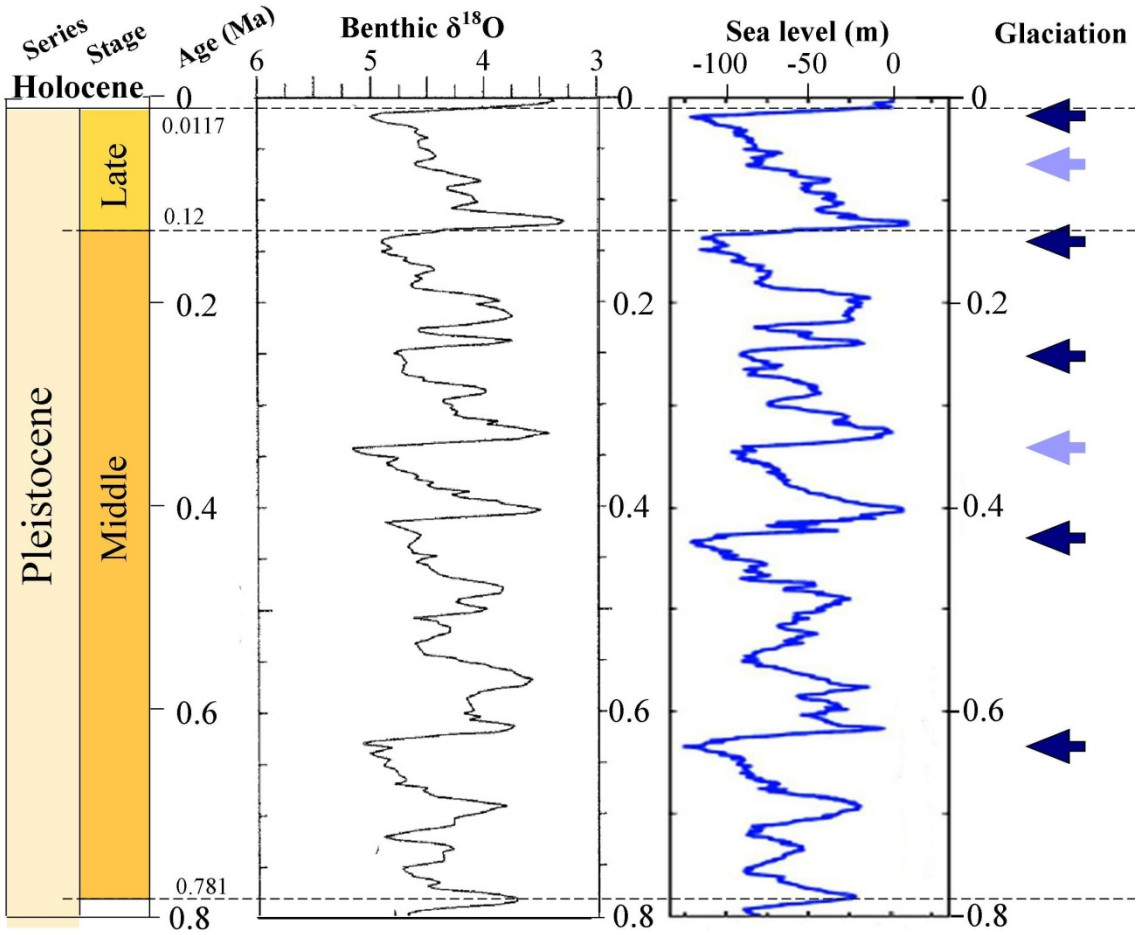

Figure 2.1 Geological time scale of Middle and Late Pleistocene (After Gibbard and Cohen, 2011) correlated to the marine benthic foraminifera $\delta^{18}O$ of ODP Site 1143, South China Sea (Tian *et al.*, 2002), the sea level from the equation account for fact that the mean Last Glacial Maximus value of $\delta^{18}O$ (Hansen *et al.*, 2013), and major/minor glaciations following marine benthic foraminifera $\delta^{18}O$ sites represented by dark/light arrows, respectively (Head and Gibbard, 2015).

2.1.1 *Ailuropoda-Stegodon* faunal complex

This faunal complex distributed from South China through Southeast Asia which extinct or has ever been shifted in distribution range. This mammal comunity was impacted by dramatic palaeoclimate and palaeoenviroment fluctuations. This faunal association was firstly described from Middle Pleistocene sites in Southern China such as Yenchingkou (Hooijer, 1958; Kahlke, 1961) an considered as a good biostratigraphic indicator for Southeast Asia and South China (Kahlke, 1961). The members of *Ailuropoda-Stegodon* faunal complex consist of archaic extinct fauna such as the stegodon elephant (*Stegodon*), the archaic elephant (*Palaeoloxodon*), the four tusks elephant (*Gomphotherium*), the giant ape (*Gigantopithecus*), the giant tapir (*Megatapirus*), the archaic antilope (*Megalovis*), the archaic chinese rhinoceros (*Rhinoceros sinensis*), the archaic spotted hyena (*Crocuta crocuta ultima*) etc. In addition, the distribution of extant faunas sucha as the orangutan (*Pongo pygmaeus*) and the giant panda (*Ailuropoda melanoleuca*) had ever shifted in distribution range (Hooijer, 1958; Kahlke, 1961; Rink *et al.*, 2008).

Ailuropoda-Stegodon faunal complex has ever been associated with recent endemic fauna of Indochinese zoogeographic subregion, which consist of Kitti's hog-nosed bat (*Craseonycteris thonglongyai*), Red-shanked douc (*Pygathrix nemaeus*), Fea's tree rat *(Chiromyscus chiropus)*, Schomburgk's deer (*Cervus schomburgki*), Kouprey (*Bos sauveli*) etc, including also the giant panda (*Ailuropoda melanoleuca*).

In Thailand, Middle and Late Pleistocene faunal assemblages were discovered in few sites which present both *Ailuropoda-Stegodon* complex and recent faunal complex.

The first discovery of Pleistocene mammal fossils in Thailand was made in the Chao Praya Basin, Nakhon Sawan Province during 1942-1949. Some fragmented remains have been identified: as an Hippopotamus skull (*Hippopotamus* sp.), a part of water buffalo skull (*Bubalus* sp.), and an upper molar of *Stegodon insignis* (Lekagul, 1949). The age of the assemblage has been correlated with the Siwalik Formation in India, where *Stegodon insignis* have been described and correlated with the Early Pleistocene (von Koenigswald, 1959). *Stegodon* sp., a member of the *Ailuropoda-Stegodon* fauna was found from Tha Chang sand pit in Nakhon Rachasima Province, but stratigraphy and dating in this area have not been clear (Nakaya *et al.*, 2003; Thasod

and Ratanathien, 2005). Moreover, *Stegodon* sp. and other fauna such as *Sinomastodon* sp. that also found in this site had lived in a long range during Miocene-Pleistocene (Thasod and Ratanathien, 2005). In addition, the late Early Pleistocene or Middle Pleistocene giant ape (*Gigantopithecus*) had ever been considered of a native fauna in South china, but recent data show a new distribution at Pha Bong, Mae Hong Son Province (Bocherens *et al.*, 2015).

Many sites with faunal assemblages associated with *Ailuropoda melanoleuca baconi*, *Crocuta crocuta ultima*, *Pongo pygmaeus*, *Pongo* sp., and *Stegodon* sp. such as Kao Pah Nam, Lampang Province (Pope *et al.*, 1981), Tham Wiman Nakin, Chaiyaphum Province (Chaimanee, 1998; Chaimanee and Jaeger, 1993; Tougard, 1998, 2001), Khok Sung, Nakhon Rachasima (Chaimanee *et al.*, 2005; Suraprasit *et al.*, 2015) were considered to to be aged to Middle Pleistocene based on biochronological correlation dating associated with some absolute dating. Kao Pah Nam is supposed to be Middle Pleistocene (more than 690 ka) based on paleomegnetic data (Pope *et al.*, 1981). The age of the main fossiliferous level in Tham Wiman Nakin is estimated to be 169±11 ka by U-series dating of carbonates and teeth (Esposito *et al.*, 1998, 2002). Khok Sung age have been considered to be late Middle Pleistocene based on magnetostratigraphy (more than 188 ka or 213 ka) (Suraprasit *et al.*, 2015), Table 2.1.

The *Ailuropoda-Stegodon* complex is well represented in North and Northeastern Thailand. However, two Southern sites Tham Pedan, in Nakhon Si Thammarat Province (Yamee and Chaimanee, 2005) and Thung Wa, in Satun province (Duangkrayom *et al.*, 2010) show member of *Ailuropoda-Stegodon* complex. Thung Wa, Satun is the first record of *Stegodon* in Thai-Malay Peninsula but have not been dated (Duangkrayom *et al.*, 2010). Only Tham Pedan which yielded some remains of *Crocuta* in Southern Thailand is considered to have a Middle Pleistocene age based on the presence of the hyena (Yamee and Chaimanee, 2005).

Late Pleistocene sites comprise archaeological sites such as Tham Lod Rockshelter, Mae Hong Son Province (Shoocongdej 2001, Wattanapituksakul 2006; Ampunsri, 2007), Moh Khiew, Krabi Province (Chaimanee, 1993), Lang Kamnan, Kanchanaburi Province (Shoocongdej, 1996), Moh Khiew II, Krabi Province (Auetrakulvit, 2004, 2005), Ban Rai, Mae Hong Son Province (Ampunsri, 2007). These

sites revealed the absence of the *Ailuropoda-Stegodon* in Thailand during Late Pleistocene time. But recent study from both the Cave of Monk (Zeitoun *et al.*, 2005, 2010) and Tham Prakai Phet (Filoux *et al.*, 2014, 2015) present faunal assemblages with member of the *Ailuropoda-Stegodon* complex such as *Ailuropoda melanoleuca*, *Crocuta crocuta*, *Pongo pygmaeus*, *Rhinoceros sinensis*, *Stegodon* sp. and they were dated to Late Pleistocene based on absolute dating and new biostratigraphic data. The dating of the Cave of Monk has been proposed as 32 ka to19 ka based on Electron Spin Resonance (ESR), (Zeitoun *et al.*, 2010). In addition, Tham Prakai Phet is considered to younger than previously study and is not contemporaneous to the Middle Pleistocene adjacent site, Tham Wiman Nakin based on biochronological data (Filoux *et al.*, 2015). The first absolute dating by U/Th gives age of 40-65 ka (Table 2.2).

According to Pleistocene fauna community in Southeast Asia correlated to both India and South China assemblages, the dispersal way hypothesis of the mammal community is the continental way from the Eurasia to the Sundaland though Thailand. the Sino-Malayan route and the Siwa-Malayan route are the two continental ways (Tougard, 2001). Sino-Malayan route is the route of faunal distribution from South China to Sunda shelf during Late Pleistocene. This route was suggested by von Koenigswald (1935, 1939) based on the occurrence of element identified with Chinese affinities in Pleistocene fauna of Sunda shelf. Siwa-Malayan route is the route of faunal distribution from India to Sunda shelf during Early to Middle Pleistocene suggested by von Koenigswald (1935) based on the occurrence of *Stegodon trigonocephalus*, *Homo erectus*, *Duboisia santeng*, and other in Sunda shelf sites, related to the Siwalik faunas in India (Tougard, 2001) (Figure 2.2).

Table 2.1 Comparison of faunal genus in *Ailuropoda-Stegodon* complex during Middle Pleistocene between Thailand and other sites in South China and Southeast Asia

Locality	*Stegodon orientali*	*S. guizhouensis*	*Stegodon* sp.	*Elephas nemadicus*	*Cuon javanicus*	*Cuon alpinus antiquus*	*Crocuta crocuta*	*C. c. ultima*	*Hyaena brevirostric sinensis*	*Hyaena* sp.	*Felis teilhardi*	*Arctonyx collaris rostratus*	*Vulpes vulgaris*	*Ailuropoda baconi*	*Ailuropoda melanoleuca*	*A. m. baconi*	*A. m. fovealis*	*Ursus thibetanus kokeni*	*Gigantopithecus blacki*	*Homo* sp.	*P. p. weidenreichi*	*Pongo* sp.	*Equus* sp.	*Rhinoceros unicornis*	*R. sinensis*	*R. sondaicus guthi*	*Megatapirus augustus*	*Tapirus sinensis*	*T. indicus intermedius*	*Dicoryphochoerus ultimus*	*Sus barbatus*	*Sus bijiashanensis*	*S. xiaozhu*	*M. muntjak margae*	*Capricornis sumatraensis kanjereus*	*C. s. guilinensis*	*Megalovis guangxiensis*
South China																																					
Yenchingkou	X			X		X		X			X				X		X									X							X	X			
Wuyun	X				X					X					X						X			X		X	X										
Daxin	X				X											X		X				X			X		X			X		X					X
Wuming			X						X							X		X							X						X						
Chihchin	X																X					X		X		X											
Chuanshan															X																				X		
Hejiang Cave	X								X				X		X			X							X		X					X					
Sanhe Cave																																					
Guanyindong	X	X					X					X											X				X										
Thailand																																					
Pha Bong																			X																		
Khok Sung			X				X																														
Tham Wiman Nakin	X			X			X			X					X		X			X			X					X		X			X				
Tham Prakai Phet							X							X							X									X							
Laos																																					
Tam Hang	X			X	X		X			X				X			X			X		X			X		X		X							
Combodia																																					
Phnom Loang							X																	X													

Remark: Yenchingkou (Colbert and Hooijer, 1953), Wuyun (Wang *et al.*, 2007; Rink *et al.*, 2008), Daxin (Rink *et al.*, 2008), Wuming (Rink *et al.*, 2008), Chihchin (Kahlke, 1961), Chuanshan (Wanpo *et al.*, 1983), Hejiang Cave (Zhang *et al.*, 2014), Sanhe Cave (Jin *et al.*, 2009), Guanyindong (Han and Xu, 1985), Pha Bong (Bocherens *et al.*, 2015), Khok Sung (Chaimanee *et al.* 2005; Suraprasit *et al.*, 2015), Tham Wiman Nakin (Tougard, 1998, 2001), Tham Prakai Phet (Filoux *et al.*, 2015), Tam Hang (Bacon *et al.*, 2011), Phnom Loang (Beden and Guérin, 1973).

Table 2.2 Comparison of faunal genus in *Ailuropoda-Stegodon* complex during Late Pleistocene between Thailand and South China and Southeast Asia

Locality	*Stegodon orientali*	*Stegodon* sp.	*Cuon javanicus antiquus*	*C. alpinus antiquus*	*C. crocuta ultima*	*Hyaenidae indet.*	*Felis teilhardi*	*Arctonyx collaris rostratus*	*Meles meles*	*Ailuropoda melanoleuca*	*A. m. baconi*	*Ursus thibetanus kokeni*	Homo sp.	*Pongo pygmaeus*	*P. p. weidenreichi*	*Pongo* sp.	*Equus hemionus*	*Rhinoceros unicornis*	*R. sinensis*	*Megatapirus augustus*	*Tapirus sinensis*	*T. indicus intermedius*	*Sus barbatus*	*S. xiaozhu*	*Cervus nippon*	*Muntiacus vuquangensis*	*Pseudoryx* sp.	*Naemorhedus goral*	*Capricornis sumatraensis kanjereus*
South China																													
Wuyun	X		X				X				X				X				X	X	X								
Lower Pubu											X						X		X		X			X					
Thailand																													
The cave of monk		X				X				X				X				X	X				X		X	X	X	X	X
Tham Prakai Phet					X					X						X							X						
Vietnam																													
Duoi U'Oi													X	X				X					X						
Ma U'Oi													X					X											
Tam Hang	X			X				X	X			X		X				X		X		X	X						
Malaysia																													
Badak Cave C																X													
Batu Cave																X													

Remark: Wuyun (Wang *et al.*, 2007; Rink *et al.*, 2008), Lower Pubu (Wang *et al.*, 2007), Duoi U'Oi (Bacon *et al.*, 2008), Ma U'Oi (Bacon *et al.*, 2004), Lang Trang (de Vos and Long, 1993), the cave of monk (Zeitoun *et al.*, 2005, 2010), Tham Prakai Phet (Filoux *et al.*, 2015), Badak Cave C and Batu Cave (Ibrahim, 2013; Ibrahim *et al.*, 2013)

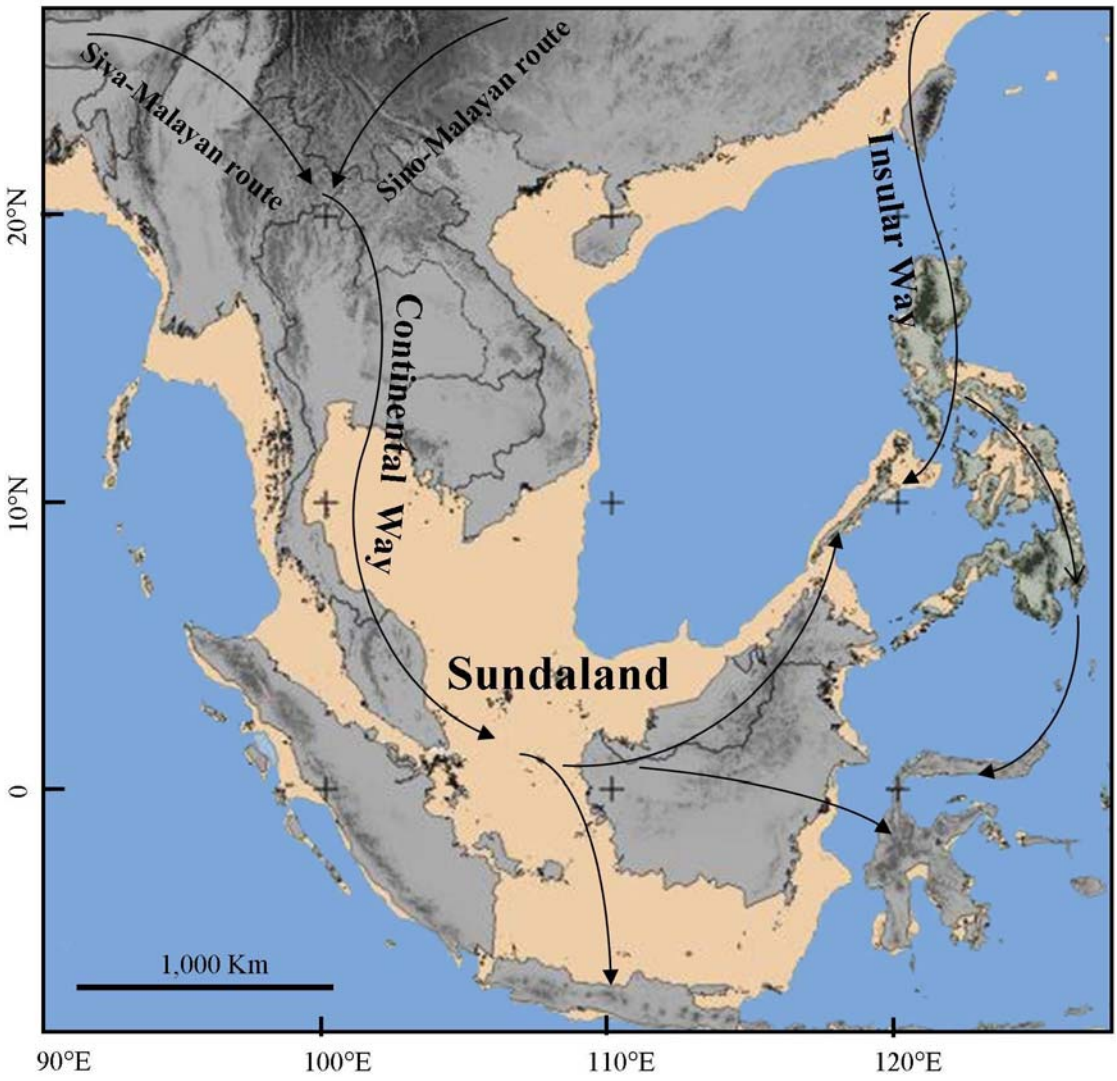

Figure 2.2 Pleistocene Fauna distribution route hypothesis in Southeast Asia (After Tougard, 2001), and map of Sundaland during the Last Glacial Maximum (After Voris, 2000)

2.1.2 Sea level change

During Pleistocene, the sea level was lower than present which affect the extension and the connection of the mainland Southeast Asia with several islands on Sunda shelf, including Sumatra, Java, Borneo, Palawan, and other small islands. This landmass was called, Sundaland (Dunn and Dunn, 1977; Lekagul and McNeely, 1977; Voris, 2000; Sathiamurthy and Voris, 2006) (Figure 2.2).

2.1.3 Palaeoclimate and Palaeoenvironment in Southeast Asia

In Southeast Asia, there are limited recent studies in each period which cannot completely respond the switching between glacial and interglacial though Middle to Late Pleistocene. They can illustrate partly dramatic fluctuation of palaeoclimate and palaeoenvironment thought this period.

Middle Pleistocene: In early Middle Pleistocene, the inland of the region: northwest of Thailand present the humid evergreen based on the occurrence of *Koompassia elegans*, dated back to 800 ka (Philippe *et al.*, 2013). After that time, no detail data are enough available on palaeoclimate and palaeoenvironment reconstruction until late Middle Pleistocene. At least 300 ka, Northwest of Thailand site as Pha Bong may illustrate to the forested part of a mosaic landscape including significant parts of savanna by the carbon stable isotopic composition analysis on dental enamel (Bocherens *et al.*, 2015). This site corresponds to Northeast of Thailand such as Khok Sung (dated either to 188 ka or 213 ka; Suraprasit *et al.*, 2015) and Tham Wiman (dated to closely 160 ka, Pushkina *et al.*, 2010) illustrate to dominant open habitat by fauna habitat reconstruction and the stable isotope analysis on dental enamel, respectively. The flora remain in Khok Sung illustrate to mixed tropical deciduous and dry evergreen forests on the upland surrounding vegetation with correlated to Indian Himalayan group (such as *Meliaazedarach* and cf. *Cyperus* sp.) at up to 2000 m of attitude (Grote, 2007).

While previous studies of palaeoclimate in South China region and South China Sea illustrates a relatively warm climatic at least 260 ka and switch to cool climate at closely 142 ka (Wang *et al.,* 2004). The summer monsoon always effect over South China during both glacial and interglacial respond to the orbital variation in the low latitude summer insolation (Ao *et al*., 2011). There is limited vegetation data in

South China during Middle Pleistocene. However, most South China region could be occupied by tropical forest (Meijaard and Groves, 2006).

Late Pleistocene: Almost the previous study during Late Pleistocene illustrate to late period or transition of the stage. Based on pollen analysis in inland of Southeast Asia such as North and Northeast of Thailand, pollen of mountainous vegetation such as Pine (*Pinus* spp.) and Oak (*Quercus* spp.) have been found in low land area such as Nong Pa Kho and Nong Han, Udon Thani Province and Kwan Phayao, Phayao Province around 40 ka to 10 ka. (Penny, 2001; White *et al.*, 2004).

The main of Sundaland became open habitat as Savanna associated. On the previous study in South China Sea and Sunda shelf indicated to northern continental of South China was covered by grassland or savanna habitat indicated to influence a drier climate than the recent while the southern continental was covered by tropical rain forest characterised of humid condition (Sun *et al*., 2000). In Sundaland, forest contracted in many areas such as peninsular Malaysia and Palawan (Wurster *et al.*, 2010). While South China region, the tropical forest may contracted and retreated southwards, after that it disappeared from most of South China, replaced by mostly subtropical forest (Meijaard and Groves, 2006).

Savanna habitat mostly occupied and distributed northwards though Sundaland during Late Pleistocene (Bird *et al.,* 2005) until the northern continental of South China Sea (Sun *et al.,* 2000). These vegetation conditions were associated with abundant phytolith or burnt charcoal in many sites of Sunda Shelf (Maloney, 1999; Hope *et al.*, 2004). However, charcoal or phytolith does not continuously occur in stratigraphy. These fire evidence indicate that fire is common and possibly a result of a climate considerably dryer and more seasonal than today (Maloney, 1999; Hope *et al.*, 2004).

In the palaeoclimate reconstruction of Southeast Asia, during 35 ka to 20 ka, inland of Southeast Asia sites such as Tham Lod and Ban Rai rockshelters, Northwest of Thailand demonstrated to wetter and relatively unstable climatic conditions based on an oxygen isotope sequence ($\delta^{18}O$) from the bivalve *Margaritanopsis laosensis* at (Marwick and Gagan, 2011). Then the climate became to drier conditions from 20 ka to 11.5 ka (Marwick and Gagan, 2011). It suggested that the intertropical convergence zone shifted southwards when the North Atlantic region cooled (Marwick and Gagan,

2011). In Sunda shelf, climate condition changed from wet to dry which effected by monsoon intensity during 20-19 ka.

In the end of Late Pleistocene (after 11.7 ka), contracted many palaeoenvironment such as mountainous vegetation and savanna were retreated as fragmented forest and disappear, respectively (Penny, 2001; White *et al.*, 2004) effected by increasing sea level and separated Sundaland. The climate condition in this region was seriously increased in precipitation and stable (Marwick and Gagan, 2011; Chabangborn and Wohlfarth, 2014).

2.2 Bovidae in Thailand

2.2.1 Recent Bovid assemblage

Bovids, the cloven-hoofed mammal, are real ruminants with four-chambered stomachs. First bovid appeared in Eurasia during early Miocene. *Eotragus*, the earliest known bovid, was similar in size to the modern gazelle which was common in Eurasia and Africa during the middle Miocene. Nowadays, there is 143 extant bovids species on the Earth (Prothero and Schoch, 2002).

In Southeast Asia, 15 species in two subfamilies are recognized in both Indochina and Sundaic subregions. Subfamily Bovinae, there are 3 species of *Bos*: including Gaur (*Bos gaurus*), Banteng (*B. javanicus*), and Kouprey (*B. sauveli*); 4 *Bubalus* species: Wild water buffalo (*B. arnee*), Lowland anoa (*B. depressicornis*), Mountain anoa (*B. quarlesi*), and Tamaraw (*B. mindorensis*); and 1 *Pseudoryx*: Saola (*Pseudoryx nghetinhensis*) (Wilson and Reeder, 2005).

A member of Subfamily Caprinae are provided to three *Capricornis*: Mainland serow (*C. milneedwardsii*), Sumatran serow (*C. sumatraensis*), and Red serow (*C. rubidus)*; three goral *Naemorhedus*: Chinese goral (*Naemorhedus griseus*), Himalayan goral (*N. goral*), and Red goral (*N. baileyi*); and one *Budorcas*: Takin (*Budorcas taxicolor*) (Wilson and Reeder, 2005).

Above Bovidae reviews, at most 7 species have been distribute in Thailand (Figure 2.3): Gaur (*Bos gaurus*), Banteng (*B. javanicus*), Kouprey (*B. sauveli*), Wild water buffalo (*B. arnee*), Mainland serow (*C. milneedwardsii*), Sumatran serow (*C. sumatraensis*), and Chinese goral (*Naemorhedus griseus*) (Duengkae, 2011). Only *B.*

sauveli has been believed extinct from Thailand at least before 1993 (Srikosamatara and Suteethorn, 1994), see recent Bovidae biology in Thailand in Table 1, Appendix I.

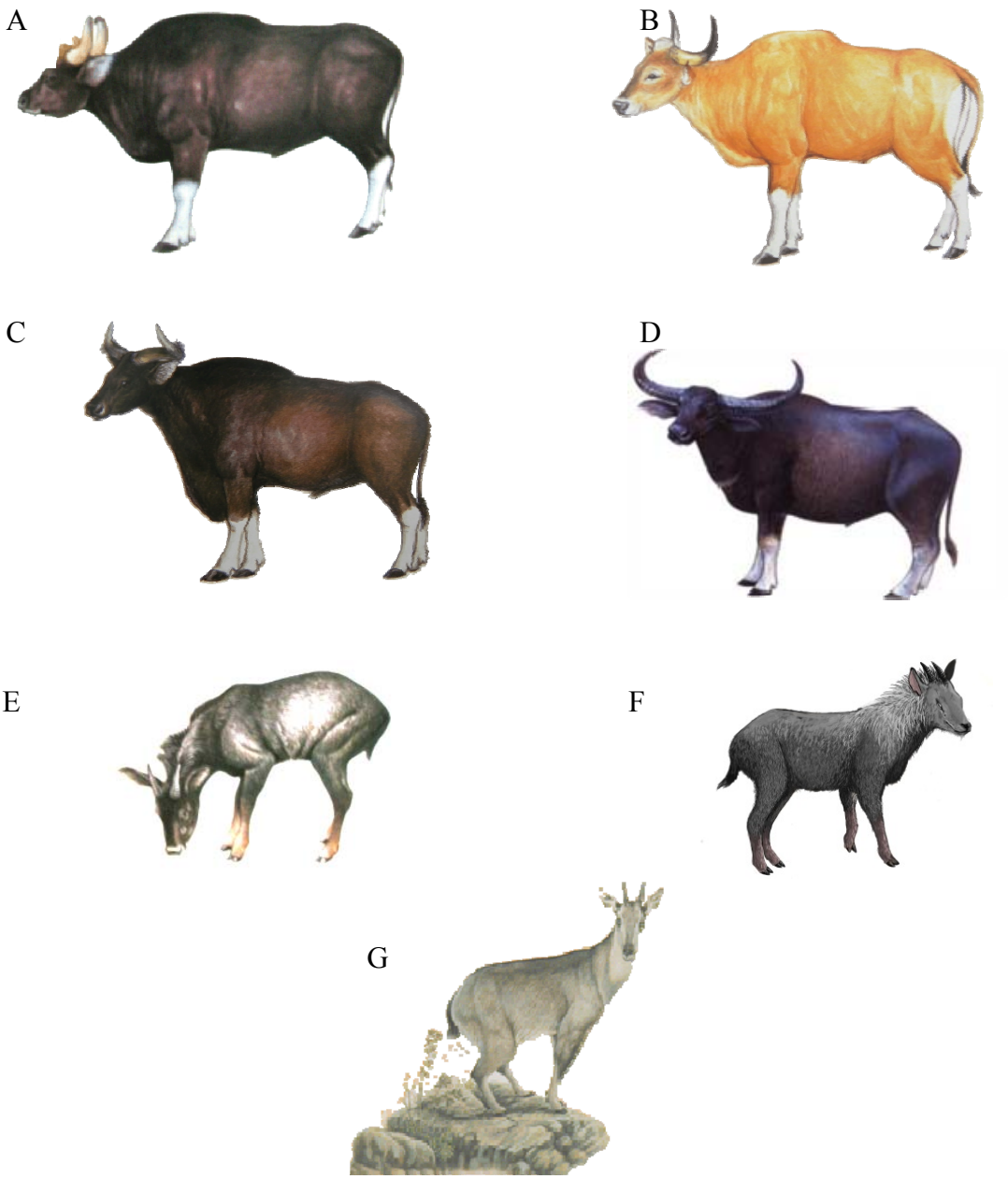

Figure 2.3 Recent bovids in Thailand: A) Gaur (*Bos gaurus*), B) Banteng (*B. javanicus*), C) Kouprey (*B. sauveli*), D) Wild water buffalo (*B. arnee*), E) Mainland serow (*C. milneedwardsii*), F) Sumatran serow (*C. sumatraensis*), and G) Chinese goral (*Naemorhedus griseus*)

Remark: Picture A- E, and G (After Par, 2003), and F drew by Mr.Kmonvish Lawan

2.2.2 Zoogeography of extant Southeast Asia bovids

Southeast Asia is currently divided into two zoogeographic subregions, including Indochinese and Sundaic subregions, which distinguished by the Kra Isthmus (Figure 2.4). The Indochinese subregion is the northern part locating in the north of the Kra Isthmus which covers northern part of Thailand, Myanmar, Cambodia, Laos, Vietnam, and South China. In addition, the Sundaic subregion locates in the south of Kra Isthmus and covers the southern part of Thailand, Malaysia, Sumatra, Java, and Borneo (Lekagul and McNeely, 1988; Corbet and Hill, 1992). The faunal boundary between these zoogeographic subregions is influenced by vegetation with the evergreen rain forest that dominate in Sundaic subregion, and the deciduous forest that dominate in the Indochinese subregion. The boundary influence the faunal dispersal especially endemic species (Chaimanee, 2007).

Seven bovids comprise of *Bos gaurus*, *B. javanicus*, *B. sauveli*, *Bubalus arnee*, *Capricornis milneedwardsii*, *C. sumatraensis*, and *Naemorhedus griseus* widely exist in the mainland of Southeast Asia including Thailand (Wilson and Reeder, 2005; Duckworth *et al.*, 2008a, 2008b, 2008c, 2008d; Hedges *et al.*, 2008; Timmins *et al.*, 2008a, 2008b). Three species live in Northern of Myanmar such as *Budorcas taxicolor*, *Capricornis rubidus*, *Naemorhedus goral*, and *N. baileyi* (Wilson and Reeder, 2005; Duckworth and MacKinnon, 2008a and 2008b; Duckworth and Zaw, 2008; Song *et al.*, 2008). *Pseudoryx nghetinhensis* have been reported in Vietnam and Laos (Dung *et al.*, 1993; Thomas, 1994; Wilson and Reeder, 2005; Timmins *et al.*, 2008). Three species of buffalo are endemic to Indonesia and Philippines: *Bubalus depressicornis* and *B. quarlesi* in Sulawesi Island (Wilson and Reeder, 2005; Semiadi *et al.*, 2008a and 2008b), *B. mindoroensis* in the island of Mindoro (Wilson and Reeder, 2005; Hedges *et al.*, 2013), Table 2.3.

Almost of them are part of the mammal community of Indochinese subregion or widespread in both subregions. *Capricornis sumatraensis* and three buffalo species present in Sunda shelf island are only present in Sundaic subregion.

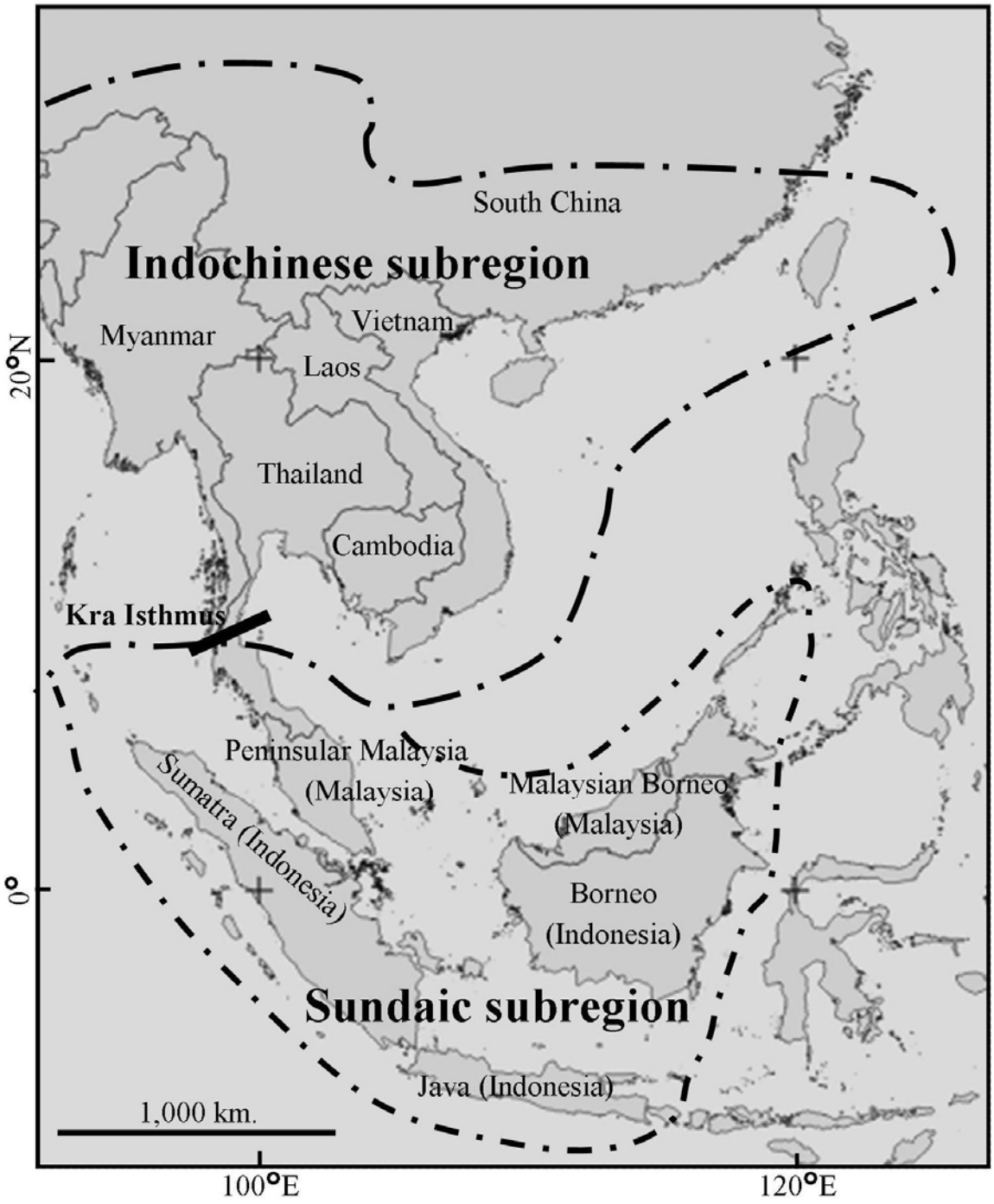

Figure 2.4 Map of the Indochinese and Sundaic zoogeographic subregions with the Kra isthmus making the terrestrial boundary (After Tougard, 2001 and Lekagul and McNeely; 1977).

Table 2.3 The zoogeography of extant bovids in Thailand and Southeast Asia.

Taxonomy	Common name	Indochinese Subregion	Thailand	Sundaic Subregion
Subfamily Bovinae				
Genus *Bos*				
Bos gaurus	Gaur	X	X	X
B. javanicus	Banteng	X	X	X
B. sauveli	Kouprey	X	X	
Genus *Bubalus*				
Bubalus arnee	Wild water buffalo	X	X	
B. depressicornis	Lowland anoa			X
B. quarlesi	Mountain anoa			X
B. mindorensis	Tamaraw			X
Genus *Pseudoryx*				
Pseudoryx nghetinhensis	Saola	X		
Subfamily *Caprinae*				
Genus *Budorcus*				
Budorcas taxicolor	Takin	X		
Genus *Capricornis*				
Capricornis milneedwardsii	Mainland serow	X	X	
C. rubidus	Red serow	X		
C. sumatraensis	Smatran serow		X	X
Genus *Naemorhedus*				
Naemorhedus griseus	Chinese serow	X	X	
N. goral	Himalayan goral	X		
N. baileyi	Red goral	X		

2.2.3 Pleistocene Bovidae

Although few archaeological and palaeontological sites with Pleistocene mammalian associations were found in Thailand (see detail in the topic: *Ailuropoda-Stegodon* fauna in Thailand). Five sites present Bovidae palaeontological data and can be correlated by biochronology with Pleistocene epoch. Khok Sung (Suraprasit *et al.*, 2015), Tham Wiman Nakin (Tougard, 1998, 2001), Tham Pedan (Yamee and Chaimanee, 2005) are considered dating to late Middle Pleistocene. The Cave of the Monk (Zeitoun *et al.*, 2005, 2010), Tham Lod rockshelter (Wattanapituksakul, 2006; Ampunsri 2007) and

Tham Prakai Phet (Filoux *et al.*, 2014, 2015) have yielded Late Pleistocene faunal assemblages. Most of bovid species in these sites are similar to the extant fauna which found at Pleistocene in Indochinese and Sundaic subregiona such as *Bos gaurus*, *B. javanicus*, *Bubalus bubalis* (former name of *Bubalus arnee*), *Capricornis sumatraensis* (former name of both *C. milneedwardsii*, and *C. sumatraensis*) and *Naemorhedus caudatus* (former name of *N. griseus*). Two endemic species from the Cave of Monk correlated to India and South China such as *N. goral* and *C. sumatraensis kanjereus*,. Teeth of *Pseudoryx* sp. in the Cave of Monk is a first record of recently extinct species (Zeitoun *et al.*, 2005, 2010) (Figure 2.5 and. Table 2.4).

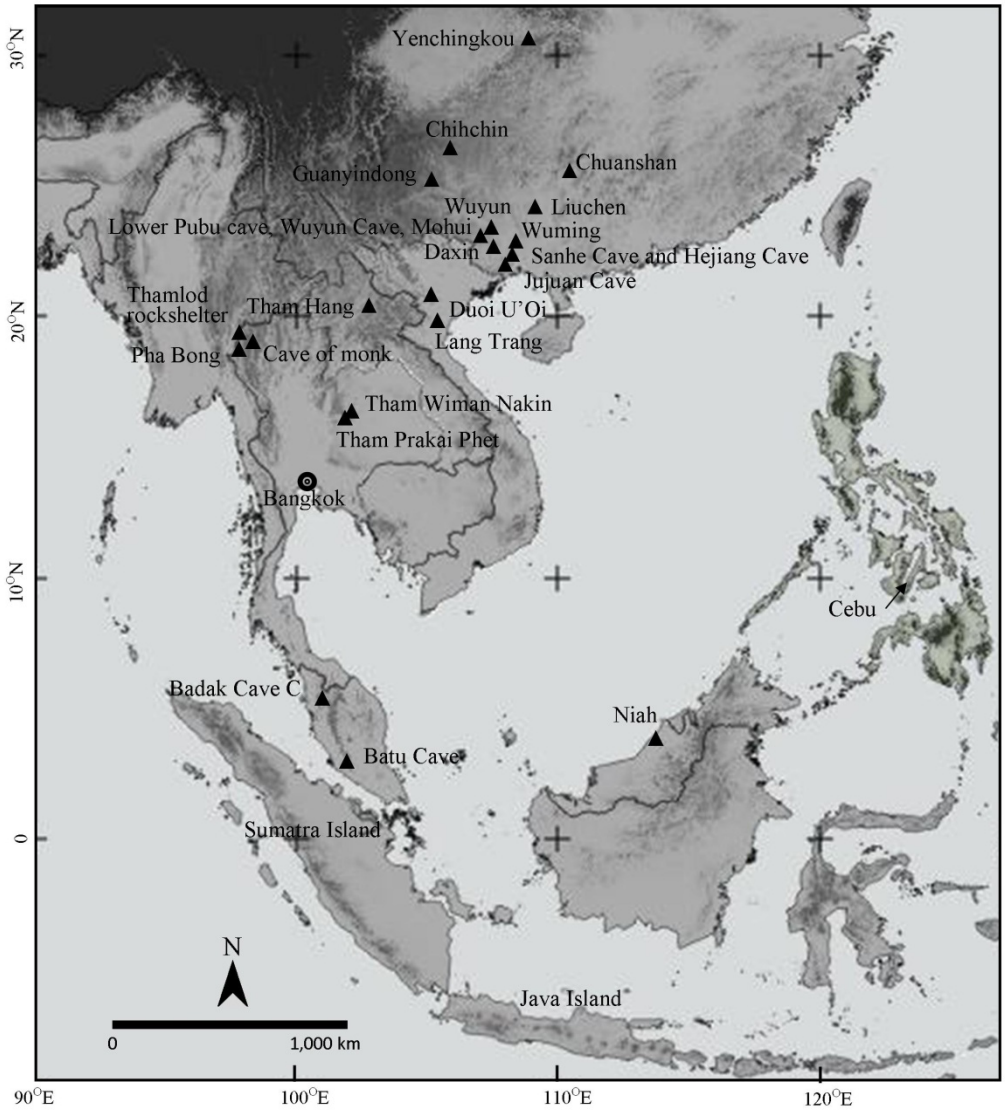

Figure 2.5 Map of Pleistocene Bovidae discoveries of Southeast Asia and South China.

Table 2.4 Inventory of Southeast Asia sites with Bovidae remains

Locality	*Bibos palaesondaicus*	*Bibos* sp.	*Bos gaurus*	*B. g. grangeri*	*B. sauveli*	*B. javanicus*	*Bos* sp.	*B. bubalis*	*Bubalus cebuensis*	*B. palaeokerabau*	*Bubalus* sp.	*B javanicus/Bubalus bubalis*	*Duboisia santeng*	*Epileptobos groeneveldtii*	Bovinae gen. et sp. indet.	*Capra hirus*	*Capricornis sumatraensis*	*C. s. gutlinensis*	*C. s. kanjereus*	*Capricornis* sp.	*Pseudoryx* sp.	*N. goral*	*Naemorhedus caudatus*	*Naemorhedus* sp.	*Megalovis guangxiensis*	Caprinae gen. et sp. indet.
Indochinese subregion																										
South China																										
Yenchingkou			X				X										X					X				
Wuyun													X		X											
Daxin		X																						X	X	
Wuming													X		X											
Liucheng		X																						X	X	
Chihchin										X								X								
Guanyindong	X									X								X								
Chuanshan																X										
Thailand[1]																										
Khok Sung							X	X																		
Tham Lod rockshelter							X	X							X								X			
The cave of monk			X		X	X	X	X					X						X							
Tham Wiman Nakin			X		X	X		X									X									
Tham Prakai Phet					X	X				X					X								X			
Laos																										
Tam Hang					X			X							X					X						
Vietnam																										
Lang Trang								X							X											
Duoi U'Oi								X							X											
Sundaic Subregion																										
Thailand[2]																										
Tham Phedan							X																			
Malaysia																										
Badak Cave C													X		X											
Batu Cave													X		X											
Niah Cave in Borneo											X			X												
Indonesia																										
Sumatra Island						X		X																		
Java Island	X								X			X	X		X											
Philiphins																										
Cebu Island								X																		

Remark: Khok Sung (Chaimanee *et al.* 2005; Suraprasit *et al.*, 2015), Tham Prakai Phet (Filoux *et al.*, 2015), Pha Bong (Bocherens *et al.*, 2015), Tham Wiman Nakin (Tougard, 1998, 2001), the Cave of Monk (Zeitoun *et al.*, 2005, 2010) Tham Lod rockshelter (Wattanapituksakul, 2006, Ampunsri 2007), Tham Phedan (Yamee and Chaimanee, 2005), Tam Hang (Bacon *et al.*, 2011), Lang Trang (de Vos and Long, 1993), Duoi U'Oi (Bacon *et al.*, 2008), Yenchingkou (Colbert and Hooijer, 1953), Wuyun, Daxin, Wuming, and Liucheng (Rink *et al.*, 2008), Chihchin (Kahlke, 1961), Guanyindong (Han and Xu, 1985) Chuanshan (Wanpo *et al.*, 1983), Juyuan Cave (Wang *et al.*, 2015), Lower Pubu cave, Wuyun Cave, and Mohui (Wang *et al.*, 2007), Hejiang Cave (Zhang *et al.*, 2014), Sanhe Cave (Jin *et al.*, 2009), Badak Cave C and Batu Cave (Ibrahim, 2013; Ibrahim *et al.*, 3013), Caves in Sumatra Island and Java (Hooijer, 1958), Cebu Island (Croft *et al.*, 2006), Niah Cave, Borneo (Medway, 1979).

CHAPTER 3

METHODOLOGY

3.1 Sites bovid in Thailand and site presentation

The subfossils faunal remains from archaeological and palaeontological sites composed the collection analyzed in this work. Most of the dental remains have never been studied. Sites are located in different environmental context and in different geographical areas: in the Northern Thailand such as Tham Lod, Mae Hong Son Province (Shoocongdej *et al.*, 2007, Marwick and Gagan, 2011); in the Northeastern Thailand such as Tham Prakai Phet (Filoux *et al.*, 2015); and in the central of Thailand such as Tham Rak Sai in Petchaburi Province (Srisuk, 2007) (Figure 3.1).

Tham Lod Rockshelter and Tham Phrakai Phet are the main sites of the research, they have the bigger collection (more than 924 specimens for the former and 721 for the latter) and the chronology of the sites is from Late Pleistocene (from MIS 4 to MIS 2)

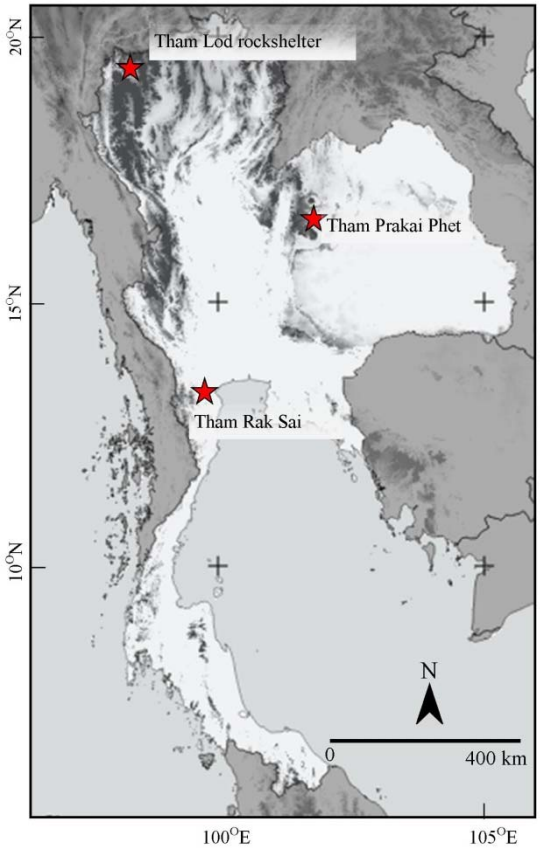

Figure 3.1 Map of Thailand showing the location of the Pleistocene archaeological and palaeontological sites with Bovidae remains analysed in this study

3.1.1 Tham Lod Rockshelter

Tham Lod rock shelter is an archaeological site located in Pang Mapha District, Mae Hong Son Province, Northwest Thailand (Figure 3.2). The rockshelter is located at the base of a cliff of the Permian limestone approximately 640 m above mean sea level and 250 m away from the Lang River (Figure 3.3). Three areas were excavated (Figure 3.4) by the Highland Archaeology Project between 2002-2006. The area 1 is the closer excavated area from the wall and correspond to a trench of 6 m^2, the area 2 (12 m^2), and the area 3 (18 m^2) are respectively 10 m and 15 m away from the North.

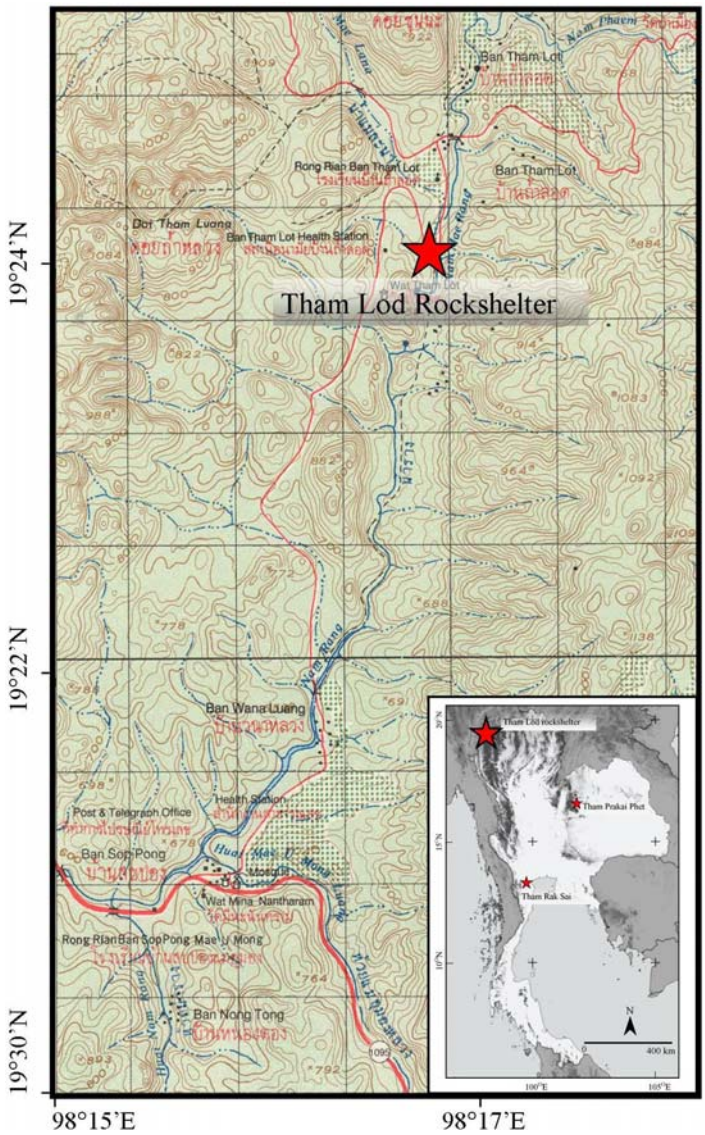

Figure 3.2 Location of Tham Lod rockshelter in Topography Map scale 1:50,000, sheet 5341I (Royal Thai Survey Department, 1991)

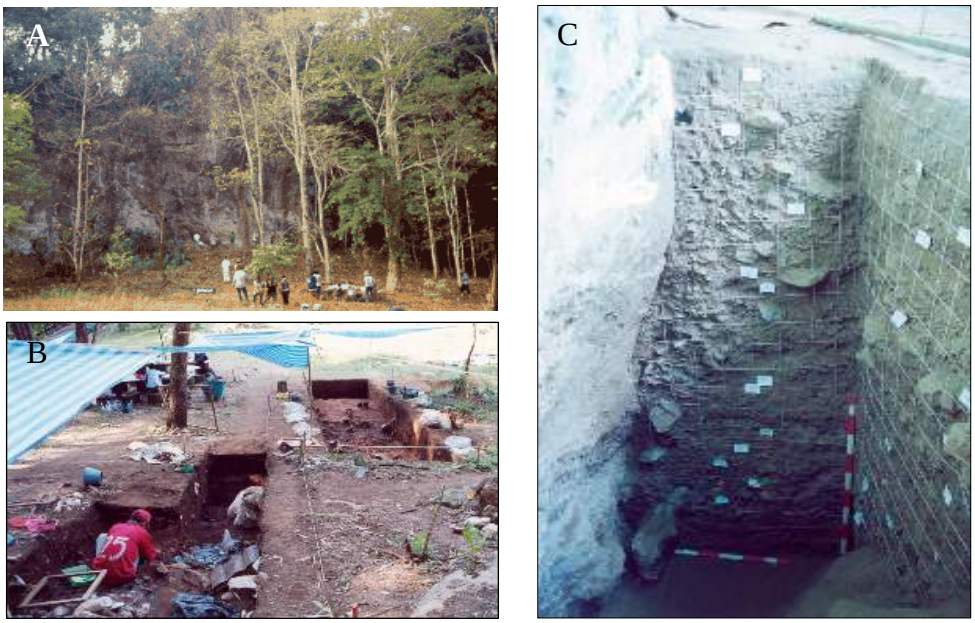

Figure 3.3 Tham Lod Rockshelter excavation; A) View of the rockshelter before the excavation, B) Excavation of the site (Area 2 and Area 3) during the 2002 campaign, and C) View of the West profile of area 1 at the end of excavation campaign (Khaokhiew, 2004)

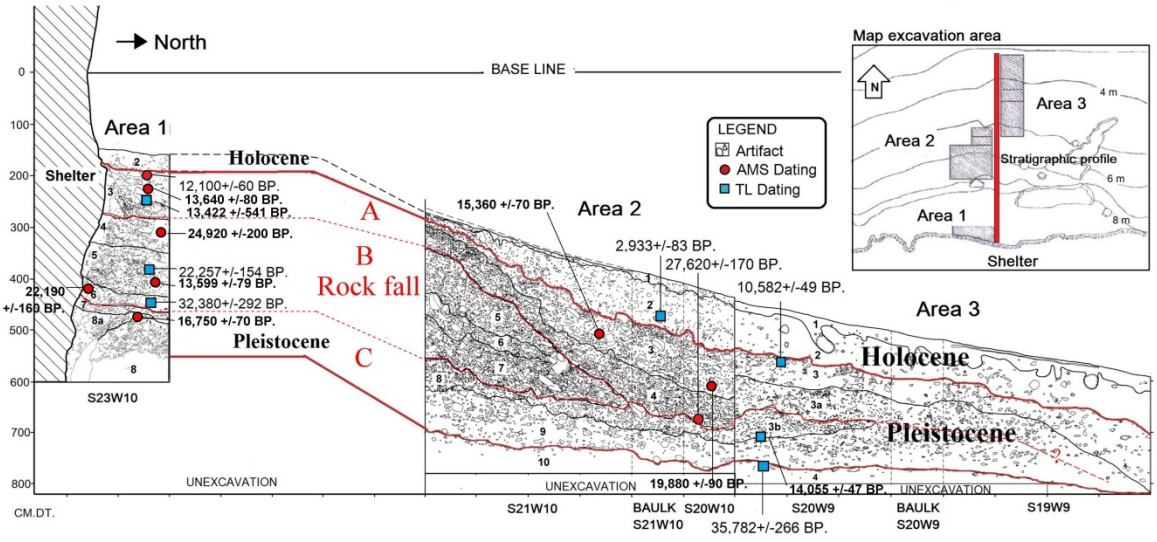

Figure 3.4 Stratigraphic profiles of the three excavated areas at Tham Lod Rockshelter with the associated dating (after Shoocongdej *et al.*, 2007)

A large quantity of faunal remains (mammal, reptile, fish, bird, and shell) associated with stone tools were found in the three excavated areas. The area 1 yielded the larger quantity of material. The stratigraphical sequence is more than 4 m thick and has been divided into ten layers (10 to 1 from the bottom to the top), ranging from Late Pleistocene to Holocene (Khaokhiew, 2004; Shoocongdej, 2006; Shoocongdej *et al.*, 2003, 2007).

The fauna analysis from Tham Lod Rockshelter has been performed only on dental material. The mammal assemblage is composed by a wide diversity of species which are typical of the Late Pleistocene mammal community in Southeast Asia. The first study conducted on the dental remains from the Area 1 (Wattanapituksakul, 2006) allowed to identified *Macaca* sp., Colobinae, Cercopithecidae, *Rhizomys* sp., *Cannomys badius*, Rhizomyidae, *Bandicota* sp., *Bandicota indica*, Hystricidae, *Ursus thibetanus*, *Ursus* spp., *Actonyx collaris*, Felidae, Carnivora, *Elephas* sp., Rhinocerotidae, *Sus scrofa*, *Muntiacus* sp., *Cervus unicolor*, Cervidae, *Bubalus* sp., *Bos* sp., Bovinae, *Naemorhedus* sp.. The reanalysis of the fauna materials in 2012-2013 allowed to better identifying some taxa. The new fauna list included among the other: *Rhinoceros sondaicus*, *Panthera tigris*, *Axis* sp., *Capricornis sumatraensis*, *Naemorhedus griseus* and *N. goral*.

Based on the study conduct on the Area 2, different artifact categories have been identified flakes, small tools, large tools, hammer stones, large fragment, small fragments and manuport (Chitkament *et al.*, 2012). A total of 10,470 artifacts have been coordinated in grey sandstone, the large and small tools are mainly shaped on cobbles fragments with unifacial shaping.

A signature of the Hoabinian technical tradition, the sumatraliths are present in the layers 6 to 4, aged between 27 and 20 ka BP. They are less represented in the lower layers 10 to 8, where the cobble tools are almost exclusively choppers (Chitkament *et al.*, 2015).

The site is recognised as a temporary shelter for hunter gatherer *Homo sapiens* where food processing and tool knapping activities took place. In the upper level of the stratigraphic sequence two burials with almost complete skeleton and two more fragmentary skeletons were discovered.

Numerous dating analysis conducted on different layers of the stratigraphic sequence have been performed. Thermoluminenscence dating gives a wide age range from Late Pleistocene to Holocene (35,782 ± 266 BP and 2,933± 83 BP) (Khaokhiew, 2004). The AMS radiocarbon dating of the two burials gives respectively an age of 12,100±60 BP and 13,640±80 BP (Khaokhiew, 2004; Shoocongdej, 2003, 2006; Shoocongdej *et al.*, 2007).

3.1.2 Tham Prakai Phet

Tham Prakai Phet is located at Wat Tham Prakai Phet, Tung Lui Lai Sub-district, Khon San District, Chaiyaphum Province (16°82'90" N and 101°84'7" E) (Figure 3.5).

The cave is formed in Permian dolomitic limestone (Nam Duk Formation) (Ueno and Charoentitirat, 2011). The cave opening lies at an altitude of 580 m above recent sea level and 20 m above the ground (Figure 3.6-3.8). The cave formed a complex network with a north-south direction (Figure 3.9-10). The surface of the anterior part of the cave was dig and grading by monks in order to construct a flat floor for Buddhist activity in 1980. Nowadays, the ground and some walls of the proximal part of the cave have been covered with concrete and many Buddha statues.

The cave was first visit for scientific purpose in 1980 by the "Mission Paléontologique Française en Thaïlande" (Tougard, 1998; Filoux *et al.*, 2015) and 14 mammalian teeth were given to the researchers by a monk. These specimens were collected after digging activities by monks. The first study of the faunal remains identified: *Crocuta crocuta ultima*, *Rhinoceros sondaicus*, *Bos sauveli*, *Sus* cf. *barbatus*, *Axis porcinus*, Cervidae indet., *Muntiacus muntjak*, and *Naemorhedus sumatraensis* (Tougard, 1998). The first analysis concluded that the faunal association could be correlated with the Tham Wiman Nakin mammalian association and can be aged to late Middle Pleistocene, around 169±11 ka, based on Uranium/Thorium (Esposito *et al.*, 1998, 2002).

This site was never systemically excavated. During 2011-2015, a new campaign of researches in Chaiyaphum Province was initiated by a team from the Palaeontological Research and Education Centre (PRC) of Mahasarakham University.

The first surveys of the cave network allowed to collect 146 dental mammalian specimens, which have been pick up on the ground. The identified taxa are the following: *Pongo* sp., *Macaca* sp., *Ailuropoda melanoleuca*, *Panthera* cf. *pardus*, *Ursus thibetanus*, *Bos javanicus*, *Bos* sp., *Bubalus* sp., *Naemorhedus* sp., *Sus scrofa*, *Rusa unicolor*, and *Hystrix* cf. *indica* (Filoux *et al.*, 2014, 2015).

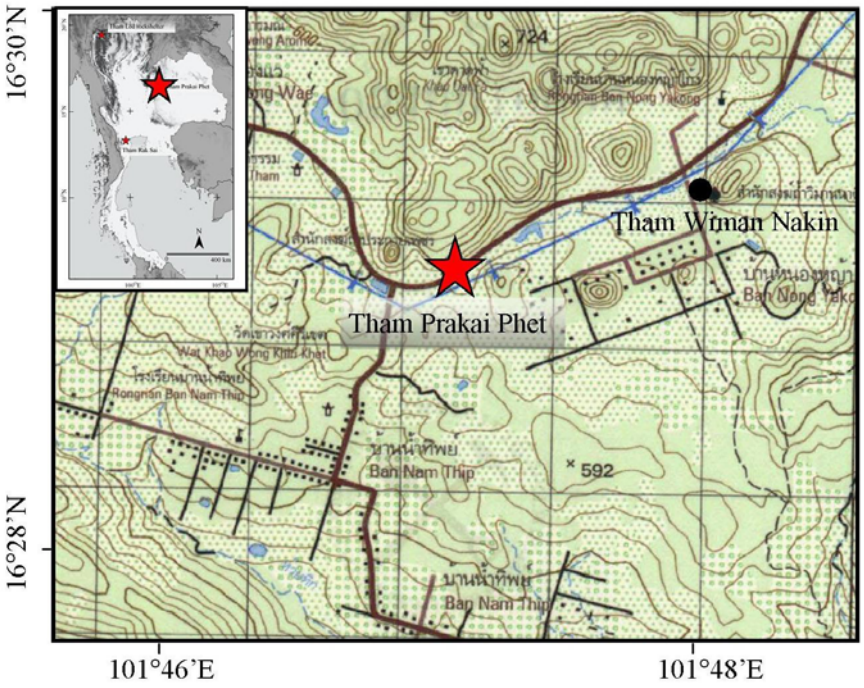

Figure 3.5 Location of the Tham Prakai Phet and Tham Wiman Nakin Caves in Topography Map scale 1:50,000, sheet 5341I (Royal Thai Survey Department, 1997)

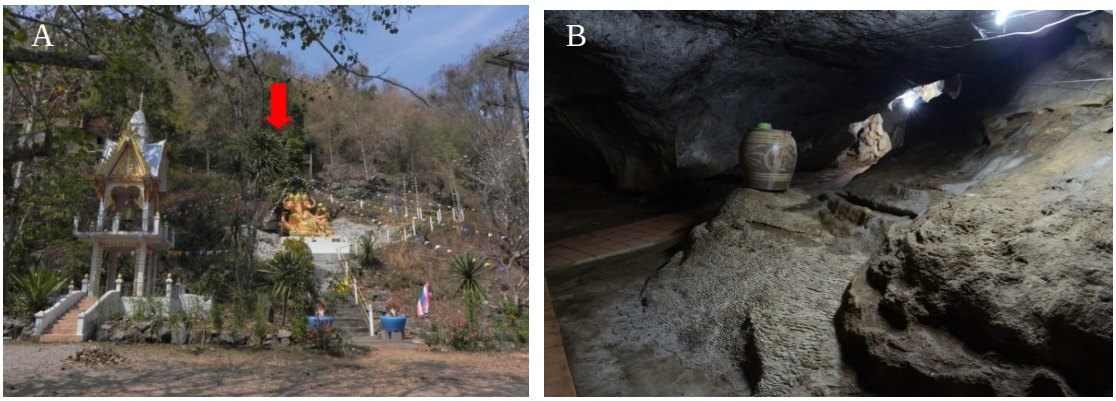

Figure 3.6 Wat Tham Pra Kai Phet A), Entrance of the Tham Prakai Phet at the top of the staircase (the arrow indicated the entrance) B) View of the tilled floor and a flow stone deposit in the proximal part of the network

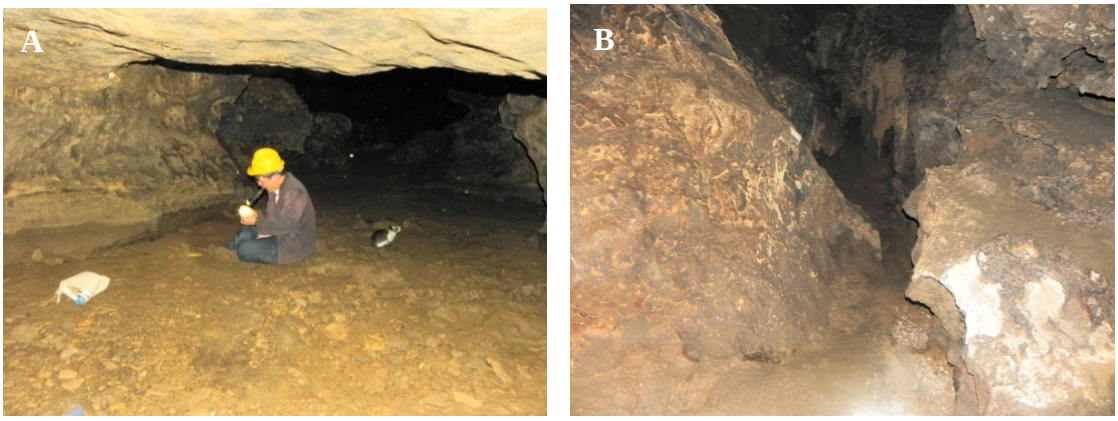

Figure 3.7 Different aspect of the network of Tham Prakai Phet; A) Collecting sample in the main network; B) Smaller secondary network

Figure 3.8 View of the excavated area in a small chamber of Tham Prakai Phet with the boundary line of the four excavated zone

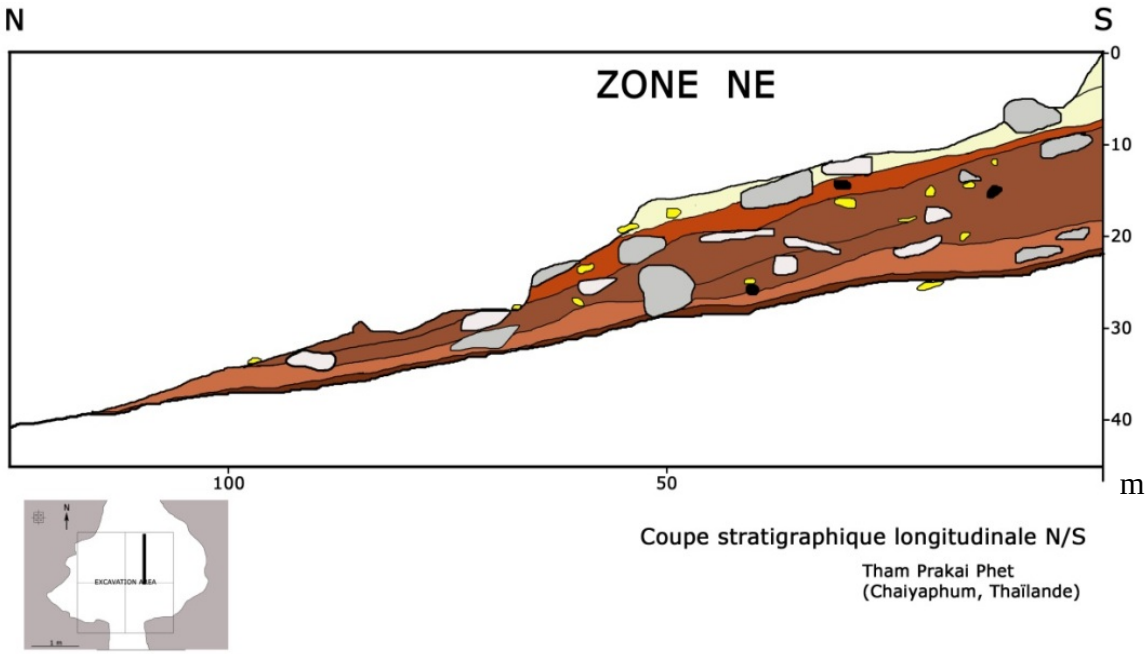

Figure 3.9 Stratigraphy section of the zone NE of the Tham Prakai Phet excavated area (Filoux, 2015, com. Pers.)

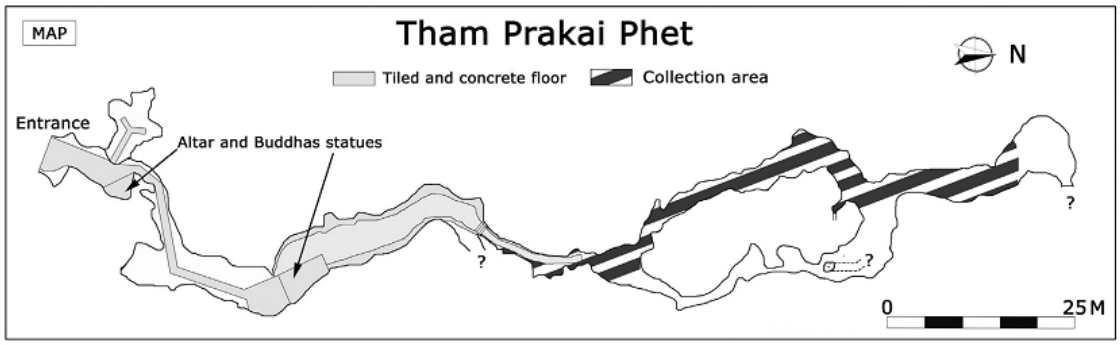

Figure 3.10 Map of Tham Prakai Phet (Map reported by PRC Team; drawing; Filoux *et al.*, 2015)

1) Chronological dating

The age of the accumulation is established by U/Th analysis and E.S.R (Electron Spin Resonance). Three bovidae teeth have been analysed **(**TPKPSW214 and TPKPNE31: *Bos javanicus*, TPKPNE102: *B. gaurus*)**.** The U-series on the three teeth yielded the following ages:

3561 (TPKPSW214): Dentine around 65 ka, enamel around 45 ka,

3562 (TPKPNE31): Dentine: 40 ka, enamel 18 ka,

3563 (TPKPNE102): Dentine: 60 ka, enamel 40 to 50 ka.

2) Biochronological dating

Based on the preliminary results the accumulation could have been formed at least between 40 Ka and 65 Ka., (Figure 3.11 and 3.12). The first age proposed for the site was contemporaneous with Tham Wiman Nakin, closed to 169±11 ka (Tougard, 1998) due to the identification of Hyena (*Crocuta crocuta ultima*). After the first excavation, newly fauna such as *Ailuropoda melanoleuca, Pongo* sp., and *Crocuta crocuta ultima* associated to other species related to the *Ailuropoda-Stegodon* faunal complex have been identified. This could validate the first assumption of late Middle Pleistocene. However, the chronological range of the *Ailuropoda-Stegodon* has been considered younger than previously though based on discovery of this association on some Late Pleistocene sites the Cave of Monk (Zeitoun *et al.*, 2010), the Tam Hang (Bacon *et al.*, 2011) and other sites in South China (Filoux *et al.* 2015). According to the last chronological study, The Tham Prakai Phet faunal association is considered aged between late Middle Pleistocene and Late Pleistocene.

Figure 3.11 Measurements of the gama dose of the sediments in different part of the excavation area for ESR analysis

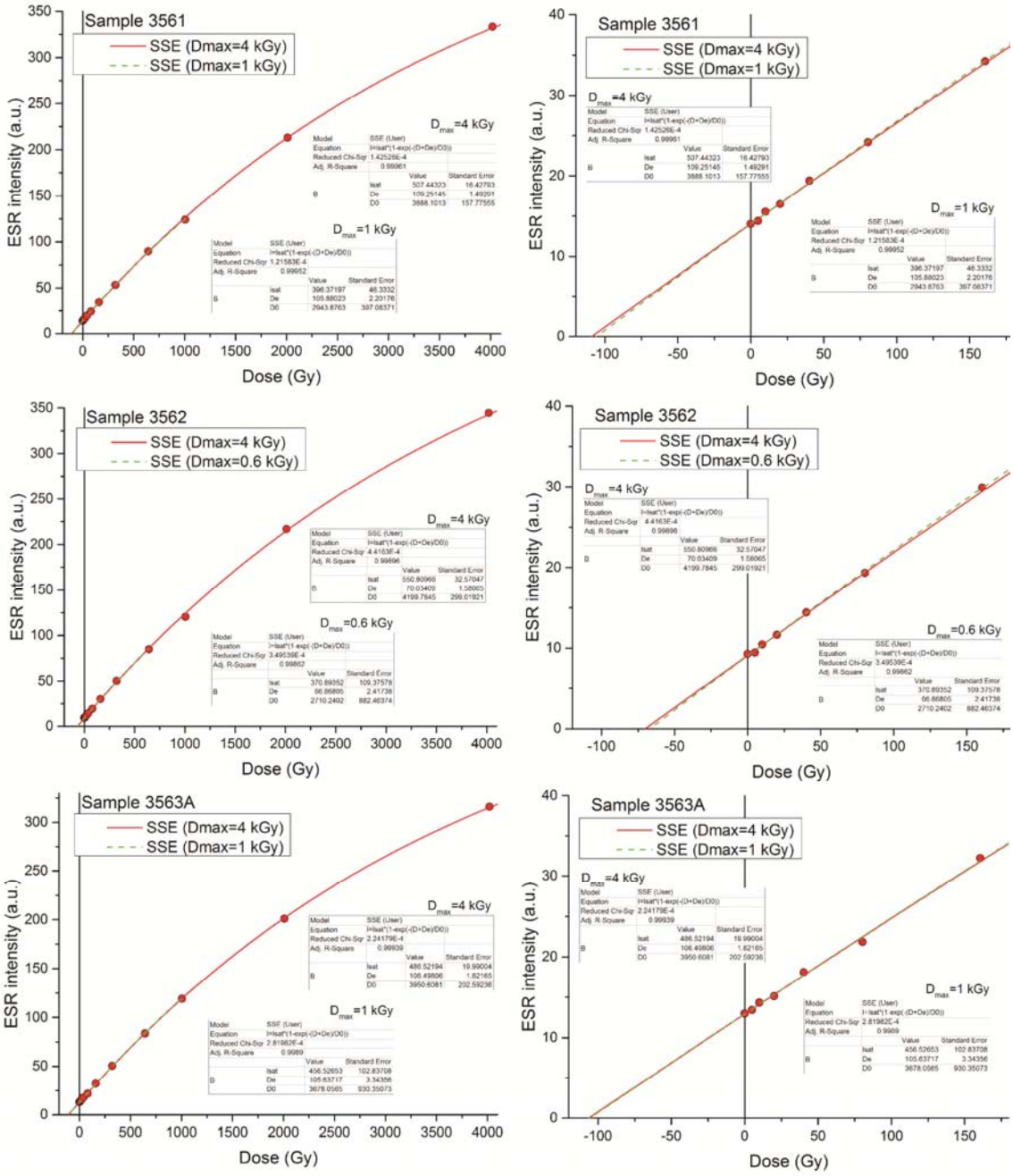

Figure 3.12 Signal intensity as a function of the different dose for three Bovidae specimens from Tham Prakai Phet excavation (Duval, 2015, com. Pers.)

3.1.3 Tham Rak Sai

The site is located at Khao E-Go, a limestone mountain in Nong Chumphon Sub-district, Khao Yoi District, Phetchaburi Province (Figure 3.13 and 3.14). The elevation of the top of the mountain is at 360 m above sea level. The mountain lays from Northwest to Southeast with 2 km length. The cave is formed into dolomitic limestone interbeded with shale and sandstone with fusulinids and brachiopods and aged to Permian (Ueno and Charoentitirat, 2011). The cave is located approximately at 100 m t above sea level. A thick deposit with a large amount of fauna remains were dug and removed by monk. They were collected and preliminary study by Paladej Srisuk around 1999 (Srisuk, 2007). Nowadays, the cave is empty and the ground is covered by cement and Buddha statues (Figure 3.15).

Tham Rak Sai fauna collection have been studied between 2007-2012, and allowed to identified *Heosemys grandis*, *Indotestudo elongata* Cervidae indet, *Muntiacus* sp., *Cervus porcinus, Capricornis sumatraensis*, *Presbytis* sp., *Macaca* sp., *Canis* sp., *Bandicota savilei, Bandicota indica, Rattus jaegeri, Mus shortridgei, M. caroli, M. cervicolor, Maxomys surifer, Cannomys badius,* Hystricidae indet., Tupaiidae indet., Soricidae indet., Chiroptera indet. (Srisuk, 2007, Wattanapituksakul *et al.*, 2011, Kamolrat *et al.*, 2011). These faunas are associated with 42 lithic industries. The raw material used is composed of chert (93%) and quartzite pebble (7%). Most of the artifacts correspond to flakes no pebble tool and sumatraliths are identified. Based on lithic tools, age of Tham Rak Sai is considered to Late Pleistocene to Middle Holocene (Figure 3.16).

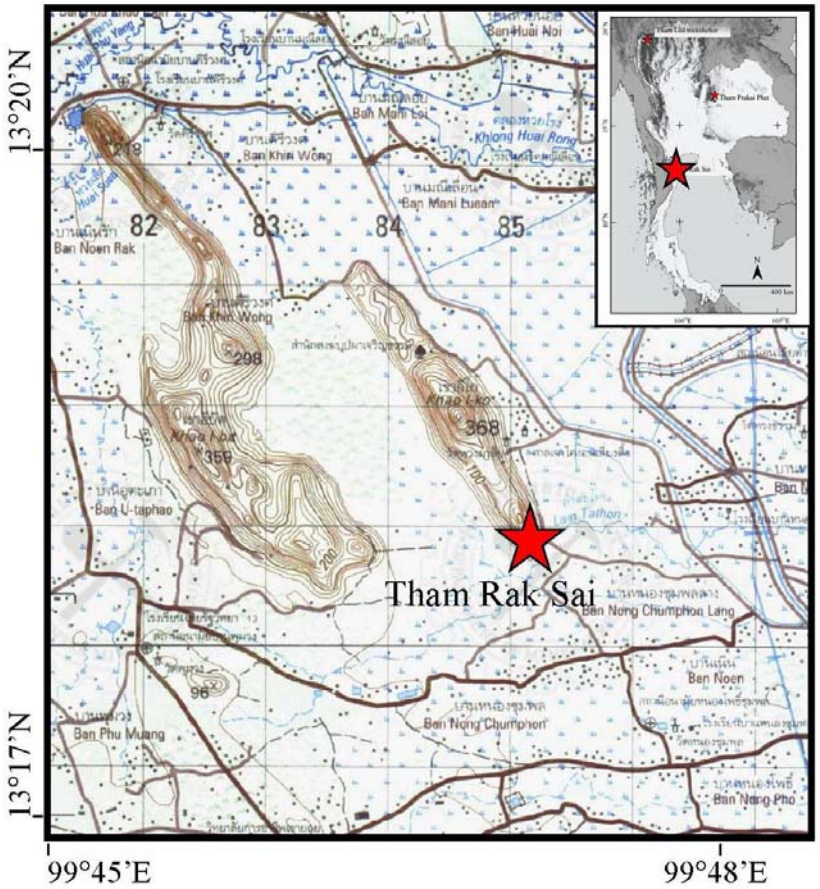

Figure 3.13 Location of Tham Rak Sai in Topography map scale 1:50,000, sheet 49351 (Royal Thai Survey Department, 2000)

Figure 3.14 View of the landscape of Khao E-go with the hill formed by the dolomitic limestone , Khao Yoi District, Phetchaburi Province

Figure 3.15 View on the Tham Rak Sai chamber with all the mofidication made for monk meditation

Figure 3.16 Lithic industry from Tham Rak Sai

2 Methodology

In this study, the methodology under the investigation can be categorized in two main aspects: the first aspect is to interpret variation and distribution of the bovid assemblage in Thailand; and the second one is to reconstruct the palaeoenvironment of these assemblages. For the variation and distribution, identification, size measurement associated with ratio comparison, and the age determination were done. For the reconstruction of palaeoenvironment, the interpretation of palaeodiet by dental mesowear and microwear methods were done. The summarized flowchart shows methodology used in this study shows in Figure 3.17.

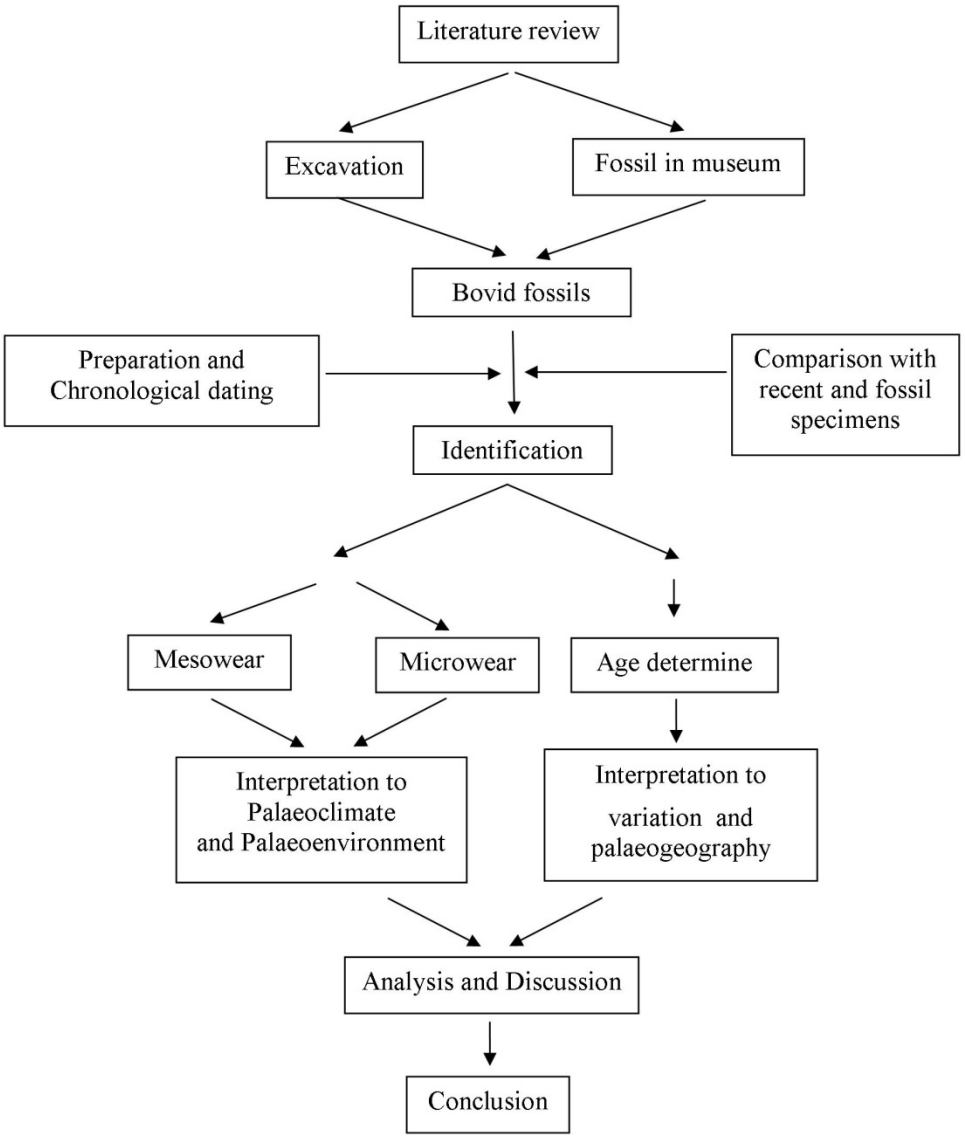

Figure 3.17 Flowchart showing the process of this study

3.2.1 Identification and anatomical description of bovid teeth

All specimens from each sites have been identified by comparison with extant and fossil specimens from different taxa of bovids and also using the description established in many scientific works (Coolidge, 1940; Hooijer, 1958; Guérin, 1966; Thein, 1974; de Vos and Long, 1993; Halstead and Collins, 2002; Zeder and Pilaar, 2010; Bacon *et al.*, 2008; Ingalls, 2010; Bacon *et al.*, 2011; Gillis *et al.*, 2011; Filoux *et al.*, 2015). The dental terminology used to described the teeth of the Caprinae and Bovidae, is based on ruminant works made by Heintz (1970), Crégut-Bonnoure (1992), Crégut-Bonnoure and Dimitrijević (2006), and Bärmann and Rössner (2011) (Figure 3.18-3.22). The specimens measurements will be taken using a vernier caliper (in mm) follow the work of Crégut-Bonnoure (1995) for Caprinae (Figure 3.23) and for Bovinae modified from the work of Thein 1974 and Crégut-bonnoure and Dimitrijević (2006) (Figure 3.24). The log ratio diagrams have been used for the dental size comparisons following the methodology of Simpson (1941).

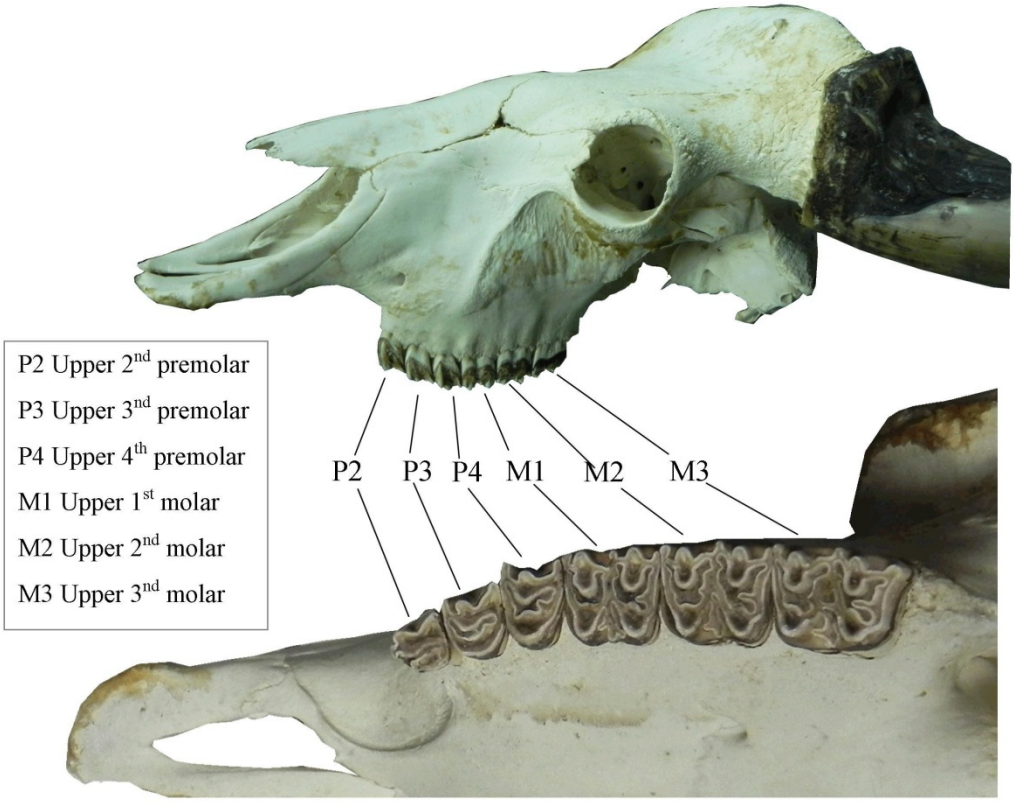

Figure 3.18 Dental position on cranium of skull bovids: Extant *Bos gaurus* from the Natural History Museum, National Science Museum Thailand

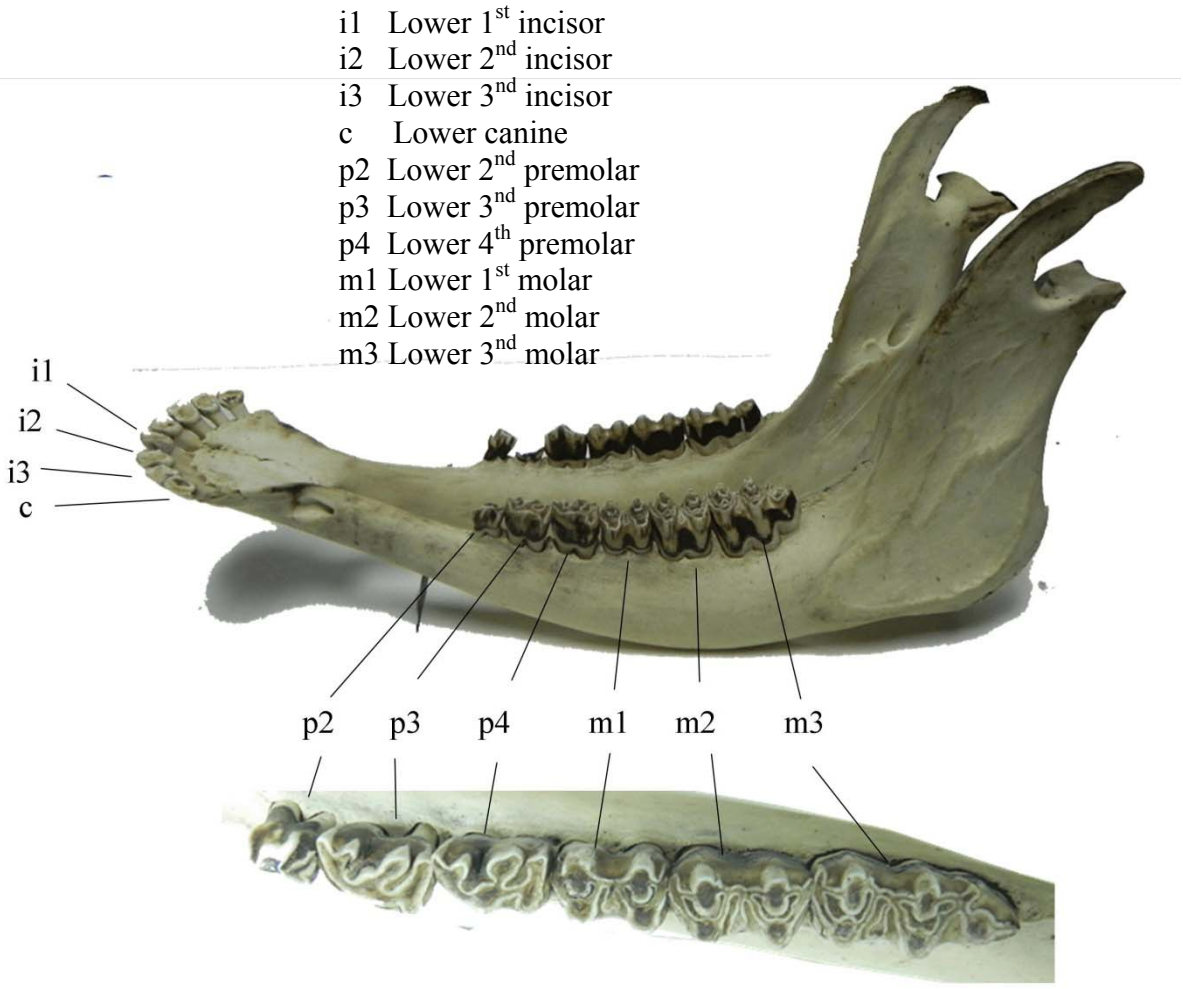

Figure 3.19 Dental position on mandible of bovids: extant *Bos gaurus* from the Natural History Museum, National Science Museum Thailand

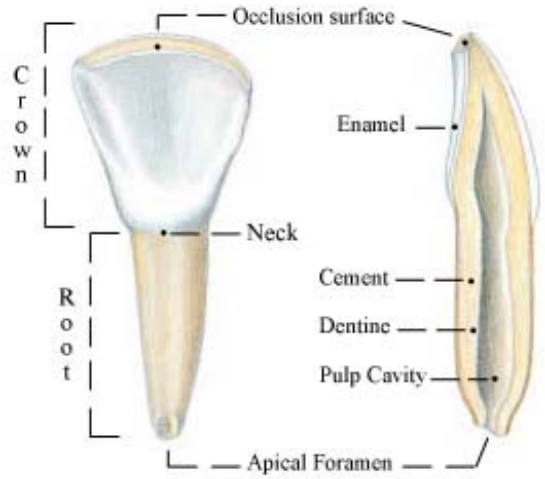

Figure 3.20 Lower incisive structure of bovids (Budras *et al.*, 2003)

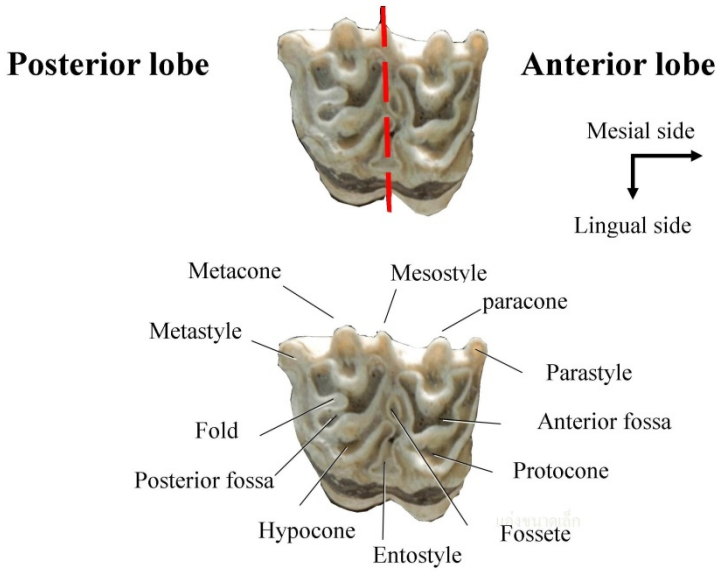

Figure 3.21 Dental structure of M3 of bovid (each character follows: Heintz, 1970; Crégut-Bonnoure, 1992; Crégut-Bonnoure and Dimitrijević, 2006; Bärmann and Rössner, 2011). Extant *Bos gaurus* from Sirindhorn Museum, Kalasin Province

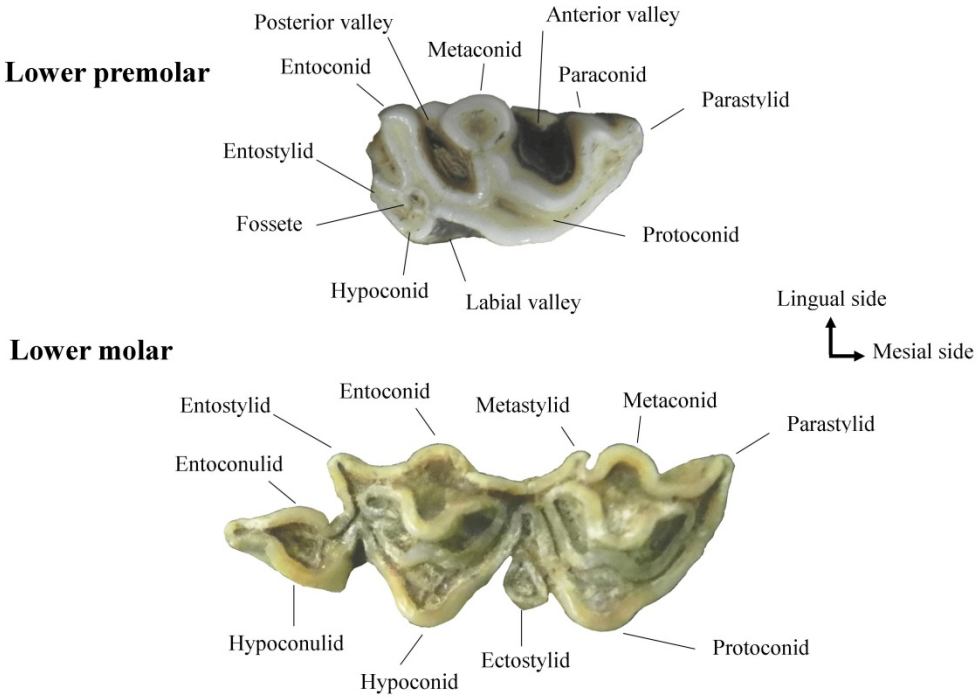

Figure 3.22 Dental structure of p4 and m3 of bovid (each character follows: Heintz, 1970; Crégut-Bonnoure, 1992; Crégut-Bonnoure and Dimitrijević, 2006; Bärmann and Rössner, 2011). Extant *Bos indicus* from Palaeontological Reasearch and Education Centre and Pleistocene *Bos javanicus* (TPKPNW5)

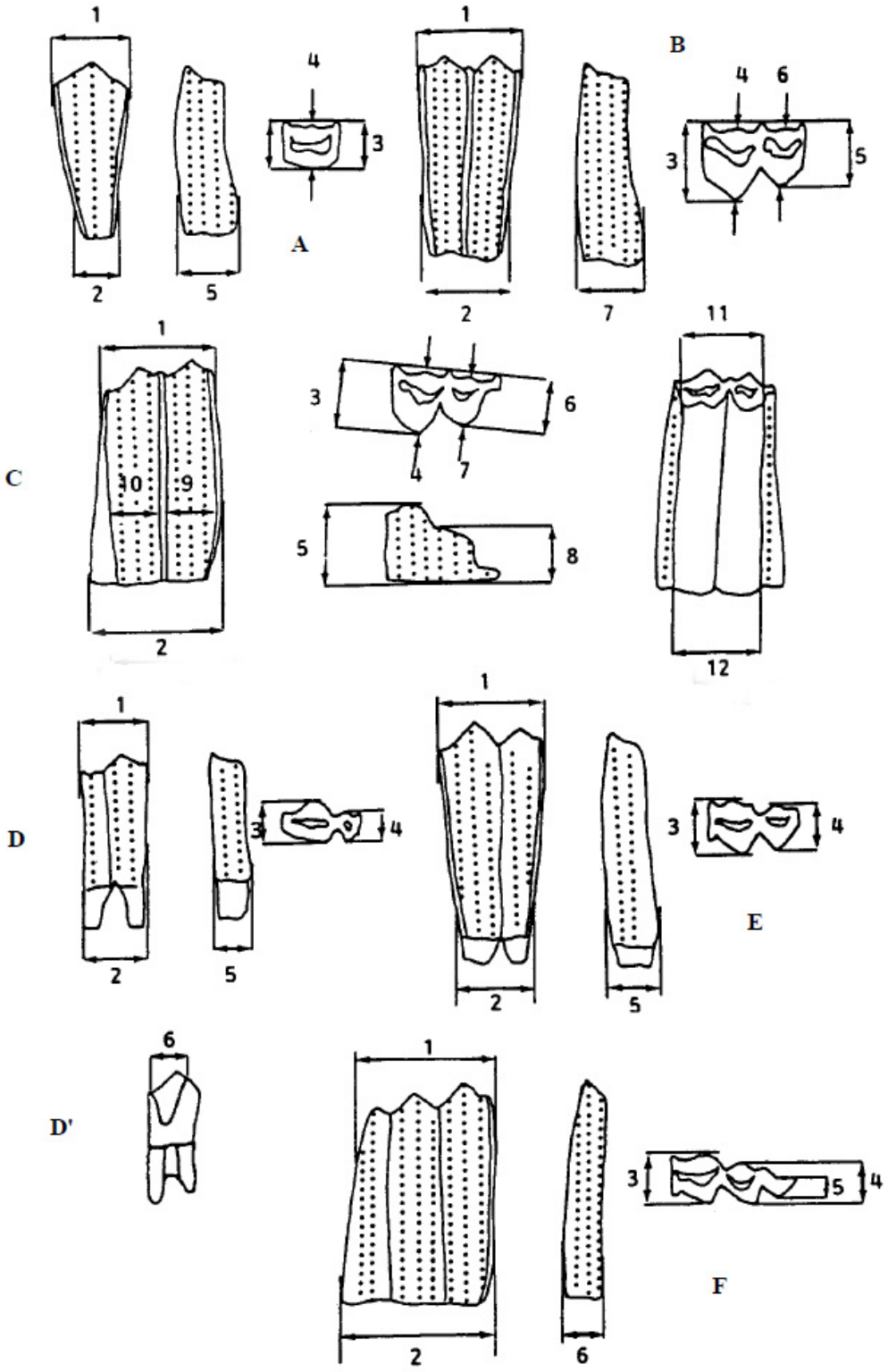

Figure 3.23 Measurement of upper and on each lower teeth for Caprinae (Crégut-Bonnoure, 1987): A) upper P2-P4; B) upper M1-M2; C) upper M3; D& D') lower p2-p4; E) lower m1-m2, and F) lower m3

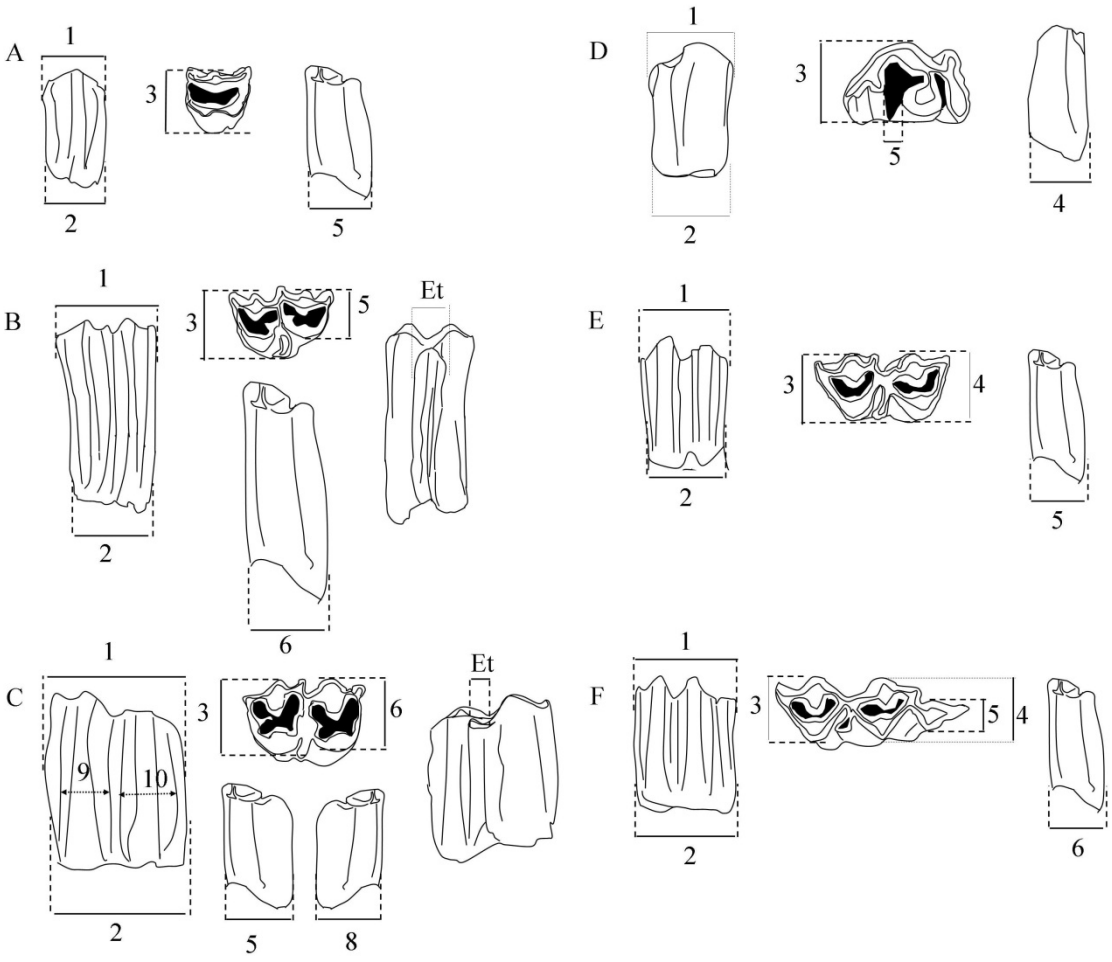

Figure 3.24 Measurement of upper and on each lower teeth for Bovinae (modified from Thein 1974; Crégut-bonnoure and Dimitrijević, 2006): A) upper P2-P4; B) upper M1-M2; C) upper M3; D) lower p2-p4; E) lower m1-m2, and F) lower m3

3.2.2 Counting specimens

This research use Number of identified specimens and Minimum number of individuals for calculating of relative frequencies taxa.

1) *Number of identified specimens (NISP)* defines to all specimens in each taxa which is a normal calculating method of relative frequencies taxa (Reitz and Wing, 2008).

2) *Minimum number of individuals (MNI)* defines the smallest identifiable number of individual that need to account for all element of specimens of a taxa in the

site (Shotwell, 1955; 1958) which is widely used category of the secondary relative frequencies data (Reitz and Wing, 2008). This analysis divide to MNIf and MNIc.

- *MNIf* defines to minimum number of individuals by frequency which calculates all minimum number of identifiable specimens of taxon.
- *MNIc* defines to minimum number of individuals by combination which correlates to layer or stratigraphic unit of the site as well as age of individual.

3.2.3 Age estimation

In order to estimate the individual age at death of the bovids, this study used the methodology follow by Rivals (2001; 2002) based on the observation of the dental eruption, the sequence of replacement and the wear of isolated teeth (Grant, 1982; Klein and Cruz-Uribe, 1984) (Figure 3.25), Seven wear stage have been created for each tooth. They are based on the height of the crown associated with some qualitative aspect (shape of occlusal face, state of the root) see below (Rivals, 2001):

Tooth wear Stage 1: Germinal tooth in formation.

Tooth wear Stage 2: Developed crown but unworn and root non-developed.

Tooth wear Stage 3: Beginning of wearing, root non-developed.

Tooth wear Stage 4: Occlusal side totally worn, root developed.

Tooth wear Stage 5: Crown height reduced by half, root closed.

Tooth wear Stage 6: Roots thickening, formation of secondary cement.

Tooth wear Stage 7: Tooth totally worn and rooted very thick.

The dental wear pattern of Bovinae also does similar method follows the Bovinae study from Caune de l'Arago (Tautavel, France) (Filoux, 2016 pers. comn).

The dental eruption sequence and wear of isolated teeth of both Bovinae and Caprinae are correlated to mean age following *Bison* study by Discamps and Costamagno (2015) and *Capricornis crispus* study by Miura and Yasui (1985) and Kita *et al.* (1987), respectively (Table 3.1-3.4).

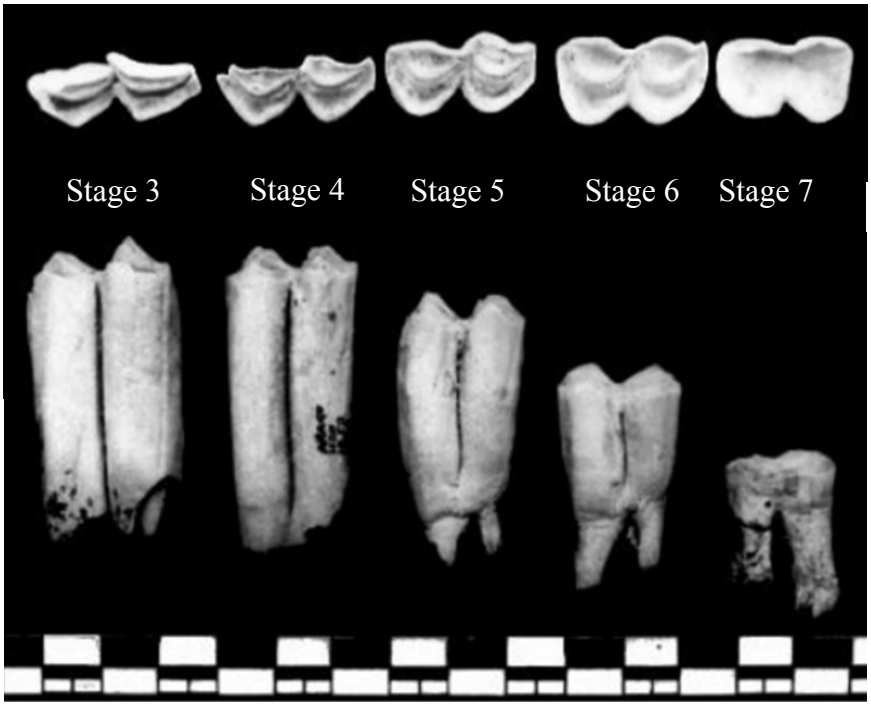

Figure 3.25 The dental eruption sequence and wear of isolated teeth from Stage 3 to 7 Tooth in Stage 1 and 2 does not erupt from jaw which (Rivals, 2002)

Table 3.1 The wearing class of the upper molar in Bovinae from Caune de l'Arago (Tautavel, France) (Filoux, 2016 pers. comn) and mean age of *Bison* (Discamps and Costamagno, 2015)

Age	Bovinae from Caune de l'Arago (Tautavel, France)										*Bison* mean Age, life span =20 years (Discamps and Costamagno, 2015)
	Class	DP2	DP3	DP4	P2	P3	P4	M1	M2	M3	
Juvenile	J1	2-3	2-4	2-4				2-3			<3 years
	J2	4-5	4-5	3-4				3	3		
	SA	6-7	6-7	5-6	2-3	2-3	2-3	4	3-4	3	
Prime adult	A1				3	3	3	4	4	3-4	3-12 years
	A2				4	4	4	5	4-5	4	
	A3				4	5	5	6	5-6	5-6	
Old adult	AA				5-6	6-7	6-7	7	6-7	6-7	>12 years

Table 3.2 The wearing class of the lower molar in Bovinae from Caune de l'Arago (Tautavel, France) (Filoux, 2016 pers. comn) and mean age of *Bison* (Discamps and Costamagno, 2015)

Age	Bovinae from Caune de l'Arago (Tautavel, France)										*Bison* mean Age, life span =20 years (Discamps and Costamagno, 2015)
	Class	dp2	dp3	dp4	p2	p3	p4	m1	m2	m3	
Juvenile	J1	2-3	2-3	2-3				2			<3 years
	J2	4-5	4-5	4-5				3-4	2-3		
	SA	6-7	6-7	6-7	2-3	2-3	2	4	3-4	2-3	
Prime adult	A1				3-4	3-4	3	4	4	3	3-12 years
	A2				4	4	4	4-5	4	4	
	A3				5	5	4-5	6	5	4	
Old adult	AA				6-7	6-7	6-7	7	6-7	5-6	>12 years

Table 3.3 The wearing class of the upper molar in *Capra* by Rivals (2002) and mean age of *Capricornis crispus* by Miura and Yasui (1985) and Kita *et al.* (1987)

Age	*Capra* (Rivals, 2002)							*C. crispus*, lifespan = 19..5 years (Miura and Yasui, 1985; Kita *et al.*, 1987)	
	Class	P2	P3	P4	M1	M2	M3	Class	Mean Age
Juvenile	I			2	4	3			
	J	2	3	3	4	3-4			
	SA	3	4	4	4	4	3	I	<2.5 years
Prime adult	A1	4	4	4	5	4	4	II	3.5 years
	A2	5	5	4-5	5	4-5	4	III-IV	3.5-8.5 years
	A3	6	5-6	5	6	5	4	V	8.5-14.5 years
Old adult	AA	7	6	6	7	6	5	VI-VII	>14.5 years

Table 3.4 The wearing class of the lower molar in *Capra* by Rivals (2002) and mean age of *Capricornis crispus* by Miura and Yasui (1985) and Kita *et al.* (1987)

Age	*Capra* (Rivals, 2002)										*C. crispus*, lifespan = 19..5 years (Miura and Yasui, 1985; Kita *et al.*, 1987)	
	Class	dp2	dp3	dp4	p2	p3	p4	m1	m2	m3	Class	Mean Age
Juvenile	I	3	4	4								
	J	4-5	5-6	5-6				3	2			
	SA	6	7	7			2	4	3	2	I	<2.5 years
Prime adult	A1				2	3	4	4	4	3	II	3.5 years
	A2				3	3-4	4	5	4	4	III-IV	3.5-8.5 years
	A3				4	4-5	5-6	6	5	5	V	8.5-14.5 years
Old adult	AA				5-6	6-7	6-7	7	6-7	6	VI-VII	>14.5 years

3.2.4 Mortality profile

In the common analysis of mortality profile, mortality profile present to three pattern from 3 majority age groups (Juvenile, Prime adult, and Old adult) consisted of L-shaped mortality pattern (displayed by a progressive decrease in the number of individuals in each age group), U-shape mortality pattern (Juvenile and Old age group being the dominance group and Prime adult being the rare group), and Prime-dominated mortality pattern (dominate by high prime adults group related to Juvenile and Old adult group) (Stiner, 1990), Figure 3.26.

In order to simple comparison of mortality pattern, frequencies of individuals in each age group has been converted to percentage and plotted in ternary diagram. Ternary displays the correlation between the area in diagram and the variation of mortality pattern. The area closed to corner of ternary corresponds 100% of each age group which provides to the dominated area of each group. Old individuals are usually rare in natural living population, so that, they are plotted in the upper half of diagram (above the level of 3 axes intersection). Left and right areas below half of diagram are considered to U-shaped and L-shaped pattern, respectively. This ternary (Stiner, 1990) is presented with 95% confidence interval around the observed age class percentages, Figure 3.27.

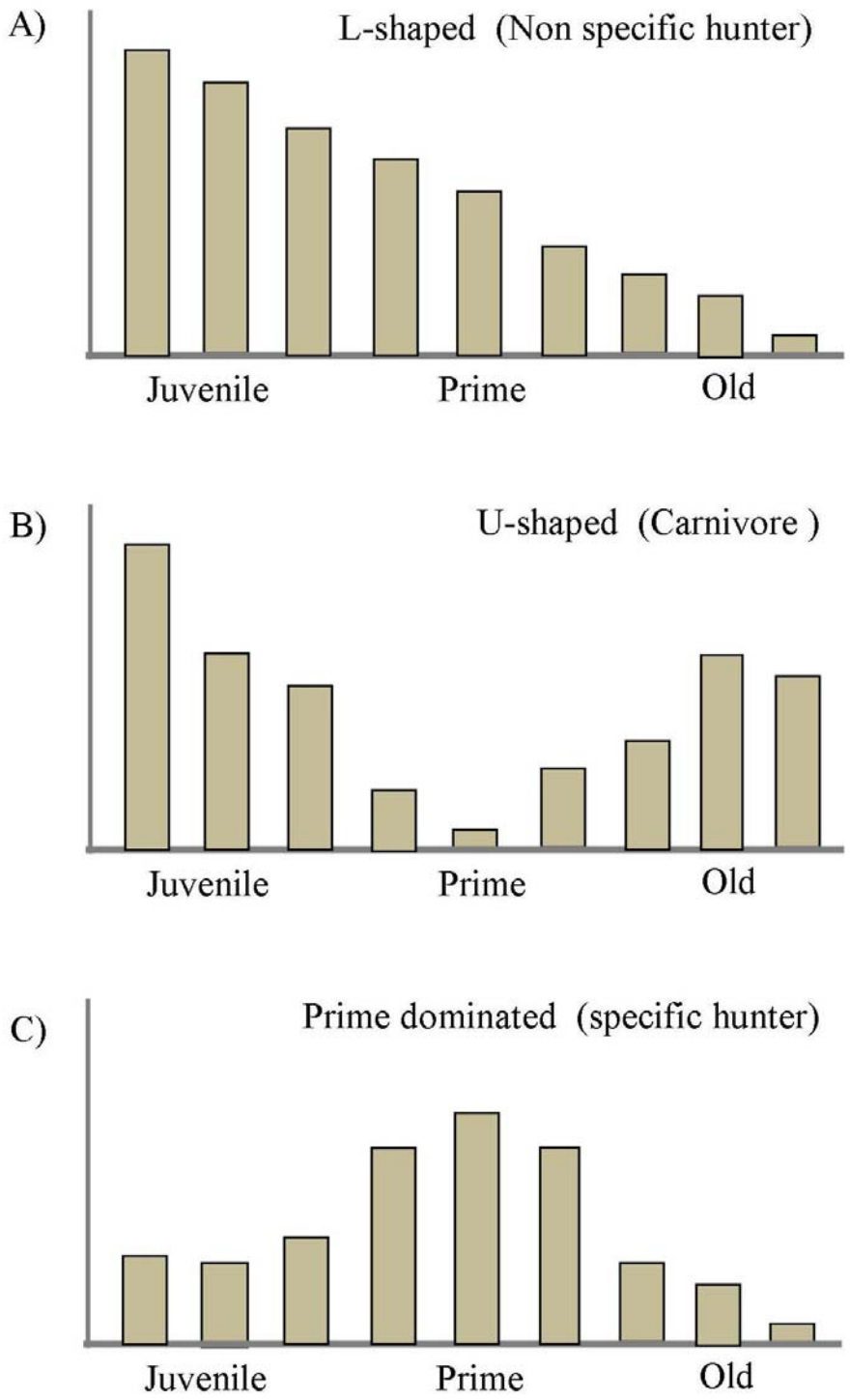

Figure 3.26 Mortality pattern in histogram: A) L-shaped, B) U-shaped, and C) Prime Dominated (after Stiner, 1990)

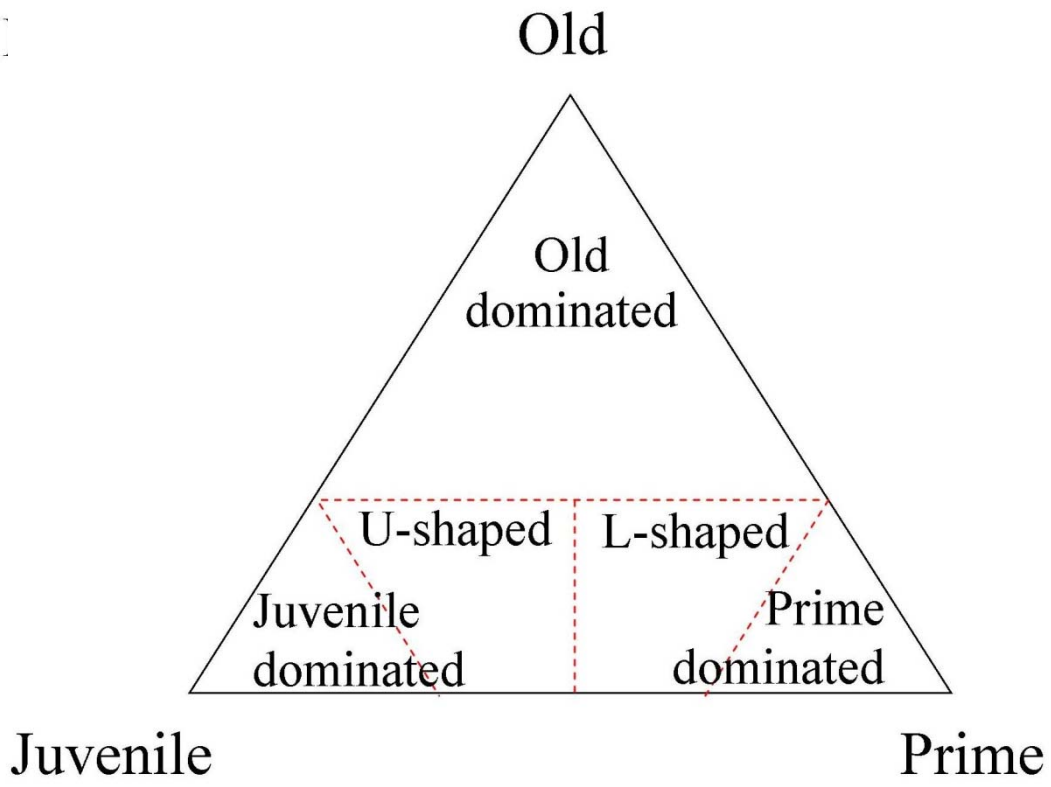

Figure 3.27 Ternary diagram of mortality profile A) 3 age axes definition B) correlation between area of diagram and type of mortality pattern (After Stiner, 1990)

Ternary diagram analysis of Stiner (1990) was improved by mathematical model as well as the ecological data reassessment, in order to, solving bias interpretations of mortality profile (Discamps and Costamagno, 2015). Improving ternary diagram analysis proposed to new zoning following to proportions corrected for age class duration such as pjc for juvenile; ppc for prim; and poc for old adult (Discamps and Costamagno, 2015):

- Juveniles-Prime-Old zone (JPO) including L-Shaped profiles but also a few U-shaped (Pjc>Ppc>Poc)
- Juveniles-Old-Prime zone (JOP) including U-shaped profiles (Pjc>Poc>Ppc)
- Prime zone (P) dominated by prime adult (Ppc>Poc>Pjc or Ppc>Pjc>Poc)
- Old zone (O) dominated by old adult (Poc>Ppc>Pjc or Poc>Pjc>Ppc)

The zoning boundary is depended on life span of each species or taxa. In this research, Bovinae and Caprinae ternary use life span of *Bison* (Discamps and Costamagno, 2015) and *Capricornis crispus* (Miura and Yasui, 1985; Kita *et al.*, 1987), respectively. Juvenile, Prime adult, and old adult of *Bison* are confined to <3 years, 3-12 years, and 12-20 years, representatively, combined by Discamps and Costamagno (2015). In life span of *Capricornis crispus*, it is mature at 2.5 years, up to 14.5 in old adult, and limited to about 19.5 years (Miura and Yasui, 1985; Kita *et al.*, 1987), , Figure 3.38.

Conditions of ternary diagram required a minimum at least 3 groups or class, at least12 individual confined by (Steele, 2005) are considered in limited analysis in taxon in each sites.

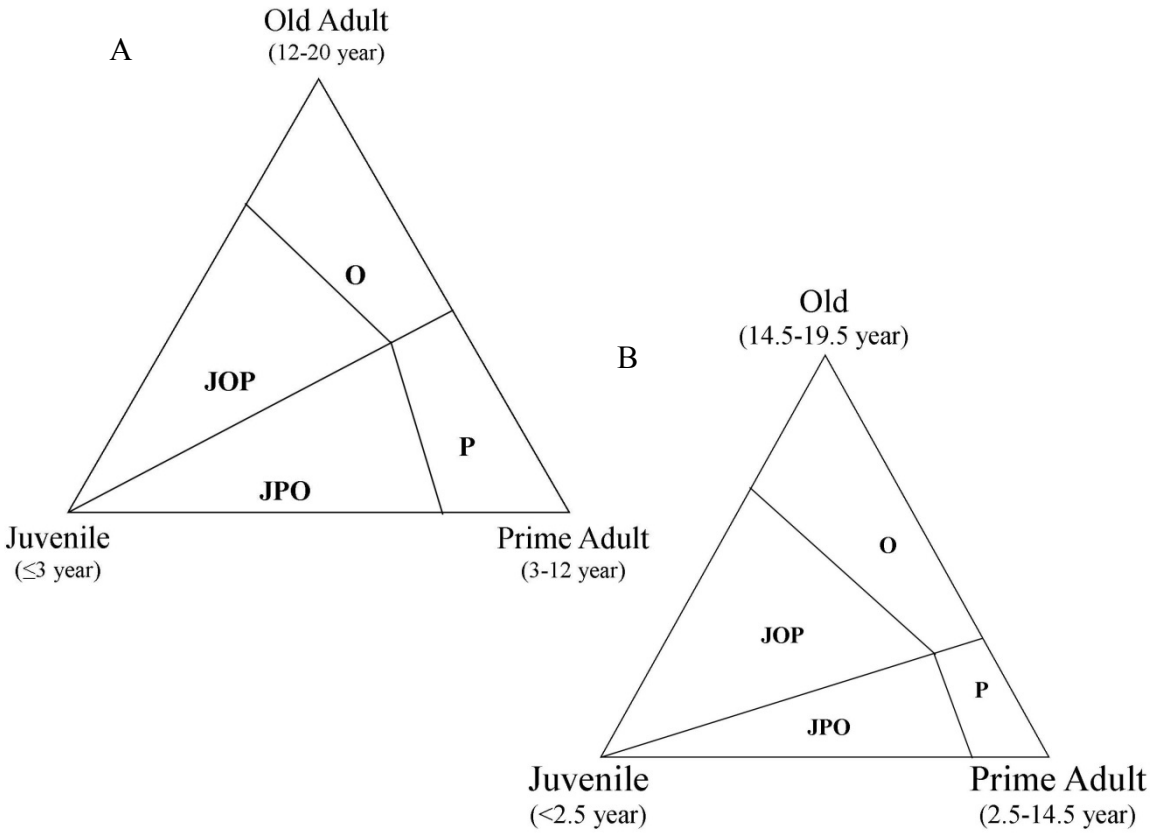

Figure 3.28 New zoning ternary diagram of mortality profile in this research: A) Bovinae ternary diagram following a life span of *Bison* (Discamps and Costamagno, 2015); and B) Caprnae ternary diagram following a life span of *Capricornis crispus* (Miura and Yasui, 1985; Kita *et al.*, 1987)

3.2.5 Palaeodiet study

The bovids palaeodiet study was conducted by dental mesowear and microwear analysis on teeth. At least three categories of ungulate feeder which are defined by Janis (1988): grazer (feeding at least 90% grass material), mixed feeder, and leaf browser (feeding at least 90% leaf material). This methodology might be used palaeoenvironment to interpreted palaeoclimate, and the resource availability in bovid habitat.

1) Dental mesowear

The dental mesowear analysis applied to the fossil Bovidae sample is the measurement of the relative proportions of tooth-to-tooth contact (attrition) and food-on-tooth contact (abrasion) on the occlusal surfaces of the dental enamel. The mesowear affects to the shapes of the worn cusp relief and the relief shape form by a long period of feeding on an individual fauna life more than the wearing stage (Fortelius and Solounias, 2000). The original method (Fortelius and Solounias, 2000) is based on two variables; the Occlusal Relief (OR) and the Cusp Shape (CS). The occlusal relief is classified as high or low and the cusp shape is scored as sharpe, round, and blunt, regarding the degree of the facet development on the labial side of the upper M2 (focus on paracone and after metacone) of adult individuals (Fortelius and Solounias, 2000, Kaiser and Solounias, 2003). Unworn (and early worn) teeth, advance worn teeth (where the crown has worn nearly to or below the dentino-enamel juntion), and broken teeth are omitted from mesowear analysis (Rivals *el al.*, 2007). The score responds to general consumer categories: browser, mixed feeder, grazer (Fortelius and Solounias, 2000; Rivals *et al.*, 2007; 2009). However, this method corresponds to the order of ten or more specimens per species which does not correspond to a very low number of specimens (Fortelius and Solounias, 2000). The original methodology was modified by selecting teeth for analysis, by Kaiser and Solounias (2003). This extended mesowear method allow to analysis lesser-extended samples of fossil teeth. To complete the mesowear method of a new mesowear scale was proposed by Mihlbachler *et al.* (2011) and later Solounias *et al.* (2013). They do not consider the characteristic variation of the cusp shape and the occlusal relief variations. The scale consist of seven stages which summarised the standard of interval along a mesowear stage, ranging from sharp to

blunt (Solounias *et al.*, 2013), as following: 0 (high and sharpest); 1 (high and sharp); 2-3 (high and rounded); 4-5 (low and blunt equals) ; and 6 (flat and bluntest). In some case, the observed cusp is an intermediate between two stage (Solounias *et al.*, 2013). Wolf *et al.* (2012) assign intermediated scores in 0.5 increments following 0.5, 1.5, 2.5, 3.5, 4.5, 5.5.

Mesowear scoring was undertaken on the original specimens and review using high-resolution photographs. The mesowear mean score was calculated following Mihlbachler *et al.* (2011) and Wolf *et al.* (2012) and the cusp shape variable relief were observed following Fortelius and Solounias (2000), Kaiser and Solounias (2003), and Kaiser *et al.* (2009) (Figure 3.29).

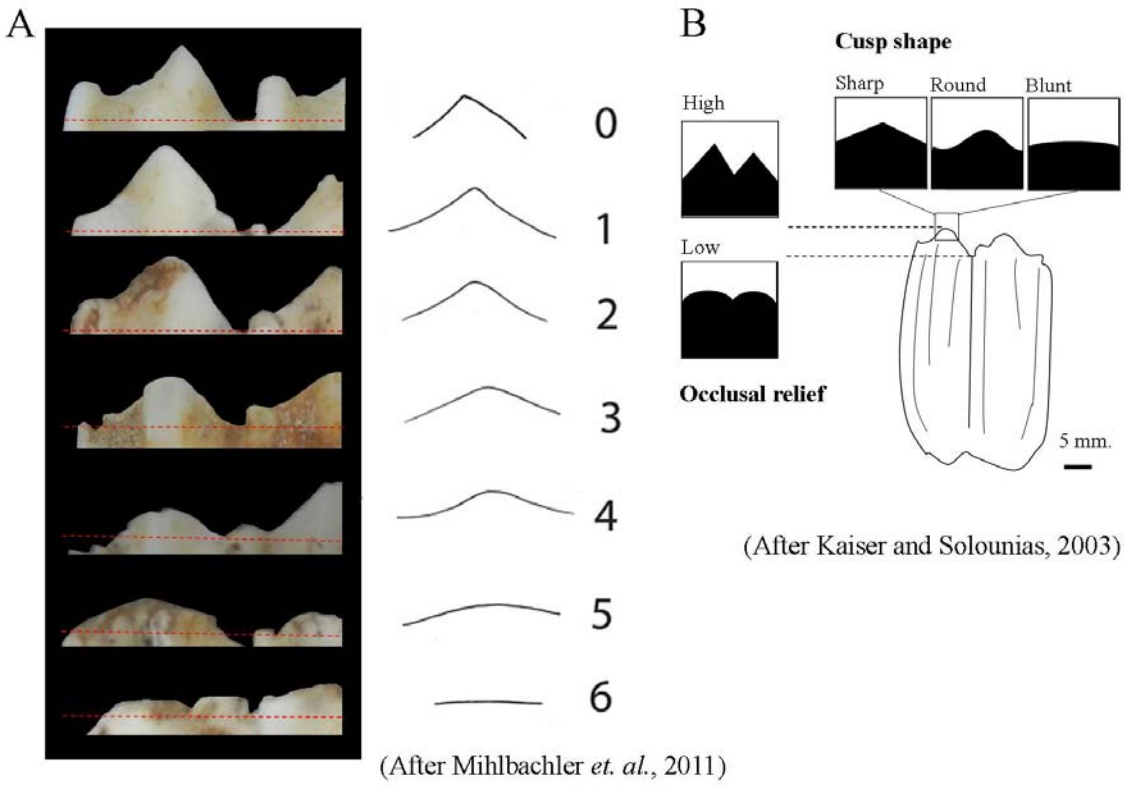

Figure 3.29 Mesowear scoring convention for ungulate cheek teeth proposed by (Fortelius and Solounias (2000). Occlusal relied scored as High or Low, Cusp shape classified as Sharp, Round or Blunt. Modified after Mihlbachler and interpretation (After Rivals *et al.*, 2009 and Solounias *et al.*, 2013)

2) Dental microwear

Dental microwear is the analysis of dental abrasion to research of unglulate palaeodiet (Solonias and Semprebon, 2002). This method indicates the palaeodiet in a short period (a few weeks or days, before death) (Semprebon *et al.*, 2004; Rivals *et al.*, 2009). Food that ungulates eat such as leaf, fruit, usually leaves scares on teeth surface. Epidermis of leaf or the cuticle consists of silica deposits (Albersheim *et al.*, 2011). Silica is usually found in many grasses, woody plants, and the primitive horsetail species. Particles of plant-derived silica is known as phytolith (Albersheim *et al.*, 2011). Phytolith in grasses usually make scratches or long scare on the teeth surface. While fruit or leaf leave the lower number of scratches but more pits (Solonias and Semprebon, 2002). Dental microwear determines the number and identification of scares on the anterior lingual blade of the paracone of the upper M2 andthe posterior labial blade of the protoconid of the lower m2 (Merceron *et al.*, 2004; Semprebon *et al.*, 2004; Rivals *et al.*, 2009). Very worn teeth are not selected for the analysis.

This microwear analysis by making mold from a polyvinylsiloxane (prepared in a President Microsystem framework) and transparent epoxy resin cast will be performed the following process, which developed by Solounias and Semprebon (2002) and using low stereo-microscope developed by Merceron *et al.* (2004). The transparent epoxy cast reduces the limitations of depth of focus throughout.

In the facets on the protocone of the upper M2 and on the protoconid of the lower m2, scratches and pits are identified and counted within a standard 0.4 mm x 0.4 mm square area (Solounias and Semprebon, 2002). The analysis observes under optical stereomicroscope (Nikon SM2800, with camera digital sight Nikon Ds-Fi1) at 40X magnification in the laboratory of Palaeontological Research and Education Centre (Figure 3.30).

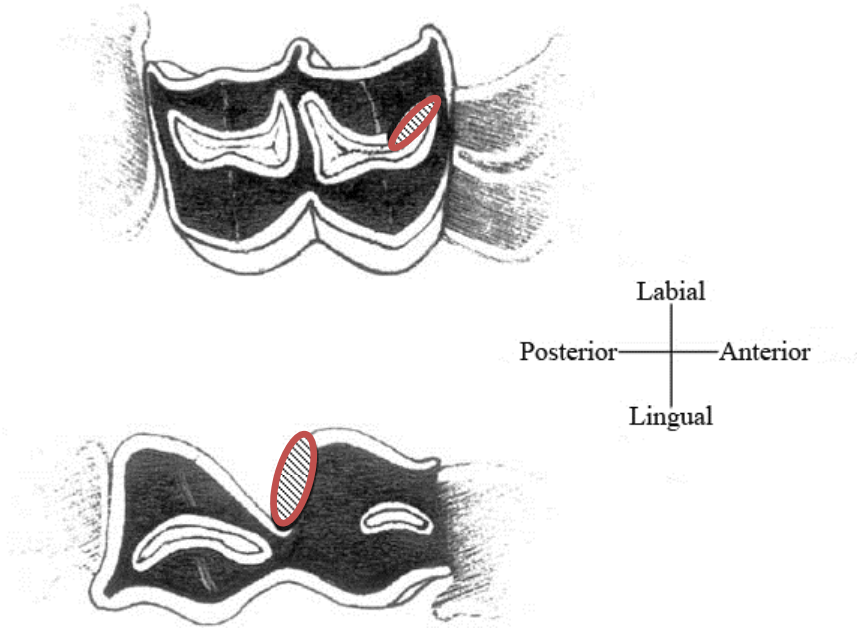

Figure 3.30 Localization of shearing facets on M2 (above) and m2 (below) of ungulates (Merceron *et al.*, 2004). Localization of shearing facets on second permanent lower(below) and upper (above) molars of ungulates (Merceron *et al.*, 2004 drawn by Sabine Riffault)

A number of scratches (elongated microwear scars with straight parallel sides) and pits (circular/sub-circular microwear scars) combine to absolutely attrition, as seen in grazers results in the highest numbers of scratches and the lowest number of pits. Typical leaf browsers have lower numbers of scratches and more disparate numbers of pits, while fruit dominated browsers tend to have intermediate numbers of scratches and high number of pits. The average values for mixed feeders extensively overlap the grazer, and to a lesser extent, the browser area (Rivals *et al.*, 2007), Figure 3.35-36.

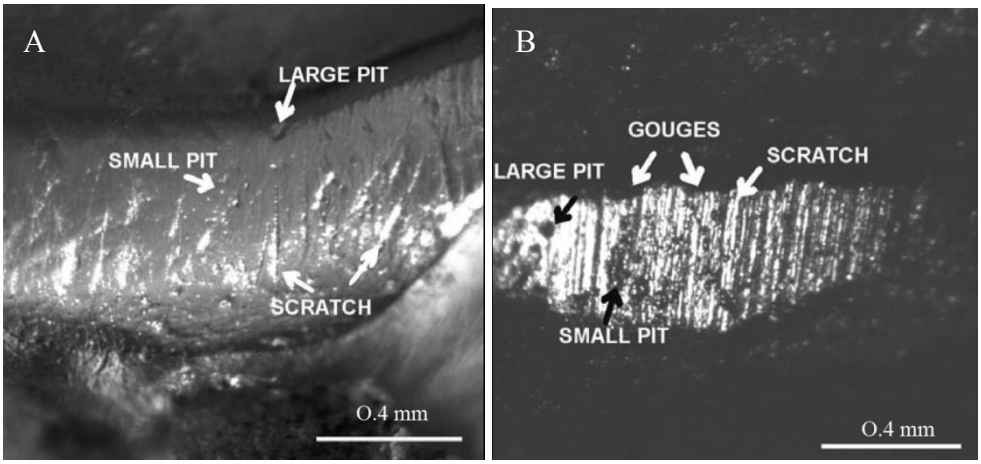

Figure 3.31 Showing characteristic of microwear categories on dental facets of antilopes, A) *Antilocapra americana*, and B) *Stockoceros onusrosagris* in 50X (Rivals, 2005)

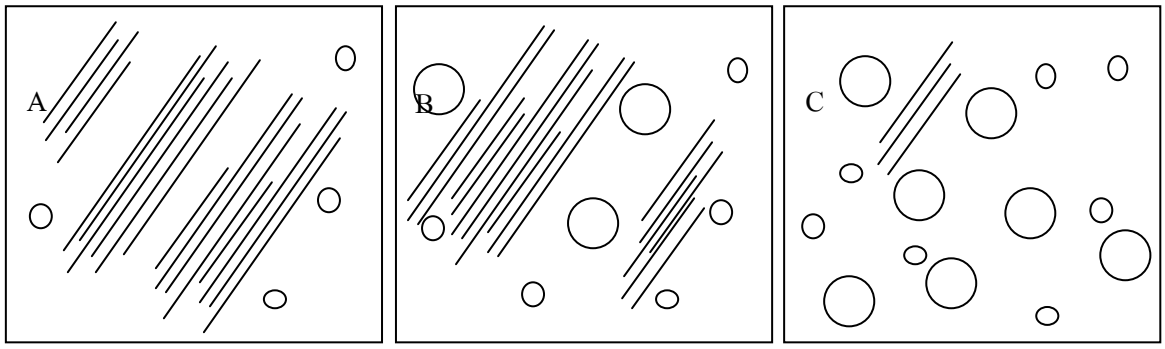

Figure 3.32 Interpretation of palaeodiet based on microwear scars on dental surface: A) Grazer feeder, B) Mixed feeder, and C) Browser feeder

3) Dietary Interpretations

Interpretations of dietary are made by comparison with a database established on extant ungulates by Fortelius and Solounias (2000) for mesowear and by Solounias and Semprebon (2002) for microwear. Data from fossils samples are average and plotted against the modern wild species whose diet is known (Rivals *et al.* 2009). These analyses showed overall correct classification of faunas into the conventional dietary categories of grazer, fruit browser, leaf browser, and mixed feeder.

A combined analysis of both mesowear and microwear are conducted in order to get an understanding on diet to reconstruct the habitat used by bovids to propose palaeoclimate and palaeoenvironment reconstruction.

CHAPTER 4

SYSTEMATIC PALAEONTOLOGY

The collection anlysed is composed of 721 bovids teeth from 3 sites including Tham Lod Rockshelter, Tham Prakai Phet, and Tham Rak Sai aged from Middle to Late Pleistocene. Eight belonging to 2 subfamilies have been identified Bovinae: gaur (*Bos gaurus*), banteng (*B. javanicus*), kouprey (*B.* cf. *sauveli*), Asiatic water buffalo (*Bubalus arnee*), and Caprinae: serow (*Capricornis sumatraensis*), Chinese serow (*C. milneedwardii*), South China goral (*Naemorhedus griseus*), and Himalayan goral (*N. goral*) (Table 4.1).

Table 4.1 Inventory of the bovid teeth of the 3 sites analysed in this resereach

Species	Tham Lod Rockshelter	Tham Prakai Phet	Tham Rak Sai	Total
Bos gaurus	112	99	0	211
B. javanicus	48	90	0	138
B. cf. *sauveli*	7	5	0	12
Bubalus arnee	24	17	0	41
Total Bovinae	**191**	**211**	**0**	**401**
Capricornis sumatraensis	36	81	4	121
C. milneedwardii	0	14	0	14
Naemorhedus griseus	148	7	12	167
N. cf. *goral*	17	104	16	321
Total Caprinae	**201**	**104**	**16**	**321**
Total Bovidae	**392**	**315**	**16**	**721**

4.1. Bovinae

4.1.1 Systematic palaeontology of Bovinae

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

Family: Bovidae Gray, 1821

Subfamily: Bovinae Gray, 1821

Genus: *Bos* Linnaeus, 1758

Species: *Bos gaurus* Smith, 1827

Localities: Tham Lod Rockshelter and Tham Prakai Phet.

Material: Tham Lod Rockshelter collection (112 NISP) is composed of 5 P2, 5 P3, 7 P4, 10 M1, 11 M2, 11 M3, 3 p2, 6 p3, 7 p4, 11 m1, 21 m2, 15 m3.

The Tham Prakai Phet collection (99 NISP) composed of 2 DP3, 2 DP3, 1 P2, 1 P3, 3 P4, 7 M1, 14 M2, 5 M3, 2 dp3, 2 dp4, 2 p2, 10 p3, 11 p4, 16 m1, 11 m2, and 10 m3.

Upper dentition:

DP3: In occlusal view, the outline of anterior lobe is square; the posterior one presents an elongated pentagonal-shaped, the paracone is larger than the metacone. The fossa of the anteriot lobe has a V-shape and locate near the mesial side. A fossette is present near the distal side. The protocone is flat and the hypocone is rounded. In labial view, all cones and styles are clearly marked. The parastyle and the mesostyle are strongly marked at the base of the tooth (Table 4.2, Figure 4.1).

Table 4.2 Upper DP3 measurements of *Bos gaurus* from Tham Prakai Phet (mm)

	Measurement				
	1	**2**	**3**	**4**	**5**
n	1	1	2	1	2
Max	-	-	15.65	-	18.33
Min	-	-	11.38	-	17.98
Mean	23.88	23.97	14.42	16.77	18.155
SD.	-	-	1.73	-	9.24

Figure 4.1 Upper a left DP3 (SE133) of *B.gaurus* 1-3) Occlusal, lingual, and labial views

DP4: The tooth is completely molarized. In occlusal view, the anterior lobe has a triangular shape and the posterior one has a pentagonal shape, styles and cones are marked. The protocone and the hypocone are well developed. Both lingual cones are perpendicular to the mesio-distal axis. In labial view, the styles and cones are marked along the tooth. The width of the top is larger than the base. In lingual view, an entostyle is strongly developed and bilobe between the protocone and the hypocone (Table 4.3 and Figure 4.2).

Table 4.3 Upper DP4 measurement of *Bos gaurus* from Tham Prakai Phet

	Measurements				
	1	**2**	**3**	**4**	**5**
N	2	2	2	2	2
Mean	26.3	26.76	18.82	16.69	21.66

Figure 4.2 Upper left DP4 of *Bos gaurus* (TPKP27) from Tham Prakai Phet 1-3)
Occlusal, lingual, and labial views

P2: In occlusal view, the outline of tooth has a heart-like shape and, the paracone is prominent and bend mesially. The metastyle is more elongated and marked than the paracone and is curved distally, is particulary true for the Tham Prakai Phet specimens. The fossa is open on mesial wall in the early wearing stage, and can be more marked (Tham Lod Rockshelter, A1507 in Area 1). The fold has a very weak development. In labial view, the tooth is clearly curveed distally, the parastyle is linked to the paracone at the base of the crown, the valley between the paracone and metacone is well marked along the tooth. The specimen from Tham Prakai Phet presents a very weak metacone. In lingual view, the wall of the protocone is rounded and a small antero-lingual groove is present. The tooth is dilated at the top and being pinched at the base (Table 4.4, Figure 4.3).

Table 4.4 Upper P2 measurement of *Bos gaurus* (mm)

Localities		**Measurement**			
		1	**2**	**3**	**4**
Tham Lod Rockshelter	n	5	4	5	3
	Max	19.55	19.72	15.57	14.90
	Min	14.18	15.76	13.41	12.95
	Mean	17.71	17.72	14.50	14.15
	SD.	2.12	1.79	0.85	1.05
Tham Prakai Phet	n	1	1	1	1
	Mean	19.37	18.50	13.83	14.91

Figure 4.3 Upper P2 of *Bos gaurus* 1-3) Occlusal, lingual, and labial view of a right P2 (TLA1507 Area 1) from Tham Lod Rockshelter

P3: In occlusal view, the tooth is more symmetric than the P2. The labial bilobation is very weak. The paracone and parastyle are moderately prominent and bends forwards. The paracone is less marked than of P2. The metacone is very weak or absent. The metastylid is marked. Unlike in P2, it presents a metacone strongly developed and the absence of metastyle. The interstylar surfaces are flat. The fossa located at the middle of the tooth is asymetrical. In labial view, the tooth is slightly curved distally. Styles and cones are marked along the tooth. The paracone is located on the center of the tooth. The parastyle is less marked than the metastyle. In lingual view, the wall is rounded, no grooves present. In distal view, the tooth is curved lingually (Table 4.5, Figure 4.4).

Tham Lod Rockshelter specimens, the fossa opens at the distal side as small groove in early wearing stage (TLA4301 in Area 1). A small fold can be observed in worn tooth (TLA3699 in Area 1 and TLA1110 in Area 2). A fossete can be found near the distal wall in advance worn tooth (A3606a in Area 1).

In Tham Prakai Phet specimens (TPKP32), the fossa is pinched at the center with two small folds. Two lingual grooves present.

Table 4.5 Upper P3 measurement of *Bos gaurus* (mm)

Localities		**Measurements**			
		1	**2**	**3**	**4**
Tham Lod Rockshelter	N	4	3	4	3
	Max	21.19	17.52	19.54	17.83
	Min	14.18	15.76	13.41	12.95
	Mean	20.15	16.84	15.78	16.49
	SD.	0.80	1.17	2.90	1.16
Tham Prakai Phet	N	1	1	1	1
	Mean	17.58	15.85	18.58	19.68

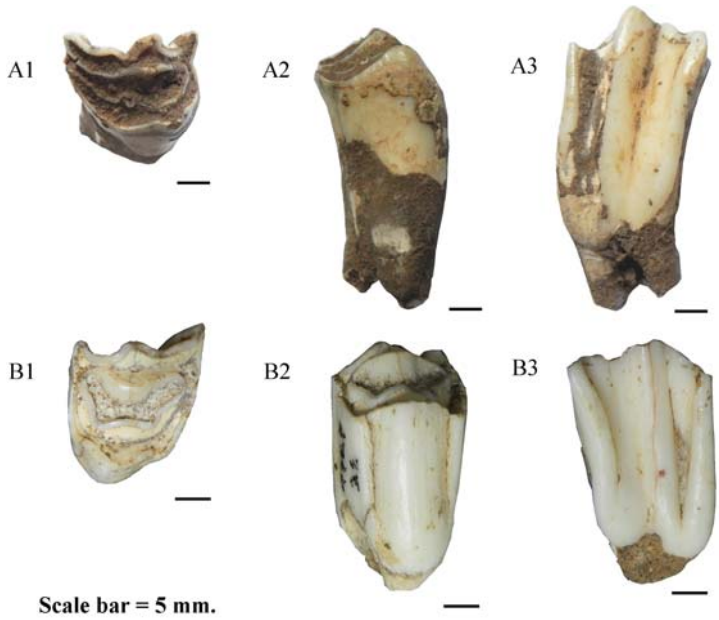

Figure 4.4 Upper P3 of *Bos gaurus* A1-3) Occlusal, lingual, and labial view of a left P3 (TLA4301 in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left P3 (TPKP32) from Tham Prakai Phet

P4: In occlusal view, the tooth is more symmetric pentagonal outline, the parastyle and the metastyle are marked and weakly perpendicular to the mesio-distal axis, the labial cone is strongly marked and located at the center, the fossa is large and pitched at the middle. In labial view, the wall is marked, the crown is narrower at the base. In lingual view, no grooves present. In distal view, the width of the base is larger than the top (Table 4.6, Figure 4.5).

In Tham Lod Rockshelter specimens, a fossete can be observed near the distal side (TLA3606b in Area1). A basal vertical rib can exists in lingual view (TLA2373 in Area 2).

In Tham Prakai Phet specimens, labial cone bends forwards, two grooves can be observed along the lingual side (TPKPSE125), A vertical rib occurs on the distal side of lingual cone in TPKPSE4. In TPKPNW81, the metastyle and parastyle are curved,

Table 4.6 Upper P4 measurements of *Bos gaurus* (mm)

Localities		**Measurement**			
		1	**2**	**3**	**5**
Tham Lod Rockshelter	N	5	4	5	4
	Max	20.18	20.05	19.45	22.18
	Min	15.74	15.72	16.60	15.73
	Mean	18.63	17.60	18.15	19.81
	SD.	1.70	1.81	1.31	2.85
Tham Prakai Phet	N	3	3	1	1
	Max	19.81	16.10	22.14	22.5
	Min	17.91	17.12	21.15	21.84
	Mean	18.79	16.57	21.65	22.17
	SD.	0.78	0.42	0.50	0.33

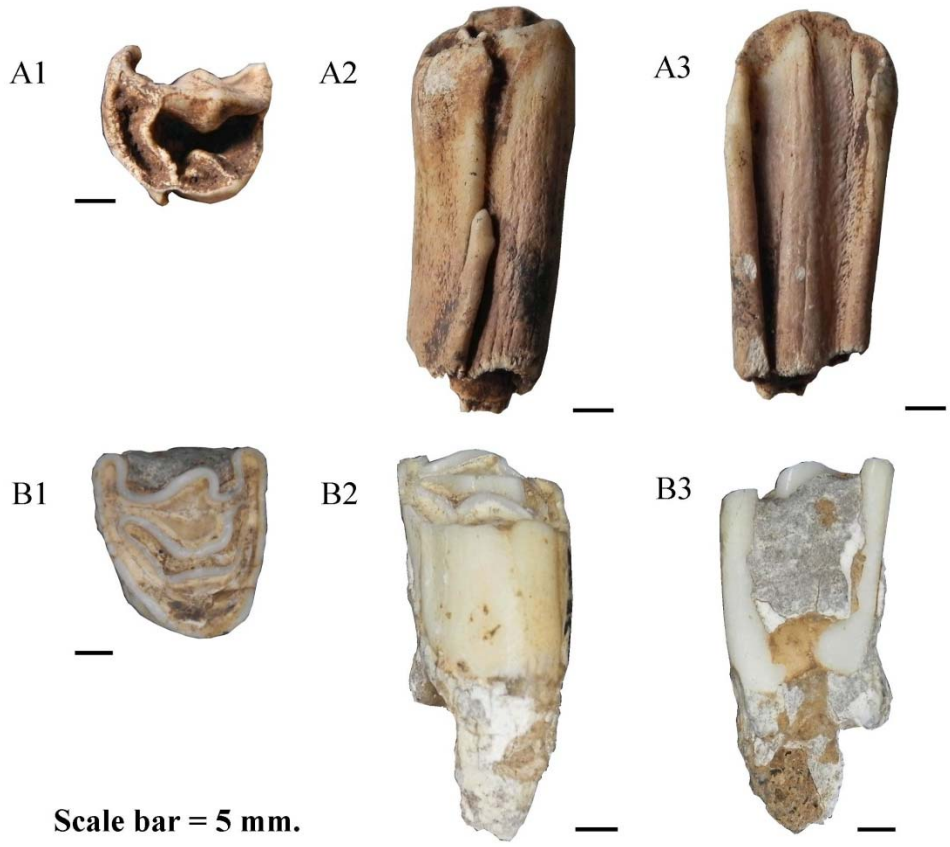

Figure 4.5 Upper P4 of *Bos gaurus* A1-3) Occlusal, lingual, and labial views of a right P4 (TLA2373 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right P4 (TPKPSE125) from Tham Prakai Phet

M1: In occlusal view, the two lobes have a triangular outline, labial styles and cones are prominent, the parastyle and the mesostyle often bends forwards, the metastyle curve backwards, the paracone and the hypocone are rounded. A large fossa is located at the center of each lobe with two small lateral folds. In labial view, the top is wider than the base. In lingual view, the entostyle is deep-rooted between the paracone and the hypoconid and has only one lobe, two grooves on lingual cones can be clearly noticed. In mesial and distal view, the base is larger than the top, walls are more rounded than on upper M2. At the base, the width is larger than the length (Table 4.7, Figure 4.6).

In Tham Lod Rockshelter specimens, the anterior lobe is often as wide as the posterior one (especially at the base) except TLA3607 in Area 1. The entostylid connect

to distal wall of the paracone except TLA1436 in Area 1 and TLA502 in Area 2. In worn tooth such as A502, an enamel island exists at a middle of the tooth.

In Tham Prakai Phet specimens, the anterior lobe is often as wide as the posterior one. Entostyle has only one lobe in all specimens. In advance stage of wear such as TPKPSW127, an enamel island occurs at the middle of the tooth.

Table 4.7 Upper M1 measurements of *Bos gaurus* (mm)

Localities		**Measurements**					**Entostyle**	
		1	**2**	**3**	**5**	**7**	**Length**	**Number of lobe**
Tham Lod Rockshelter	N	9	9	7	9	7	4	
	Max	32.83	27.78	20.46	20.92	28.89	6.46	2
	Min	25.54	21.29	14.59	14.50	23.84	5.54	1
	Mean	27.89	24.37	18.61	18.29	25.75	6.06	
	SD.	2.36	1.99	2.04	1.87	1.77	0.38	
Tham Prakai Phet	N	6	5	7	6	5	4	
	Max	28.51	26.70	21.19	22.26	25.35	6.21	1
	Min	23.43	22.19	16.61	15.74	23.92	2.81	1
	Mean	26.77	24.14	18.60	18.54	24.48	5.06	
	SD.	1.84	2.04	1.76	2.50	0.58	1.56	

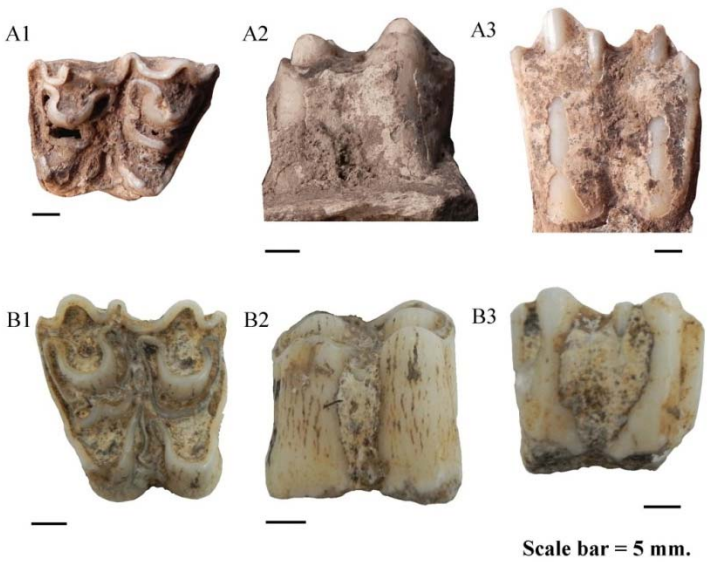

Figure 4.6 Upper M1 of *Bos gaurus* A1-3) Occlusal, lingual, and labial view of a left M1 (TLA540b in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right M1 (TPKPSW127) from Tham Prakai Phet

M2: The tooth is larger than upper M1. In occlusal view, lobes present a relatively pentagonal outline, the anterior lobe is larger than the posterior one. The parastyle and the mesostyle are prominent and is curved forwards. They are more marked than the metastyle. Labial cones show subrounded outline. The entostylid is fromed from the distal side of protocone and is perdendicular to the mesio-distal axis. In labial view, labial styles and conids are marked and straight along the tooth. The length of the top is larger than the base. In lingual view, the entostyle is deep-rooted, two grooves can be observed on lingual cones. In mesial and distal view, the base is as well as than the top (Table 4.8, Figure 4.7).

In Tham Lod Rockshelter specimens, an asymmetric U-shape fosseta is located at the center in each lobe with a small fold formed from distal side. An enamel island can exists between the two lobes (TLA3608 in Area 1). In almost all the specimens, the entostyle presents uni-lobe or bilobe, the length of tooth base is smaller than the width.

For Tham Prakai Phet specimens, only posterior fossa presents U-shape and a long fold, the specimen TPKPNE196 presents many folds in both anterior and posterior fossa. In TPKPNE227, the tooth shows an enamel island, a large teardrop-like fossa. Almost all the specimens present and entostyle with one to three lobes.

Table 4.8 Upper M2 measurements of *Bos gaurus* (mm)

Localities		**Measurements**					**Entostyle**	
		1	**2**	**3**	**5**	**7**	**Length**	**Number of lobe**
Tham Lod Rockshelter	n	11	10	11	10	10	3	
	Max	34.12	30.34	22.56	20.98	30.01	9.88	2
	Min	22.67	22.00	16.54	15.22	23.65	7.66	1
	Mean	28.27	25.80	19.36	17.88	26.25	8.61	
	SD.	3.18	2.57	1.86	1.86	2.19	1.15	
Tham Prakai Phet	n	13	12	12	13	10	11	
	Max	34.07	29.42	26.08	26.56	31.09	8.49	3
	Min	24.41	23.30	17.82	17.12	24.76	4.51	1
	Mean	29.21	26.60	21.82	21.62	27.59	6.18	
	SD.	2.77	1.70	2.64	3.10	1.90	1.31	

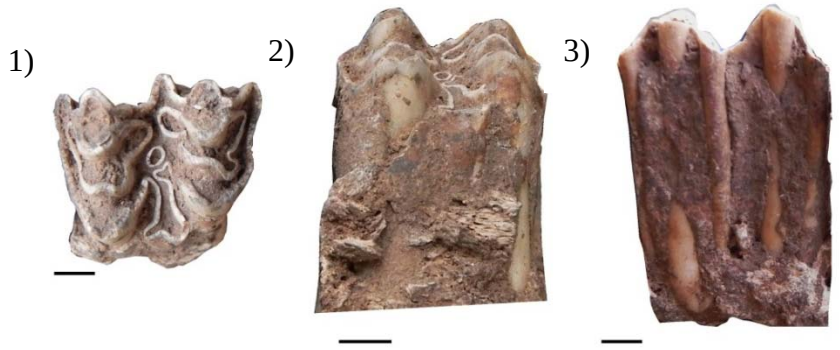

Figure 4.7 Upper M2 of *Bos gaurus* 1-3) Occlusal, lingual, and labial view of a left M2 (A3608 in Area 1) from Tham Lod Rockshelter, scale bar = 5 mm

M3: The tooth is larger than upper M2. In occlusal view, each lobe has a pentagonal outline. The anterior lobe is larger than the posterior one and they are perpendicular to the mesio-distal axis of the tooth. A metastylar wing is developed from the top to the base. The anterior fossa is large and presents a asymmetric outline, pinched at the middle with one or-two folds. A small fold occurs at the distal wall of the anterior fossa. Lingual conids are sub-angular. The entostyles is attached from the distal side of the protocone. In labial view, the metastylar wing is more developed distally than other styles. The top of the labial cones are often smaller than the base. The interstylar spaces of anterior lobe are larger than the posterior one. In lingual view, the entostyle is also deep-rooted between cones. Two grooves exist on the lingual cones. In mesial view, the base is strongly wider than the top, the mesial wall is flat. In distal view, the distal wall show shallow groove which is related to a remarkable metastylar wing. At the base of the tooth, the length is larger than width (Table 4.9, Figure 4.8).

The Tham Lod Rockshelter specimens present entostyle with one or two lobes.

The Tham Prakai Phet specimens, only TPKPSE116 has a very long fold in the posterior lobe. In the advance worn stage, the tooth presents enamel island between the anterior and the posterior lobe (TPKPNE102, TPKPNW9, TPKPSE116). The entostyle has one to three lobes.

Table 4.9 Upper M3 measurements of *Bos gaurus* (mm)

Localities		Measurements					Entostyle	
		1	**2**	**3**	**5**	**7**	**Length**	**Number of lobe**
Tham Lod Rockshelter	n	8	8	9	9	6	7	
	Max	34.26	36.31	24.98	22.43	24.24	8.74	2
	Min	28.13	28.11	16.75	8.05	21.85	4.65	1
	Mean	31.08	30.70	21.38	17.97	23.02	6.99	
	SD.	1.81	2.48	2.29	4.20	0.98	1.87	
Tham Prakai Phet	N	5	4	3	3	4	4	
	Max	35.57	33.75	21.52	27.68	23.46	8.86	3
	Min	30.39	23.33	16.48	21.06	16.90	8.08	1
	Mean	32.45	30.30	19.45	25.39	19.52	8.35	
	SD.	2.04	4.76	2.64	3.75	2.95	0.36	

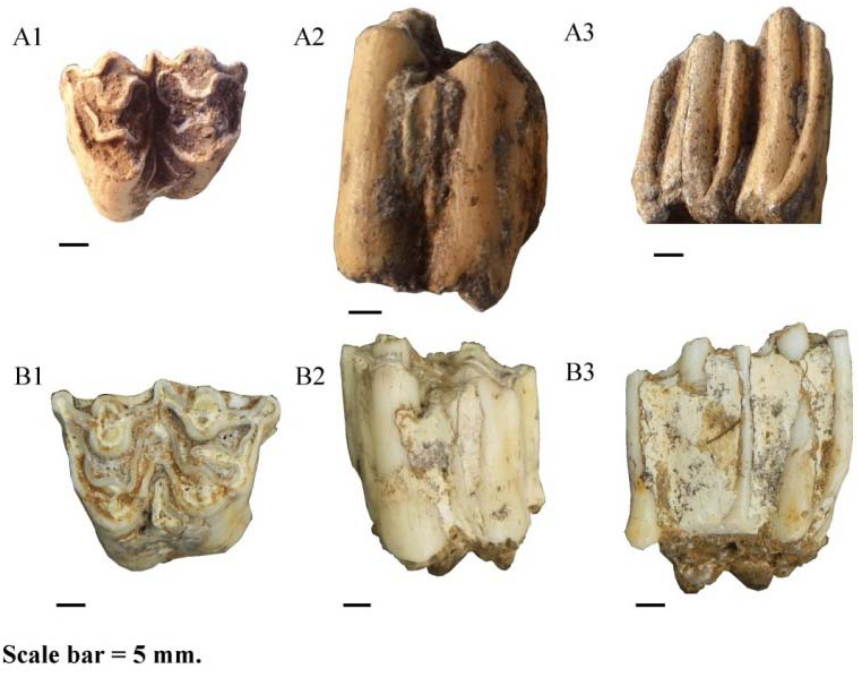

Figure 4.8 Upper M3 of *Bos gaurus* A1-3) Occlusal, lingual, and labial view of a left M3 (A1911 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left M3 (NE102) from Tham Prakai Phet

Lower dentition

dp3: In occlusal view, the tooth shows a triangular outline. The parastylid is prominent. The paraconid has a triangular shape. The valley between the parastylid and the paraconid is very wide. The anterior valley has an angular outline. The mataconid is

weakly developed. The posterior valley is not completely enclosed. The protoconid and hypoconid are rounded. The hypoconid is prominent. The valley between the protoconid and the hypoconid is shallow which is extended at the top and decreased at the base. In lingual view, the protoconid is strongly inclined mesially. The lingual valley exists along the tooth. In lingual view, the paraconid is prominent, the anterior valley is wide and shallow, the metaconid is moderatly marked. The posterior valley is completely closed near the base (Table 4.10, Figure 4.9).

Table 4.10 Lower dp3 measurements of *Bos gaurus* from Tham Prakai Phet (mm)

	Measurements				
	1	**2**	**3**	**4**	**5**
n	2	2	2	2	2
Max	23.54	21.75	11.18	10.99	7.25
Min	23.01	20.54	9.55	9.91	7.20
Mean	23.28	21.15	10.37	10.45	7.23
SD.	0.37	0.86	1.15	0.76	0.04

Figure 4.9 A left lower dp3 (NW127) of *B. javanicus* from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views

dp4: The tooth presents three lobes. In occlusal view, each lobe has slightly trapezoid outline, the first lobe is as long as the second lobe, the third lobe is larger than the others, the parastylid and the entostylid are marked, the mesotyle occurs as a rib, lingual conids are sharp, two ectostylid exist between the lobes. In lingual view, the length of the base is smaller than the top. In the mesial view, the top is as wide as the base (Table 4.11, Figure 4.10).

Table 4.11 Lower dp4 measurements of *Bos gaurus* from Tham Prakai Phet (mm)

	Measurements					
	1	**2**	**3**	**4**	**5**	**6**
n	1	1	2	2	1	1
Max	-	-	13.14	14.60	-	-
Min	-	-	12.58	13.25	-	-
Mean	40.03	32.08	12.86	13.93	13.8	16.02
SD	-	-	0.40	0.95	-	-

Figure 4.10 A lower right dp4 (SE101) of *Bos gaurus* from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views.

p2: : In occlusal view, the tooth has a triangular shape, the lingual side is flat and inclined mesially, the lingual valley is rarely marked, the parastylid is very low, the anterior valley is weak. The metaconid and the entoconid are marked. The posterior valley is very marked as V-shape. In labial view, the mesial side inclined backwards, the distal side is straight, the labial valley is marked from the top to the middle. In lingual view, the mesial side is inclined to backwards. All lingual valleys are marked from the top to the middle (Table 4.12 and Figure 4.11).

Table 4.12 Lower p2 measurements of *Bos gaurus* (mm)

Localities		**Measurements**			
		1	**2**	**3**	**4**
Tham Lod Rockshelter	n	3	3	3	3
	Max	16.67	16.48	9.15	10.53
	Min	12.97	13.14	7.46	9.69
	Mean	14.43	14.83	8.56	10.20
	SD.	1.97	1.67	0.95	0.45
Tham Prakai Phet	n	2	2	2	2
	Max	14.20	14.19	8.15	9.92
	Min	13.10	13.50	8.04	9.5
	Mean	13.65	13.85	8.10	9.71
	SD.	0.78	0.49	0.08	0.30

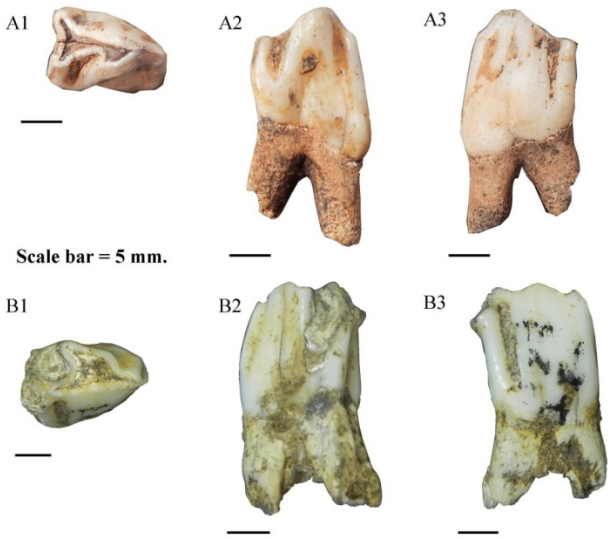

Figure 4.11 Lower p2 of *Bos gaurus* A1-3) Occlusal, lingual, and labial views of a left p2 (A180 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right p2 (NE3) from Tham Prakai Phet

p3: In occlusal view, the parastylid and the paraconid are marked, the groove between the parastylid and the paraconid is V-shape and shallow, the metaconid is marked and bends backwards, the anterior valley present a U-shape, the posterior valley is marked as V-shape. The entostylid merged from the entoconid. In lingual view, the protoconid is rounded, the hypoconid is a little marked and decreased from the top to the base. The lingual valley is weak. In labial view, all valleys, stylids, and conids are marked along the crown, the length at the top is larger than at the base. (Table 4.13, Figure 4.12).

The Tham Prakai Phet specimens show a metaconid which is extended and bend backwords and enclosing of the posterior valley.

Table 4.13 Lower p3 measurements of *Bos gaurus* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	5	2	5	3	2
	Max	22.13	18.80	12.83	13.01	4.21
	Min	20.94	18.64	12.24	12.45	4.08
	Mean	21.65	18.72	12.56	12.73	4.15
	SD.	0.55	0.11	0.23	0.28	0.09
Tham Prakai Phet	n	6	6	6	6	5
	Max	25.77	24.60	15.60	15.02	4.30
	Min	21.66	20.41	12.72	12.77	1.60
	Mean	23.70	22.70	14.08	13.82	3.20
	SD.	1.71	1.84	1.04	0.76	1.38

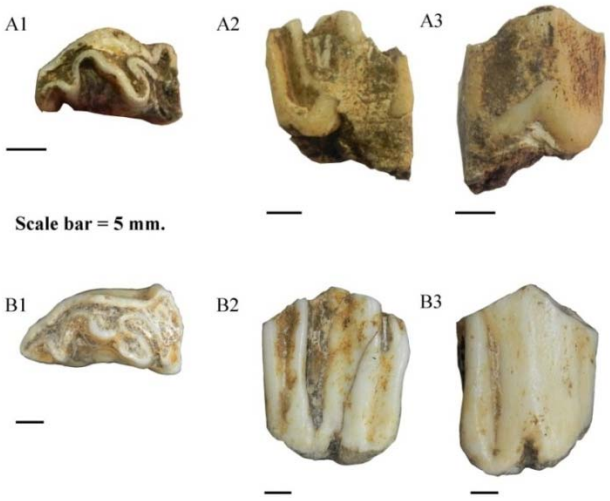

Figure 4.12 Lower p3 of *Bos gaurus* A1-3) Occlusal, lingual, and labial view of a right p3 (A91 in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right p3 (SW119) from Tham Prakai Phet

p4: The outline of tooth is triangular. All conids are more marked than on p3. In occlusal view, the protoconid is strongly rounded, the metaconid is large and perpendicular to mesio-distal axis, the lingual valley is large and has a square outline. The metaconid is strongly rounded and bends backwards. The middle of metaconid is very marked. The anterior valley is a wide U-shape, the posterior valley present a

narrow opening. The entostylid is fused to the entoconid. On the lingual side, lingual grooves are marked along the crown, the length of the top is larger than the base. In labial view, the hypoconid and labial valley are marked along the tooth (Table 4.14, Figure 4.13).

In Tham Lod Rockshelter, some specimens present a parastyle often fused to the paraconid which is influenced by attrition (TLA3432 in area 1).

In Tham Prakai Phet, some specimens show a metaconid extended backwards and enclosed the posterior valley to form a isolated enamle island (TPKPSW136 and TPKPNW29).

Table 4.14 Lower p4 measurements of *Bos gaurus* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	6	4	6	5	3
	Max	25.97	22.44	13.21	14.24	3.90
	Min	21.12	18.72	11.06	11.18	3.26
	Mean	22.72	20.85	12.08	13.06	3.54
	SD.	1.80	1.55	0.93	1.17	0.33
Tham Prakai Phet	n	9	9	9	9	9
	Max	23.67	22.06	14.25	14.16	6.70
	Min	19.11	18.42	11.00	11.48	1.94
	Mean	21.69	20.23	12.42	12.70	4.99
	SD.	1.48	1.40	0.96	0.99	1.67

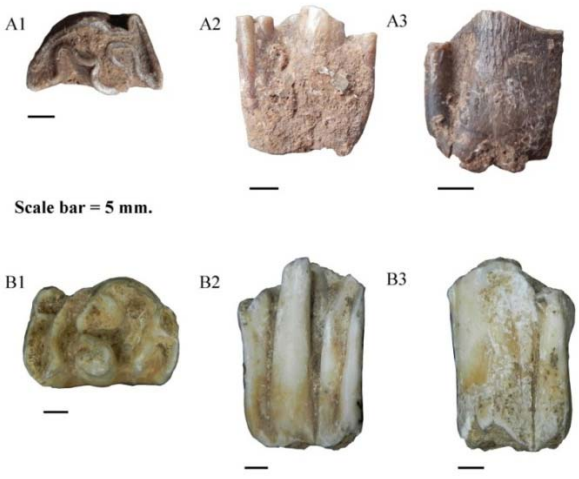

Figure 4.13 Lower p4 of *Bos gaurus* A1-3) Occlusal, lingual, and labial view of a right p4 (A3432 in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left p4 (NE39) from Tham Prakai Phet

m1: : In occlusal view, lobes present trapezoid shapes, the parastylid is weakly prominent, the metastylid is undeveloped, the entostylid is marked and is curved backwards, the metaconid and the entoconid are well developed, the lingual valley has a U-shape, the ectostylid is not bilobed and connect to the back side of the hypoconid and bend mesially. In labial view, the ectostylid is deep-rooted, the paraconid and the hypoconid present lateral grooves at the mesial and distal sides. In lingual view, the paraconid and the metaconid are weaky parallel and closed at the base. In distal view, the base is narrower than the top (Table 4.15, Figure 4.14).

Table 4.15 Lower m1 measurements of *Bos gaurus* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	8	6	8	8	6
	Max	28.31	25.86	19.00	18.22	20.90
	Min	21.06	18.29	13.01	13.38	14.41
	Mean	25.51	23.26	15.55	15.64	18.09
	SD.	2.71	2.65	2.10	2.00	2.24
Tham Prakai Phet	n	14	12	14	11	11
	Max	27.14	26.71	19.48	19.27	20.35
	Min	23.24	16.87	13.31	13.11	15.01
	Mean	25.12	23.02	15.90	15.83	17.42
	SD.	1.27	2.44	1.93	1.79	1.78

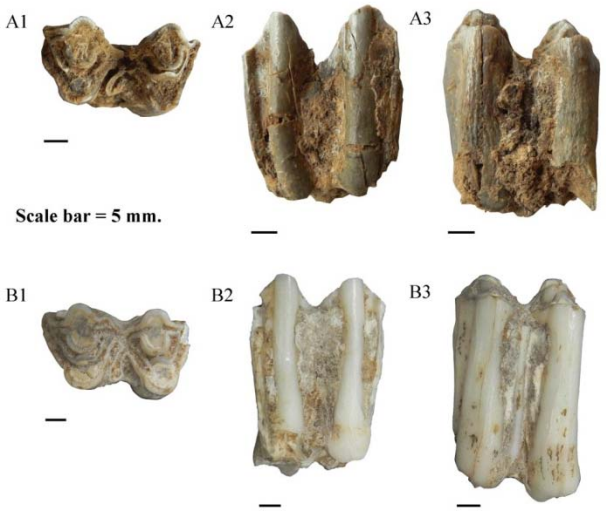

Figure 4.14 Lower m1 of *Bos gaurus* A1-3) Occlusal, lingual, and labial view of a left m1 (A1506 in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right m1 (SE100) from Tham Prakai Phet.

m2: In occlusal view, two lobes show trapezoid outlines, the parastylid is prominent and perpendicular to the mesio-distal axis, the metastylid is developed as a rib, the entostylid is prominent and points distally, the metaconid is often larger than the entoconid, the labial valley is a wide U- shape, the ectostylid connect to the anterior side of the hypoconid and bend mesially, the labial conids are more rounder than those of lower m1, the fossa located at the center of the tooth has an U-shape outline, associated with fold that occurred at the middle. In labial view, the ectostylid is deep-rooted, the labial wall is rounded. Both lingual grooves can be clearly noticed at the mesial side of the paraconid and the distal side of the hypoconid which are more marked than those of the other tooth (Table 4.16, Figure 4.15).

. Table 4.16 Lower m2 measurements of *Bos gaurus* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	20	16	21	20	18
	Max	33.05	27.55	18.99	18.73	20.68
	Min	24.69	21.08	11.87	12.25	15.01
	Mean	28.48	24.97	14.47	14.29	18.22
	SD.	2.48	1.83	1.79	1.69	1.60
Tham Prakai Phet	n	12	9	10	10	9
	Max	37.63	32.99	18.45	18.17	20.68
	Min	25.37	25.04	10.72	10.03	16.44
	Mean	30.78	27.44	15.21	14.69	18.25
	SD.	3.36	3.25	2.55	2.56	1.34

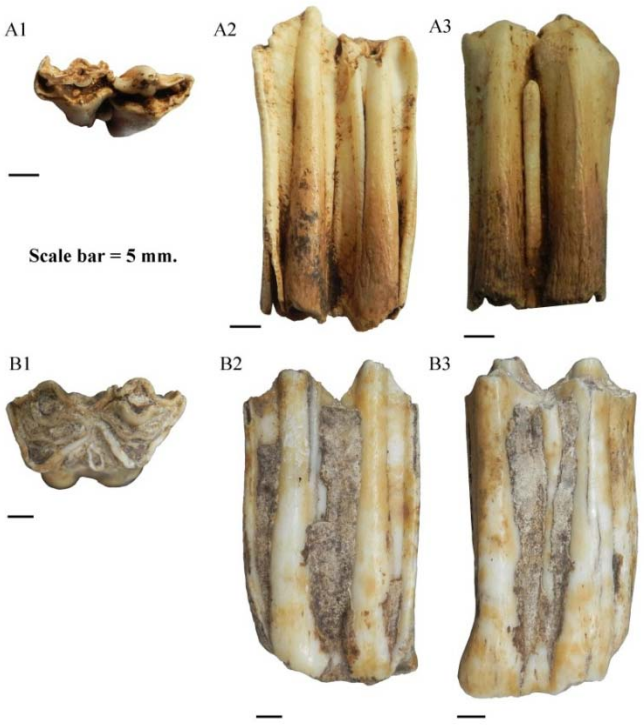

Figure 4.15 Lower m2 of *Bos gaurus* A1-3) Occlusal, lingual, and labial views of a left m2 (A119 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right m2 (SE13) from Tham Prakai Phet

m3: In occlusal view, the first lobe is larger than the second one, each lobe has a triangular shape in early wearing stage and a trapezoid shape in advanced wearing stage. The lingual conids are developed, the metastylid is weakly marked, the parastylid is strongly marked and bend mesially, the entostylid is strongly marked, the labial valley between the metaconid and the entoconid is a wide U-shape. The U-outline fossa located at the middle of the tooth is associated with a pinching at the middle. The protoconid and the hypoconid are marked and semi-circular. A lateral groove is present in each conid. Both the entoconulid and hypoconulid are rounded. A ridge exits at the end of the third lobe and bends disto-lingually. The ectostylid is connected to the hypoconulid and curved mesially, the posterior ectostylid exists. In lingual view, all conids and stylids are marked along the crown, the tooth has a weak dilation. In labial view, all conids are rounded; both ectostylid and posterior ectostylid present. In some spcimens such as NW135 in Tham Prakai Phet, the posterior ectostylid is absent (Table 4.17, Figure 4.16).

Table 4.17 Lower m3 measurements of *Bos gaurus* (mm)

Localities		**Measurements**					
		1	**2**	**3**	**4**	**5**	**6**
Tham Lod Rockshelter	n	12	9	11	11	7	7
	Max	45.58	44.90	17.90	17.83	8.44	20.10
	Min	30.59	35.20	12.32	12.58	5.23	14.19
	Mean	36.75	38.69	15.17	14.56	6.77	17.69
	SD.	3.75	3.29	1.76	1.49	1.11	2.16
Tham Prakai Phet	n	9	9	9	9	10	9
	Max	44.42	46.29	19.12	17.02	10.13	44.42
	Min	36.33	35.13	12.79	13.27	5.97	36.33
	Mean	41.67	42.27	16.31	15.16	8.33	41.67
	SD.	2.90	3.88	2.24	1.50	1.58	2.90

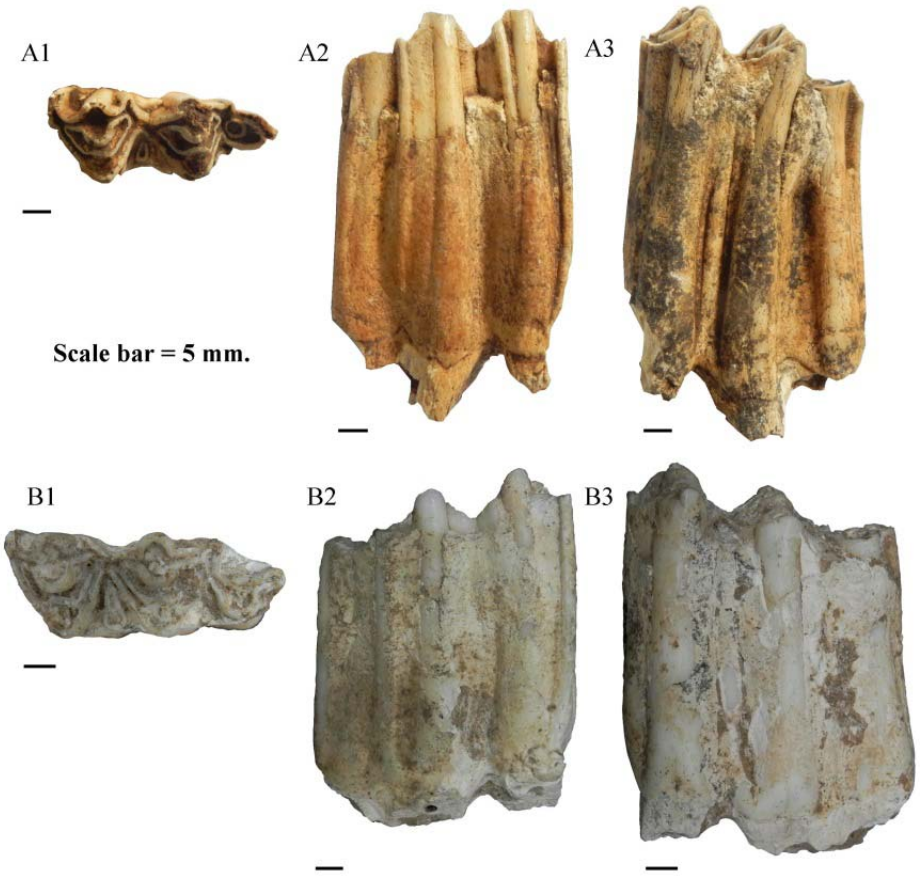

Figure 4.16 Lower m3 of *Bos gaurus* A1-3) Occlusal, lingual, and labial views of a left m3 (A134 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left m3 (SE71) from Tham Prakai Phet

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

Family: Bovidae Gray, 1821

Subfamily: Bovinae Gray, 1821

Genus: *Bos* Linnaeus, 1758

Species: *Bos javanicus* d'Alton, 1823

Localities: Tham Lod Rockshelter and Tham Prakai Phet

Material: Tham Lod Rockshelter: Totally 48 NISP consist of 2 P2, 3 P3, 3 P4, 2 M2, 6 M3, 2 p2, 5 p3, 4 p4, 8 m1, 6 m2, 7 m3.

Tham Prakai Phet**:** Totally 90 NISP consist of 2 DP3, 3 DP3, 5 P2, 2 P3, 5 P4, 4 M1, 6 M2, 5 M3, 3 dp3, 2 dp4, 2 p2, 11 p3, 6 p4, 11 m1, 11 m2, and 12 m3.

Upper dentition

DP3: The tooth shows bilobation. In occlusal view, the shape of the anterior lobe is square, the posterior one is elongated and triangular, the paracone is larger than the metacone which bends mesially, the parastyle is developed as well as the mesostyle, the metastyle is weakly developed, the outline of the fossa is a V-shape and located at the center of each lobe, an enamel island occurs at the middle of the tooth, the protocone is flat, the hypocone is sharped. The distal side is flat. In lingual view, metacone is weakly developed (Table 4.18, Figure 4.17).

Table 4.17 Upper DP3 measurements of *Bos javanicus* from Tham Prakai Phet (mm)

	Measurements				
	1	**2**	**3**	**4**	**5**
n	1	1	1	1	1
Mean	20.61	20.03	11.89	15.15	16.68

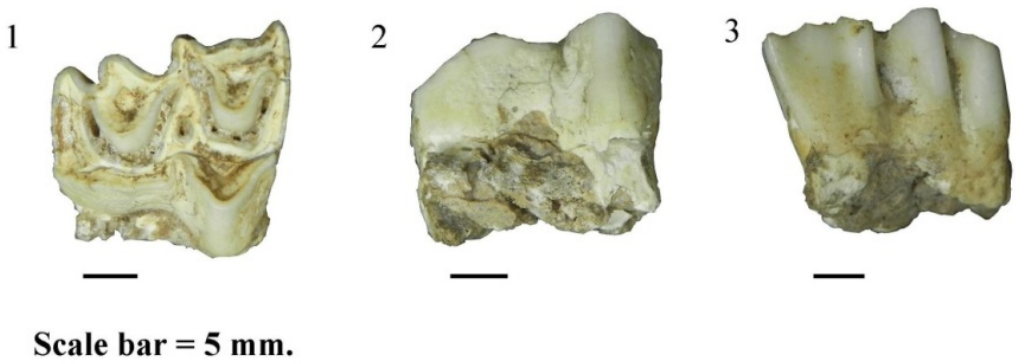

Figure 4.17 Upper left DP3 of *Bos javanicus* (SE77) from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views

P2: In occlusal view, the outline of crown is a trapezoid shape, the paracone is more marked than the metacone, the parastyle is developed and bends mesially, the metastyle is fused to the metacone and curved distally. The outline of fossa represents two oval shapes in worn teeth (TPKP47, TPKPSE67). No bilobation occurs in lingual side. In lingual view, the lingual side is flat or not developed. The length of tooth decreases from the top to the base. In labial view, the tooth bends distally. In mesial view, the small groove can be observed by touching. In labial view, the tooth bends distally (Table 4.19, Figure 4.18).

Table 4.19 Upper P2 measurements of *Bos javanicus* from Tham Prakai Phet (mm)

	Measurements			
	1	**2**	**3**	**4**
n	2	2	2	2
Max	21.48	18.77	14.76	14.98
Min	20.46	18.54	14.29	14.86
Mean	20.97	18.66	14.53	14.92
SD.	0.72	0.16	0.33	0.08

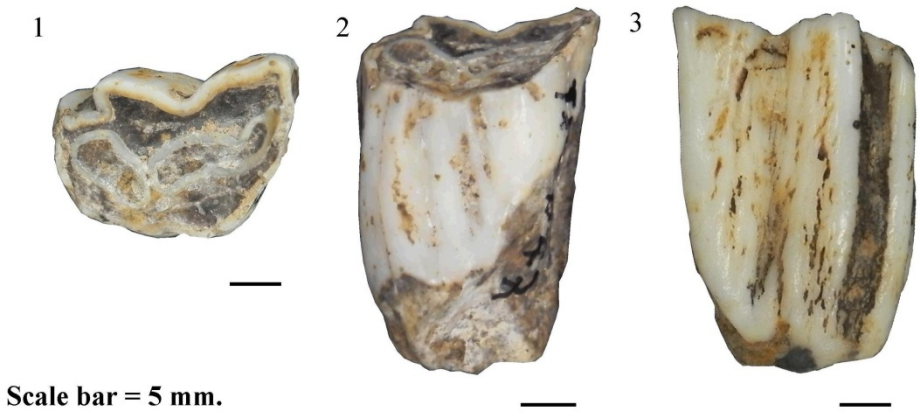

Figure 4.18 Upper a left P2 (TPKP 47) of *B. javanicus* 1-3) Occlusal, lingual, and labial views

P3: In occlusal view, the corwn outline is trapezoidal, the paracone is more prominent than the metaconid, the parastyle is developed and bends mesially, the metastyle is fused to the metacone, the outline of the fossa is a wide U-shape, being asymetrical. The protocone is very marked. The hypoconid is not developed and flat which inclines backwards. In lingual view, the wall is flat and not present any groove. In labial view, the conids and stylids are marked along the crown. The paracone is closed to the parastyle at the base. The top of the crown is larger than the base. In mesial view, a small groove can be observed (Table 4.20 and Figure 4.19).

In Tham Lod Rockshelter specimens, the labial bilobation is marked. The metaconid is morderately developed.

In Tham Prakai Phet specimens, the labial side exibits a weak bilobation which can be observed along the tooth. They present a small fold on the distal part a metaconid strongly marked (such as TPKPSE224) and a small fossete on the metastyle (such as TPKPSE224).

Table 4.20 Upper P3 measurements of *Bos javanicus* (mm)

Localities		**Measurements**			
		1	**2**	**3**	**4**
Tham Lod Rockshelter	N	3	3	3	3
	Max	22.67	21.84	19.26	17.93
	Min	20.53	18.17	13.92	16.27
	Mean	21.31	19.62	15.76	16.86
	SD.	1.18	1.95	3.04	0.93
Tham Prakai Phet	N	2	2	2	2
	Max	20.84	19.28	20.07	19.57
	Min	19.24	18.72	16.44	17.95
	Mean	20.04	19.00	18.26	18.76
	SD.	1.13	0.40	2.57	1.15

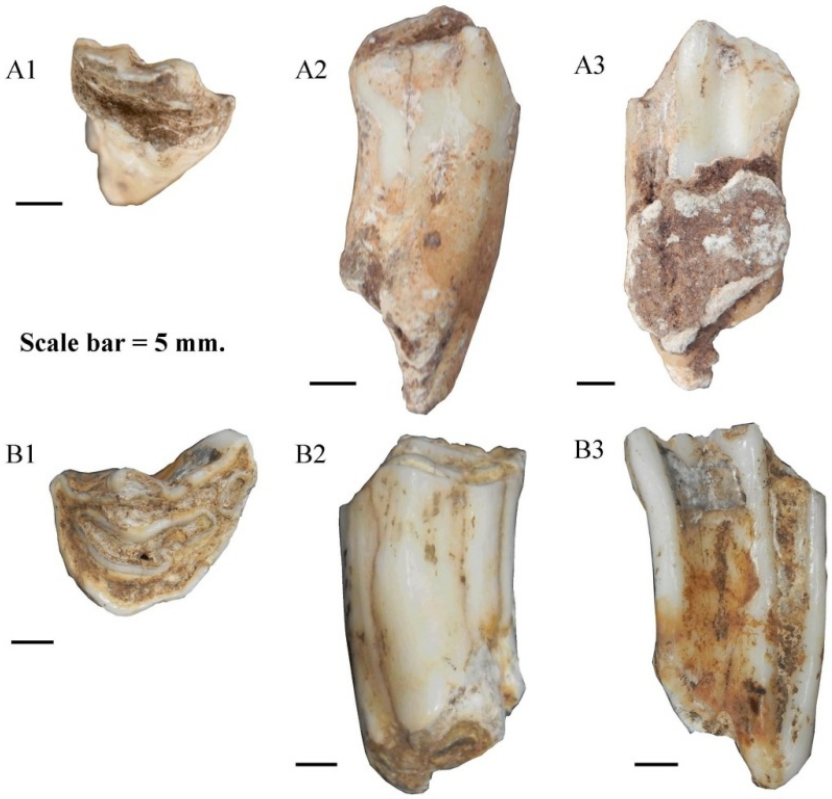

Figure 4.19 Lower P3 of *B. javanicus* A1-3) Occlusal, lingual, and labial views of a right P3 (A613 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left P3 (SE224) from Tham Prakai Phet

P4: In occlusal view, the tooth shows an asymmetric pentagonal shape. The bilobation occurs at the lingual side. The parastyle is marked and perpendicular to mesio-distal axis of the teeth, it is less important than the metastyle. The metastyle is also perpendicular to mesio-distal axis. The lingual cone is marked especially hypocone. The valley between the hypocone and the paracone is small and shallow. In labial view, the length of the tooth is expanded at the top and slightly pinched at the base. All cones and styles are marked along the tooth. In lingual view, a bilobation is present at the top, being rounded. In mesial view, the top is slightly narrower than at the base (Table 4.21 and Figure 4.20).

Tham Lod Rockshelter specimens present a weak bilobation at the lingual side.

Tham Prakai Phet specimens, the labial side is fromed bilobation. There is a small fossete near the distal side on TPKPSE85.

Table 4.21 Upper P4 measurements of *Bos javanicus* (mm)

Localities		**Measurements**			
		1	**2**	**3**	**4**
Tham Lod Rockshelter	N	2	2	2	2
	Max	19.21	17.58	19.25	22.53
	Min	17.99	15.95	14.17	19.06
	Mean	18.60	16.77	16.71	20.80
	SD.	0.86	1.15	3.59	2.45
Tham Prakai Phet	N	5	5	2	2
	Max	19.66	18.73	18.42	21.53
	Min	16.79	13.44	18.39	20.85
	Mean	18.73	16.57	18.41	21.19
	SD.	1.19	1.94	0.02	0.48

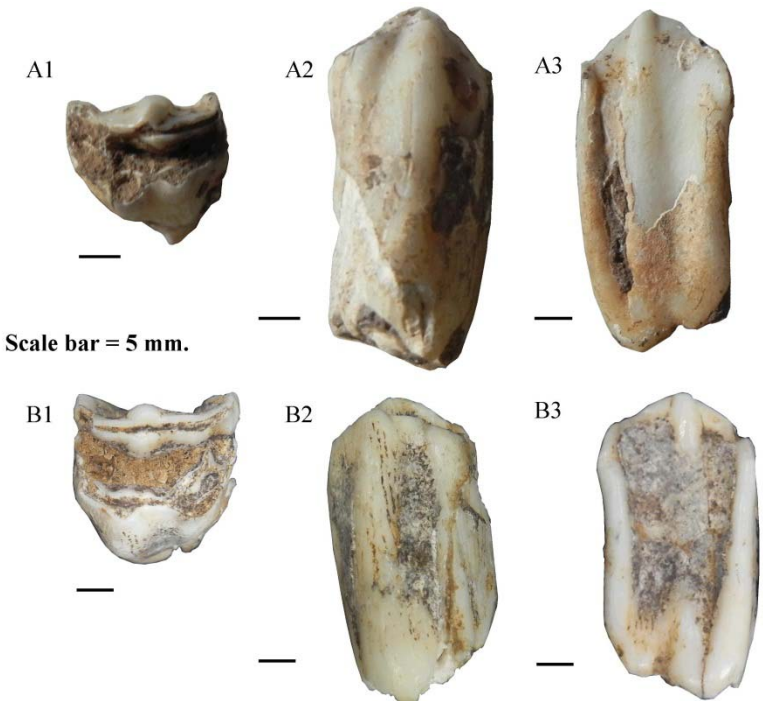

Figure 4.20 Lower P4 of *B. javanicus* A1-3) Occlusal, lingual, and labial views of a right P4 (A614 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left P4 (TPKPSE85) from Tham Prakai Phet

M1: In occlusal view, lobes present pentagonal shapes, the anterior lobe is smaller than the posterior one, labial styles and cones are prominent especially the mesostyle, lingual cones are rounded, the entostyle connects to distal side of the protocone, fossa are symmetrical especially in the posterior lobe. In some specimens a small fold is fromed from the distal side. The entostyle present one or two lobes. In labial view, the top of the crown is more dilated than the base, the paracone and the metacone are expanded at the base, labial styles are expanded on the top especially the metastyle. In lingual view, the entostyle is deep-rooted between the protocone and the hypocone, two grooves can be observed on lingual lobes. In mesial and distal view, the width is increased from the top to the base, the wall are more rounded than M2. At the base, the width is narrower than the length, (Table 4.22 and Figure 4.21).

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Table 4.22 Upper M1 measurements of *Bos javanicus* from Tham Prakai Phet (mm)

	Measurements					Entostyle	
	1	**2**	**3**	**5**	**7**	**Length**	**Number of lobe**
n	3	3	3	3	0	3	
Max	24.73	17.01	24.73	15.83	-	6.62	2
Min	22.51	16.15	22.51	15.33	-	5.36	1
Mean	23.34	16.44	23.34	15.57	-	5.85	
SD.	1.21	0.49	1.21	0.25	-	0.68	

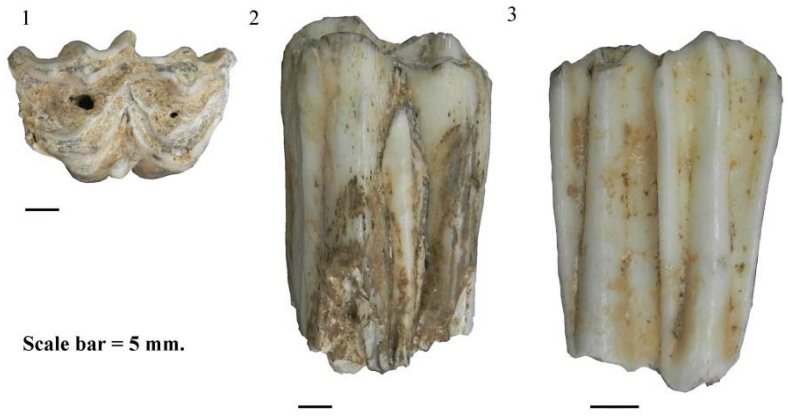


Figure 4.21 Upper a right M1 (TPKPSE49) of *B. javanicus* from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views

M2: The tooth is larger than the M1. In occlusal view, lobes have a pentagonal outline, the anterior lobe is larger than the posterior one. The parastyle and the mesostyle are prominent and curved forwards. They are more marked than the metastyle; an asymmetric fossa is located in each lobe with a small fold formed from the distal side. Labial cones show subrounded outline. The entostylid is formed from the distal side of the protocone and is perdendicular to the mesio-distal axis, It extends and has two lobes. In labial view, styles and conids are marked and straight along the tooth. The length of the top is as well as that of the base. In lingual view, the entostyle is deep-rooted, two grooves can be observed on lingual cones. In mesial and distal view, the base is more extended than the top. The length of tooth base is smaller than the length (Table 4.23 and Figure 4.22).

In Tham Lod Rockshelter specimens, the entostyle is extended and has usually uni-lobe. Only A41 in Area 2 has three lobes.

In Tham Prakai Phet specimens, the entostyle has one lobe.

Table 4.23 Upper M2 measurements of *B. javanicus* (mm)

Localities		Measurements					Entostyle	
		1	**2**	**3**	**5**	**7**	**Length**	**Number of lobe**
Tham Lod Rockshelter	n	3	3	3	3	3	3	
	Max	28.53	25.07	20.42	20.34	22.91	6.91	3
	Min	25.16	23.02	18.22	16.46	25.06	5.15	1
	Mean	26.33	23.79	19.32	18.00	24.55	6.02	
	SD.	1.90	1.12	1.10	2.06	22.91	0.88	
Tham Prakai Phet	n	5	4	6	5	3	3	
	Max	32.54	27.79	24.97	25.15	26.30	6.62	1
	Min	27.50	25.91	18.67	16.00	24.80	5.36	1
	Mean	29.80	26.74	21.08	20.16	25.63	5.85	
	SD.	1.90	0.91	2.25	3.43	0.76	0.68	

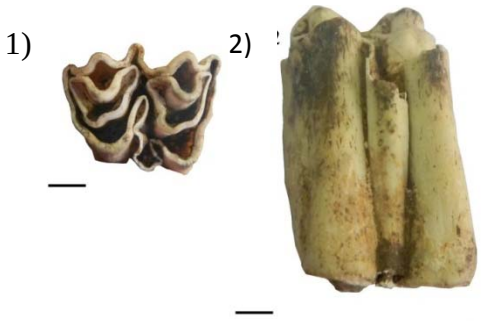


Figure 4.22 Upper M2 of *B. javanicus* 1-2) Occlusal and lingual views of a right M2 (TLA2329 in Area 2) from Tham Lod Rockshelter, scale bar = 5 mm

M3: The tooth is larger than upper M2. In occlusal view, the tooth is asymmetric. The anterior lobe is larger than the posterior one. They is perpendicular to the mesio-distal axis. Labial cones and styles are marked. Fossa is large and slightly asymmetric with one or two folds (consist of tiny fold and extended fold). Only the anterior fossa has a small fossa. The entostyle is formed from the distal side of the protocone and bends backwards. In labial view, the metastylar wing is marked. The top of labial cone are smaller than at the base. Interstylar of anterior lobe is often developed as well as the posterior one. In lingual view, the entostyle is deep-rooted. Two grooves exist on lingual cones. In mesial view, the base is strongly wider than the top, the mesial wall is flat. In distal view, the tooth shows a shallow groove related to a remarkable metastylar wing. (Table 4.24 and Figure 4.23).

In Tham Lod Rockshelter, the specimen TLA2330 in Area 2 present a metasrtylar wing less developed than others and, a large vertical rib occurs near the distal groove. A small subcircular fossete occurs between lobes in worn tooth (TLA434 and TLA2105 in Area 2). Lingual conids are subangular. The entostyle has one to three lobes which are marked on the top. At the base of the tooth, the length is larger than the width.

In Tham Prakai Phet specimens, the metastylar wing is less developed than others in TPKPNE11. A small rounded fossete can occurs between cones in worn tooth (TPKP26). The entostyle is fromed one or two lobes. At the base, the tooth is square shape or rectangular-shape.

Table 4.24 Upper M3 measurements of *Bos javanicus* (mm)

Localities		**Measurements**					**Entostyle**	
		1	**2**	**3**	**5**	**7**	**Length**	**Number of lobe**
Tham Lod Rockshelter	n	6	5	5	5	3	4	
	Max	31.87	31.53	21.20	27.68	22.19	7.30	3
	Min	26.87	24.21	16.43	21.06	14.76	5.87	1
	Mean	28.49	28.43	18.45	25.50	17.40	6.42	
	SD.	1.97	2.70	2.23	2.75	2.87	0.67	
Tham Prakai Phet	n	1	3	5	5	1	3	
	Max		31.73	21.74	27.17		8.52	2
	Min		27.16	17.78	24.64		4.09	1
	Mean	28.80	29.12	19.55	26.13	18.58	6.59	
	SD.		2.35	1.86	1.11		2.27	

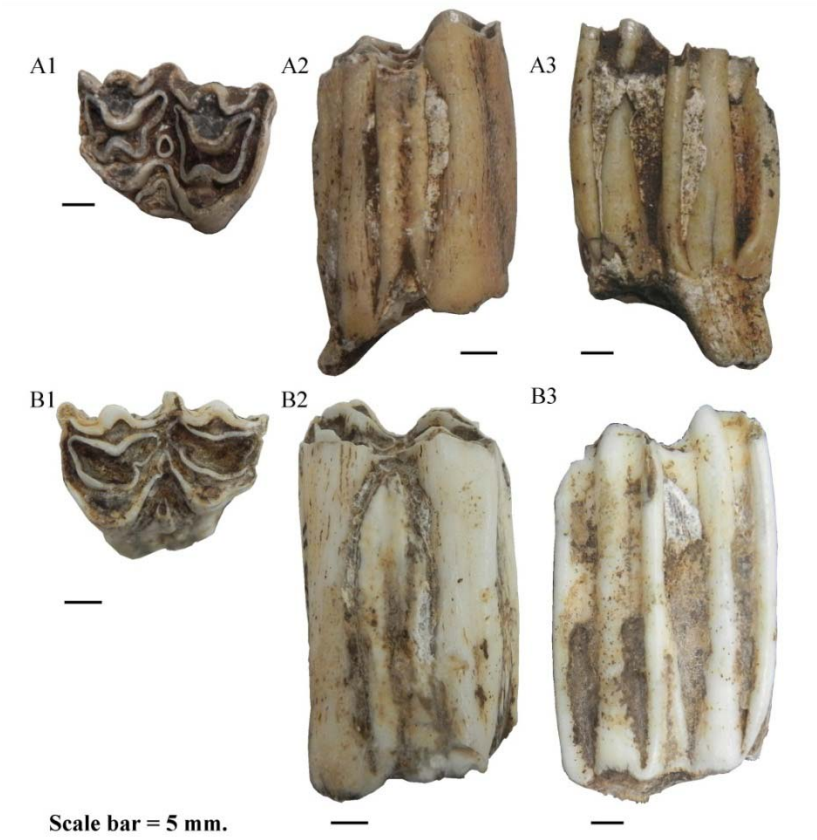


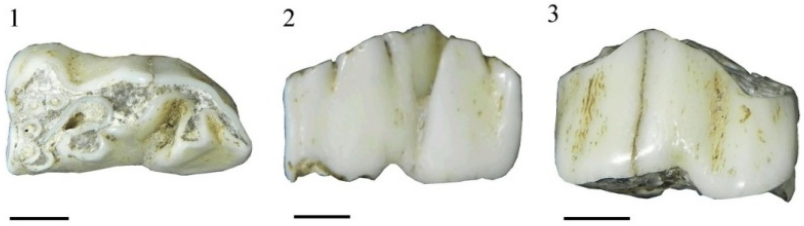
Figure 4.23 Upper M3 of *B. javanicus* A1-3) Occlusal, lingual, and labial views of a right M3 (TLA2105) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left M3 (TPKPNE11) from Tham Prakai Phet

Lower dentition:

dp3: The tooth is brachyodont. In occlusal view, the outline of the tooth is a triangular shape, the parastyle is marked, the paraconid is strongly developed and rounded. The valley between the paraconid and the parastylid is small and clearly deep. The anterior valley is wide and rounded. The middle of the metaconid is marked. The metaconid has a semicircular shape. The posterior valley is enclosed. The entoconid merges from the entostylid. The protoconid is rounded and inclined mesially. The hypoconid is prominent and rounded. The lingual valley is shallow. The distal wall is flat. In lingual view, the parastylid is marked along the tooth. The metaconid is dilated at the base. The width of the anterior valley is decreased from the top to the base. In labial view, the wall is rounded. The labial valley exists from the top to the base (Table 4.25 and Figure 4.24).

Table 4.25 Lower dp3 measurements of *Bos javanicus* from Tham Prakai Phet (mm)

	Measurements				
	1	**2**	**3**	**4**	**5**
n	3	3	3	3	3
Max	23.07	21.76	10.56	11.02	4.33
Min	18.93	19.34	9.61	9.75	4.19
Mean	20.73	20.32	10.16	10.44	4.26
SD.	2.12	1.27	0.49	0.64	0.07



Scale bar = 5 mm.

Figure 4.24 Lower dp3 of *Bos javanicus* 1-3) Occlusal, lingual, and labial views of a left dp3 (NW6) from Tham Prakai Phet

dp4: The tooth is three-lobe shape. In occlusal view, the first has a triangular shape, the second and the third lobe have a trapezoid outline. The first lobe is smaller than others, the third lobe is the largest. The labial stylids are marked especially the entostylid, the mesotyle bends mesially, lingual conids are sharp especially the third one, two ectostylid exists between lobes. In lingual view, the length of the base is shorter than the length at the top, the metastylid occurs at the top of the tooth. In the mesial view, the top is slightly larger than the base (Table 4.26, Figure 4.25).

Table 4.26 Lower dp4 measurements of *Bos javanicus* from Tham Prakai Phet (mm)

	Measurements					
	1	**2**	**3**	**4**	**5**	**6**
N	2	2	2	2	2	2
Max	40.89	31.86	11.44	12.42	12.37	17.71
Min	34.93	29.03	11.01	11.57	12.06	16.97
Mean	37.91	30.45	11.23	12.00	12.22	17.34
SD	4.21	2.00	0.30	0.60	0.22	0.52

Figure 4.25 A left lower dp4 (TPKPSW162) of *B. javanicus* from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views

p2: In occlusal view, the tooth has a triangular shape, the lingual side is rounded, the lingual valley is very weak, the parastylid is weakly developed, the anterior valley is also slightly marked. The posterior valley occurs at the end of the tooth. In lingual view, the tooth is straight; the lingual valley is marked only at the top of the crown. In lingual view, the mesial side is inclined backwards, the posterior valley is developed at the top (Table 4.27, Figure 4.26).

Table 4.27 Lower p2 measurements of *B. javanicus* from Tham Prakai Phet (mm)

Localities		**Measurements**			
		1	**2**	**3**	**4**
Tham Lod Rockshelter	n	2	2	1	2
	Max	10.28	11.81	6.10	8.69
	Min	9.89	11.07	6.10	8.54
	Mean	10.09	11.44	6.10	8.62
	SD.	0.28	0.52	-	0.11
Tham Prakai Phet	n	2	2	2	2
	Max	13.57	14.00	11.09	10.11
	Min	12.68	13.62	7.86	9.43
	Mean	13.13	13.81	9.48	9.77
	SD.	0.63	0.27	2.28	0.48

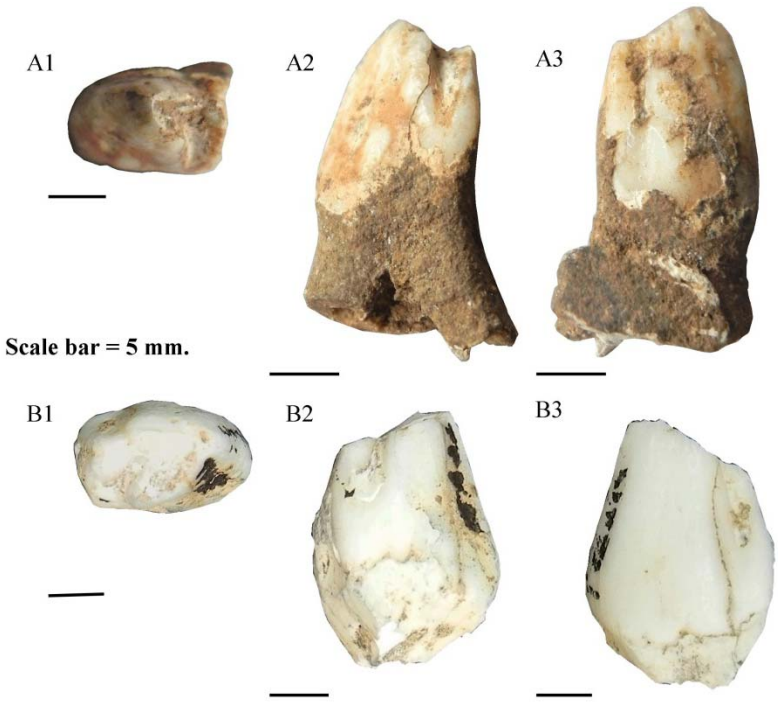


Figure 4.26 Lower p2 of *B. javanicus* A1-3) Occlusal, lingual, and labial views of a right p2 (TLA1269 in Area 1) in Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left p2 (TPKPNW24) from Tham Prakai Phet

p3: The tooth has a triangular-outline. In occlusal view, the paraconid is more marked than the parastylid, the valley between the paraconid and the parastylid is marked, the anterior valley has a wide U-shape. The metaconid is extended and bends backwards. Both the entoconid and the entostylid are developed. The labial face is rounded. The labial valley is marked. In labial view, the valley is marked along the crown. In lingual view, the anterior valley is marked from the top to the base, other valleys are only present at the top of the crown (Table 4.28, Figure 4.27).

In Tham Lod Rockshelter specimens, the posterior valley of TLA928b in Area 1 is enclosed. A fossete can occurs between the entoconid and the entostylid in TLA7703 in Area 1.

In Tham Prakai Phet specimens, the posterior valley is never enclosed

Table 4.28 Lower p3 measurements of *Bos javanicus* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	3	2	3	2	1
	Max	24.56	20.29	12.54	11.78	5.58
	Min	19.73	18.98	8.99	10.16	5.58
	Mean	21.73	19.64	10.61	10.97	5.58
	SD.	2.52	0.93	1.80	1.15	-
Tham Prakai Phet	n	7	6	6	6	5
	Max	22.89	20.56	12.74	13.60	5.98
	Min	20.41	19.04	10.25	11.83	4.41
	Mean	21.75	19.80	11.71	12.37	5.08
	SD.	0.80	0.56	0.91	0.66	0.64

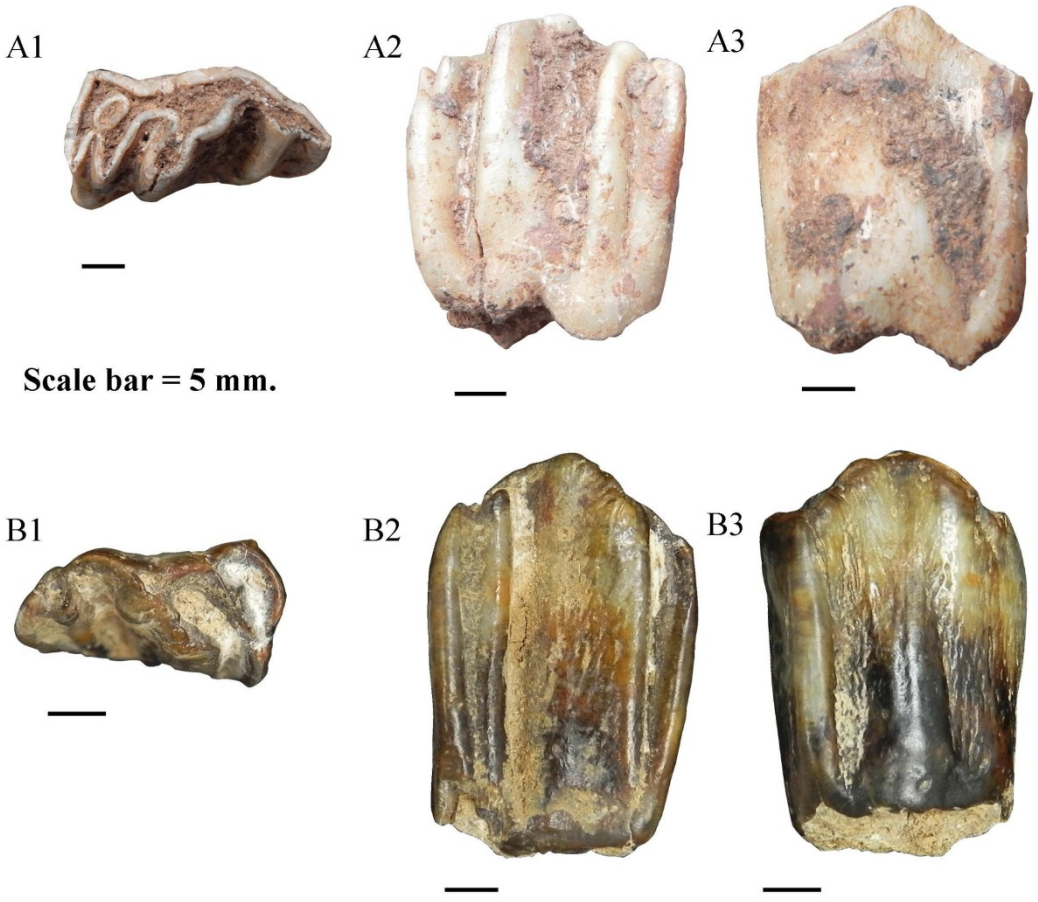


Figure 4.27 Lower p3 of *B. javanicus* A1-3) Occlusal, lingual, and labial views of a left p3 (A7703 in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right p3 (SW37) from Tham Prakai Phet

p4: In occlusal view, the paraconid and the parastylid are prominent, the valley between paraconid and parastylid is slightly marked, the anterior valley is wide. The metaconid is elongated, rounded at the end, and it bends distally, the middle of the metaconid is marked. The entoconid merges to the entostylid. The posterior valley is an elongated U-shape. The protoconid is marked and rounded. The lingual valley has a wide square outline. The hypoconid is marked. In labial view, the valley is marked along the crown. In lingual view, the anterior and the posterior valley are marked from the top to the base (Table 4.29, Figure 4.28).

In advance worn teeth, posterior valley are slightly enclosed (in A571, Area 2 from Tham Lod Rockshelter and TPKPNE262, TPKPNW148 and TPKP NW85 from Tham Prakai Phet).

Table 4.29 Lower p4 measurements of *Bos javanicus* from Tham Prakai Phet (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	4	4	4	4	3
	Max	23.92	24.93	12.44	12.78	6.66
	Min	20.73	20.61	10.72	11.00	2.14
	Mean	22.63	22.88	11.33	11.82	4.38
	SD.	1.52	1.79	0.77	0.90	2.26
Tham Prakai Phet	n	1	1	1	1	1
	Max	25.27	21.79	15.22	13.67	6.78

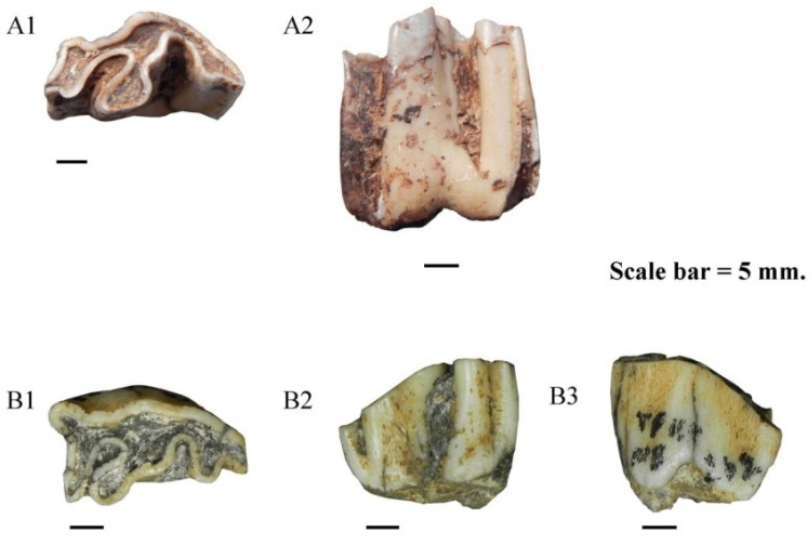


Figure 4.28 Lower p4 of *B. javanicus* A1-3) Occlusal, and lingual views of a left p4 (TPKPA2344 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left p4 (TLNE262) from Tham Prakai Phet.

m1: In occlusal view, the anterior lobes is more robust than the posterior one, the parastylid is prominent and perpendicular to the mesio-distal axis, the metastylid is rarely developed, the entostylid is marked and bends backwards, the lingual valley is flat and wide, the ectostylid merged from the mesial side of the hypoconid and bends mesially, the fossa located at the center of the tooth has an U-shape associated with a fold, the protoconid is square, the hypoconid is sharp. For a most all the teeth, the width of anterior lobe is closed to the lenght of the posterior one. In lingual view, the top of the crown is clearly larger than the base, the metaconid and the entoconid are parallel and morderately marked along the crown. In labial view, the ectostylid is deep-rooted, a distal grooves can be clearly noticed at the paraconid and the hypoconid (Table 4.30, Figure 4.29).

Table 4.30 Lower m1 measurements of *Bos javanicus* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	8	7	8	7	7
	Max	26.96	23.91	14.51	15.39	15.50
	Min	23.10	20.83	11.71	11.42	14.43
	Mean	25.14	22.27	13.38	13.31	15.02
	SD.	1.31	1.16	1.05	1.39	0.44
Tham Prakai Phet	n	10	10	10	10	10
	Max	28.48	28.48	28.48	28.48	28.48
	Min	24.41	24.41	24.41	24.41	24.41
	Mean	26.00	26.00	26.00	26.00	26.00
	SD.	1.24	1.24	1.24	1.24	1.24

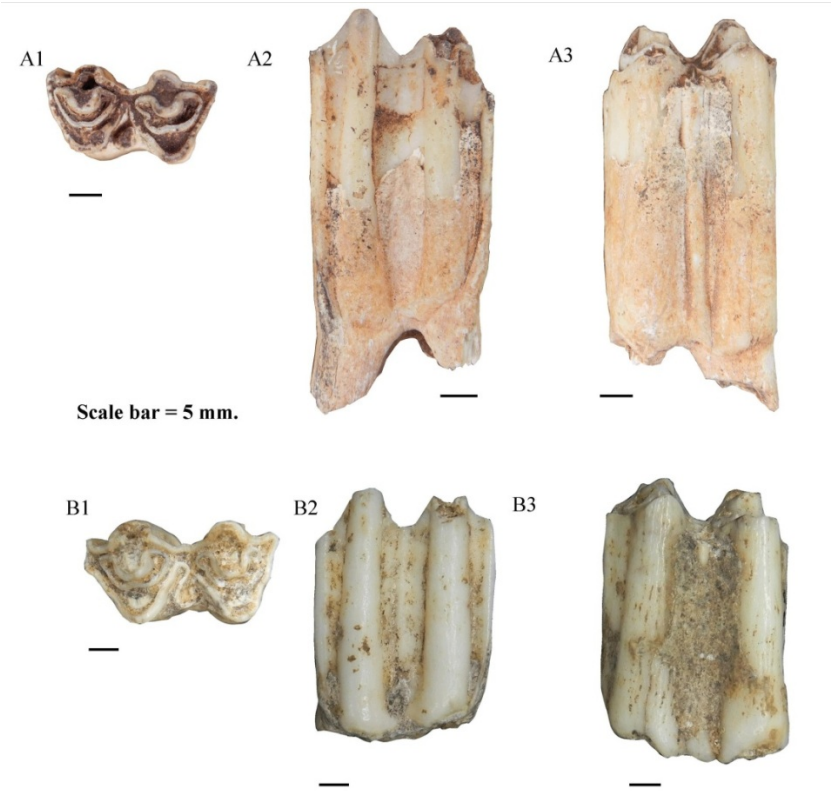


Figure 4.29 Lower m1 of *B. javanicus* A1-3) Occlusal, lingual, and labial views of a right m1 (TLA570 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left m1 (TPKPSE112) from Tham Prakai Phet

m2: The characteristics of the tooth are closed to m1. In occlusal view, each lobe has a trapezoid outline, lingual stylids are less marked than on the m1, the parastylid is prominent and perpendicular to the mesio-distal axis, the entostylid is less developed than the parastylid and clearly bends distally, the metastylid is weakly marked as a small rib, the metaconid is as wide as the entoconid, the labial wall is sharper than m1, the labial valley is flat and wide. In the mesial and the distal side, the top is as wide as the base (Table 4.31, Figure 4.30).

In Tham Lod Rockshelter specimens, the width of anterior lobe is clearly larger than the posterior one, unlike in m1. Except TLA920 in Area 1, the anterior lobe is slightly as wide as the posterior one

In Tham Prakai Phet specmines, the width of anterior lobe is as well as the posterior one, like in m1, except TPKP30 and TPKPSE255. The anterior lobe is larger the posterior one in TPKPSW96.

Table 4.31 Lower m2 measurements of *Bos javanicus* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	3	3	3	3	3
	Max	33.59	29.37	15.02	14.98	16.97
	Min	26.11	23.29	12.98	12.46	15.71
	Mean	28.91	25.50	13.72	13.39	16.26
	SD.	4.08	3.37	1.13	1.39	0.65
Tham Prakai Phet	n	12	9	11	11	10
	Max	34.83	30.30	19.56	19.36	20.37
	Min	26.99	26.69	10.55	10.70	13.72
	Mean	29.93	28.01	15.60	15.70	18.60
	SD.	2.39	1.22	3.11	3.25	2.00

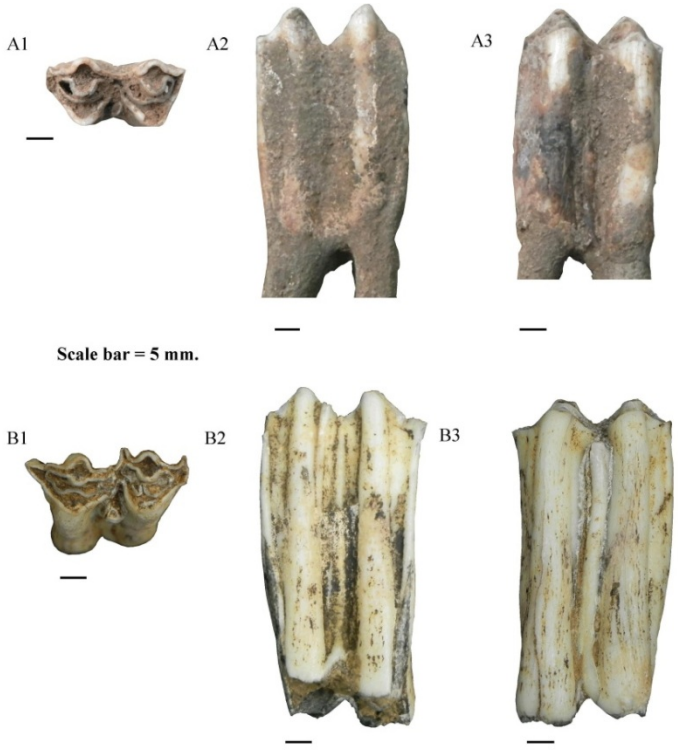


Figure 4.30 Lower m2 of *B. javanicus* A1-3) Occlusal, lingual, and labial views of a left m2 (TLA1288 in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right m2 (TPKPSW214) from Tham Prakai Phet

m3: In occlusal view, the parastylid is moderately developed, the entostylid is weakly marked and bends distally, the metastylid is rarely developed. The valley between the metaconid and the entoconid, it is flat. The hypoconulid is rounded. The distal ridge exists at the end of the third conid and bends distally (Table 4.32, Figure 4.31).

In Tham Lod Rockshelter specimens, the parastylid bends forwards, no metastylid exists.

In Tham Prakai Phet specimens, lobes have triangular shape in early stage, rounded in advance stage, the parastylid is straight, the metastylid presents only on top of unworn crown.

Table 4.32 Lower m3 measurements of *Bos javanicus* (mm)

Localities		**Measurements**					
		1	**2**	**3**	**4**	**5**	**6**
Tham Lod Rockshelter	n	5	2	5	5	4	5
	Max	38.23	42.45	16.60	14.06	7.33	17.66
	Min	31.25	39.52	12.00	11.96	4.75	14.88
	Mean	35.26	40.99	13.79	12.92	6.11	16.23
	SD.	2.68	2.07	1.85	0.82	1.12	1.02
Tham Prakai Phet	n	9	8	10	11	10	9
	Max	44.89	45.95	15.49	16.96	8.85	19.60
	Min	36.42	35.87	12.71	11.71	5.09	15.20
	Mean	40.23	41.01	14.43	14.49	6.86	17.82
	SD.	2.59	3.08	0.95	1.43	1.09	1.55

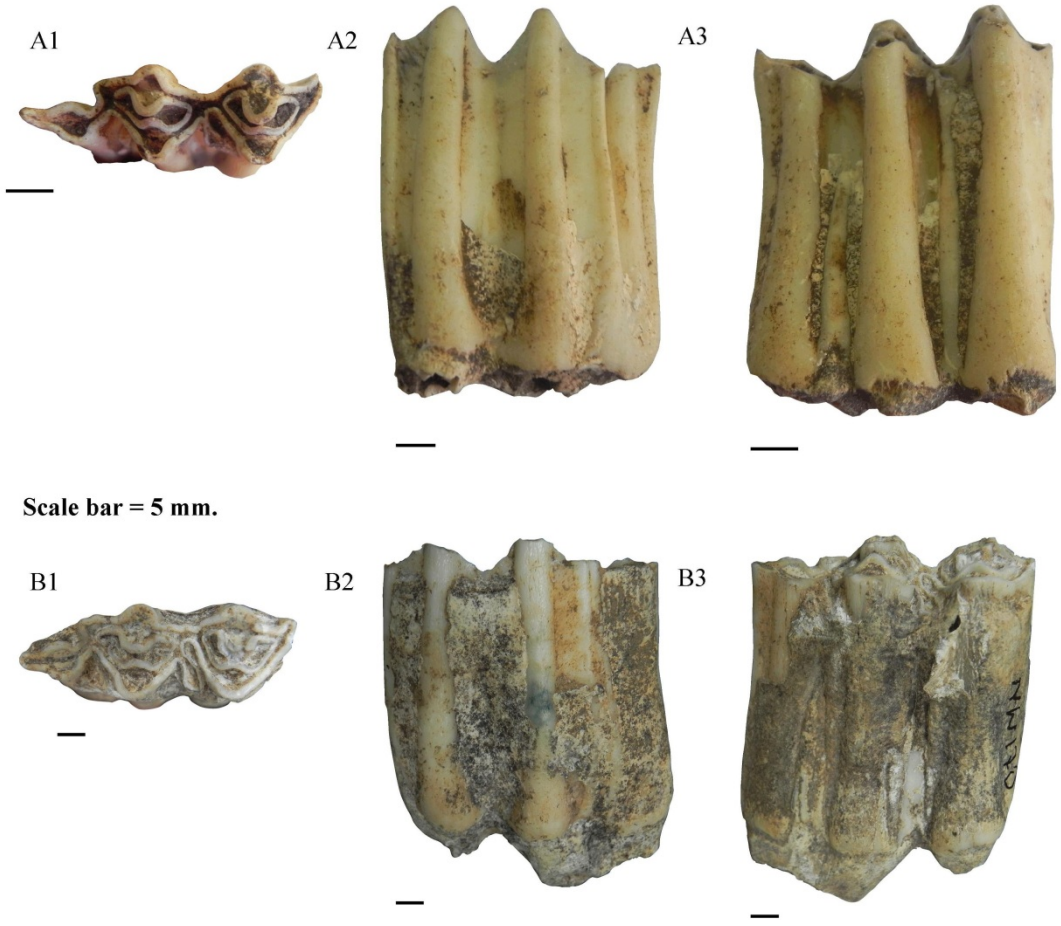


Figure 4.31 Lower m3 of *B. javanicus* A1-3) Occlusal, lingual, and labial views of a right m3 (TLA2328 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right m3 (TPKPNW170) from Tham Prakai Phet

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

Family: Bovidae Gray, 1821

Subfamily: Bovinae Gray, 1821

Genus: *Bos* Linnaeus, 1758

Species: *Bos* cf. *sauveli*

Localities: Tham Lod Rockshelter and Tham Prakai Phet.

Material: Tham Lod Rockshelter: Totally 7 teeth, 1 M3, 1 p3, 1 p4, and 4 m3. Tham Prakai Phet: Totally 5 teeth, 1 M2, 2 p3, and 2 p4.

Upper dentition:

M2: In occlusal view, the mesostyle is well developed and larger than the others styles, fossa present U-shape with distal fold, the fosseta is absent. In labial view, all cones and styles are marked, the top is slightly dilated, the base is relatively straight. In lingual view, the entostyle is deep-rooted and bilobed at the top, two shallow grooves on the labial face can be observed on mesial wall of the protocone and distal wall of the hypocone. In mesial and distal view, no groove occurs, both mesial and distal sides are slightly flat. At the base, the tooth is square (Table 4.33, Figure 4.32).

Table 4.33 Upper M2 measurements of *Bos* cf. *sauveli* (mm)

	Measurements					**Entostyle**	
	1	**2**	**3**	**5**	**7**	**Length**	**Number of lobe**
n	1	1	1	1	1	-	-
mean	29.06	27.7	24.88	26.05	28.09	-	-

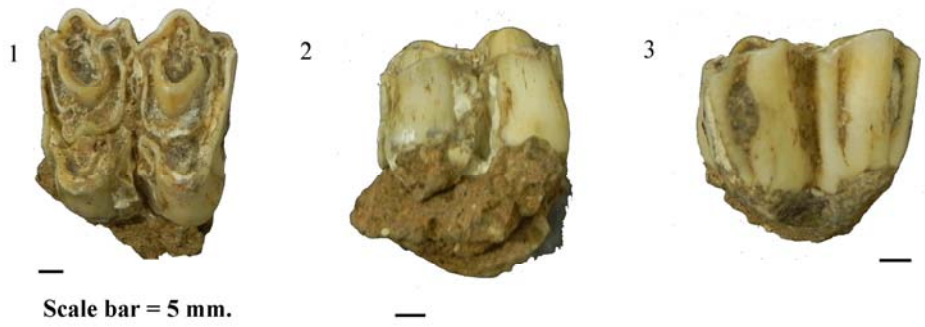


Figure 4.32 A right upper M2 (TPKPSE53) of *B.* cf. *sauveli* from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views

M3: In occlusal view, the anterior lobe is clearly larger than the posterior one, the parastyle is prominent and curves mesially. The mesostyle and the parastyle are developed and perpendicular to the mesio-distal axis. The metastylar wing is also marked and is curved distally. The paracone is more prominent than the metacone. Fossa are large and slightly asymmetric associated to an extended lingual fold. Lingual walls are well-developed and slightly bend mesio-lingually. The entostyle is fromed at the anterior lobe bended backwards. In lingual view, the entostyle is deep-rooted between the protocone and the hypoconid. Two lateral grooves present at the mesial corner of the protocone and at the distal corner of the hypocone. In labial view, the

length of the top is as long as the lenght of the base, the metastylar wing is strongly marked and straight along the tooth. The anterior interstylar space is smaller than the posterior one. In distal view, the top is larger than the base a shallow groove exists which is related to a reamakable metastylar wing. At the base, the tooth has rectangular outline (labio-lingually), Table 4.34 and and Figure 4.33).

Table 4.34 Upper M3 measurements of *Bos sauveli* (mm)

	Measurements								**Entostyle**	
	1	**2**	**3**	**5**	**6**	**8**	**9**	**10**	**Length**	**Number of lobe**
n	1	1	1	1	1	1	1	1	1	
Mean	34.84	34.14	24.09	21.58	21.87	25.91	13.29	10.40	7.24	1

Figure 4.33 Upper M3 of *B.sauveli* 1-3) Occlusal, lingual, and labial views of a right M3 (A1607 in Area 1) from Tham Lod Rockshelter

Lower Denition

p3-p4: In occlusal view, the paraconid and the parastylid are fused in p3 but are not fused and marked in p4, the valley between the paraconid and the metaconid has a deep U-shape. The metaconid is extended and closed to the entoconid. The lingual wall is flat. The labial wall is rounded. The posterior valley is enclosed, then, it is a large ovale fossa in advance wearing stage. In lingual view, the wall is slightly marked. In mesial view, the wall is rounded. The p4 present a larger and more marked hypocone than the p3 (Table 4.35, Figure 4.34).

In Tham Lod Rockshelter specimens, the labial valley is weakly developed.

In Tham Prakai Phet specimens, only fragmented teeth were discovered especially the posterior part of the tooth. The hypocone is marked, the labial valley is

marked, the lingual side is seem falt even if, these teeth are broken. They show many fossa in the center of posterior part.

Table 4.35 Lower p4 measurements of *Bos sauveli* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	1	1	1	1	-
	Max	25.21	25.86	13.70	14.02	-
Tham Prakai Phet	n	2	2	2	2	2
	Max	23.91	23.51	14.20	13.59	3.92
	Min	22.38	21.39	12.00	11.66	3.33
	Mean	23.15	22.45	13.10	12.63	3.63
	SD.	1.08	1.50	1.56	1.36	0.42

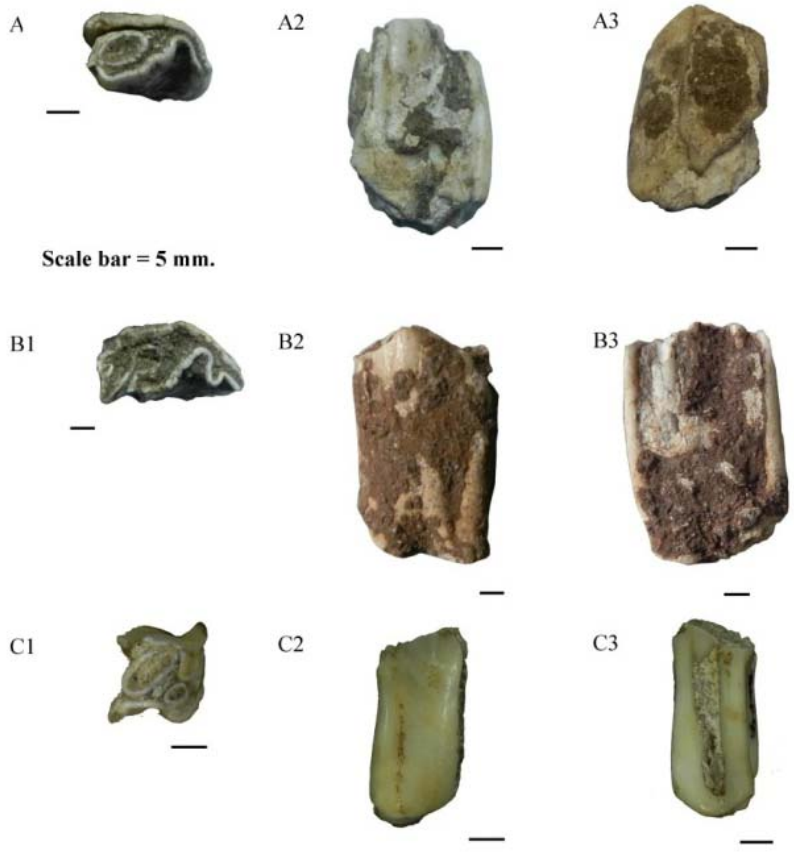


Figure 4.34 Lower p3-p4 of *B. sauveli*: A1-3) Occlusal, lingual, and labial view of a broken left p3 (TLA1303 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial view of a left p4 (TLA1282 in Area 2) from Tham Lod Rockshelter; C1-3) Occlusal, lingual, and labial of a broken left p3 (TPKPSE41B) from Tham Prakai Phet

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

Family: Bovidae Gray, 1821

Subfamily: Bovinae Gray, 1821

Genus: *Bubalus* Smith, 1827

Species: *Bubalus arnee* (Kerr, 1792)

Localities: Tham Lod Rockshelter and Tham Prakai Phet

Material: Tham Lod Rockshelter24 teeth, 1 P2, 1 P3, 1 P4, 2 M1, 3 M2, 4 M3, 2 i1, 1 i, 1 p3, 1 m1, 2 m2, and 5 m3, .

Tham Prakai Phet : totally 17 teeth: 1 DP2, 1 P2, 1 P3, 2 P4, 3 M2, 2 insicor, 1 p4, 5 m2, and 1 m3.

DP2: In occlusal view, the tooth present a strong bilobation in both labial and lingual sides, the parastyle and the metastyle are very marked, the paracone and the metacone show triangular shape, the labial valley has V-shape, the mesial edge bend forwards, the protocone and hypocone are rounded, the labial valley show an U-outline, the distal edge is straight. In ligual view, the tooth bends forwards. In labial view, cones and styles are marked along the tooth (Table 4.36, Figure 4.35).

Table 4.36 Upper DP2 measurements of *Bubalus arnee* from Tham Prakai Phet

	Measurements			
	1	**2**	**3**	**4**
n	1	0	1	1
Mean	20.25	-	16.93	18.25

Figure 4.35 A right DP2 TPKP(NW171) of *Bubalus arnee* from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views

P2: In occlusal view, the paracone is more marked than the metastyle which shows an asymmetrical shape and bends mesially. The parastyle is weakly prominent. The metastyle is predominent and perpendicular to the mesio-distal axis. The metastyle is curved backwards. The fossa presents a U-shape. The lingal cone is very round and robust. In labial view, the tooth clearly is curved distally. All styles and cones are strongly marked along the tooth, except the metastyle. The metastyle is present only on the top of the crown. In lingual view, the wall is strongly rounded. The tooth is slightly dilated at the top (Table 4.37, Figure 4.36).

At Tham Prakai Phet, the specimens present an absence of bilobation. The fossa pinched at the middle with many small folds. The lingal cone is flat.

Table 4.37 Upper P2 measurements of *Bubalus arnee* (mm)

Localities		**Measurements**			
		1	**2**	**3**	**4**
Tham Lod Rockshelter	N	1	1	1	1
	Mean	20.26	18.52	16.84	15.71
Tham Prakai Phet	N	1	1	1	1
	Max	20.25	19.15	16.93	18.25

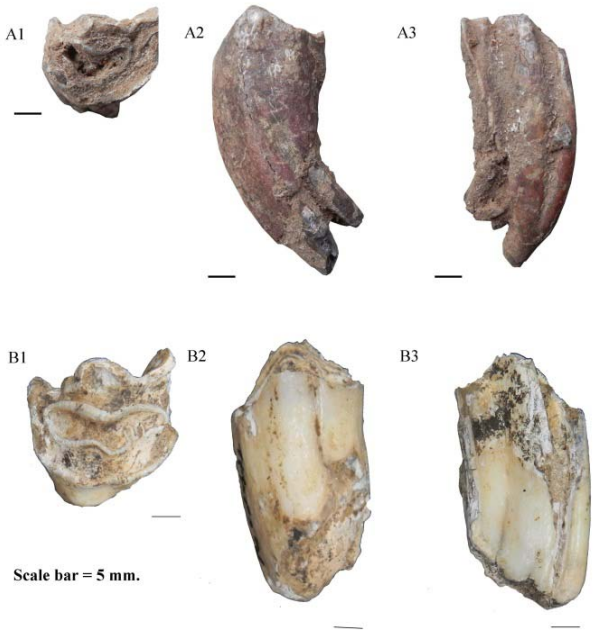


Figure 4.36 Upper P2 of *B. arnee* A1-3) Occlusal, lingual, and labial views of a left P2 (TLA2210 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right P2 (TPKPSW39) from Tham Prakai Phet

P3: In occlusal view, the tooth is more symmetric than P2. No bilobation can be noticed. The outline is triangular. The conid and stylids are prominent. The parastylid is more marked than the metastylid. The fossa has an asymetric U-shape outline. The fossete are absent. In labial view, the tooth is less curved distally than P2. Styles and conids are strongly marked along the tooth. In lingual view, the wall is rounded, no grooves present. In distal view, the tooth slightly is curved backwards (Table 4.38, Figure 4.37).

Table 4.38 Upper P3 measurements of *Bubalus arnee* (mm)

Localities		**Measurements**			
		1	**2**	**3**	**4**
Tham Lod Rockshelter	N	1	1	1	1
	Mean	21.71	17.58	21.35	20.09
Tham Prakai Phet	N	1	1	1	1
	Max	19.14	16.34	18.84	18.85

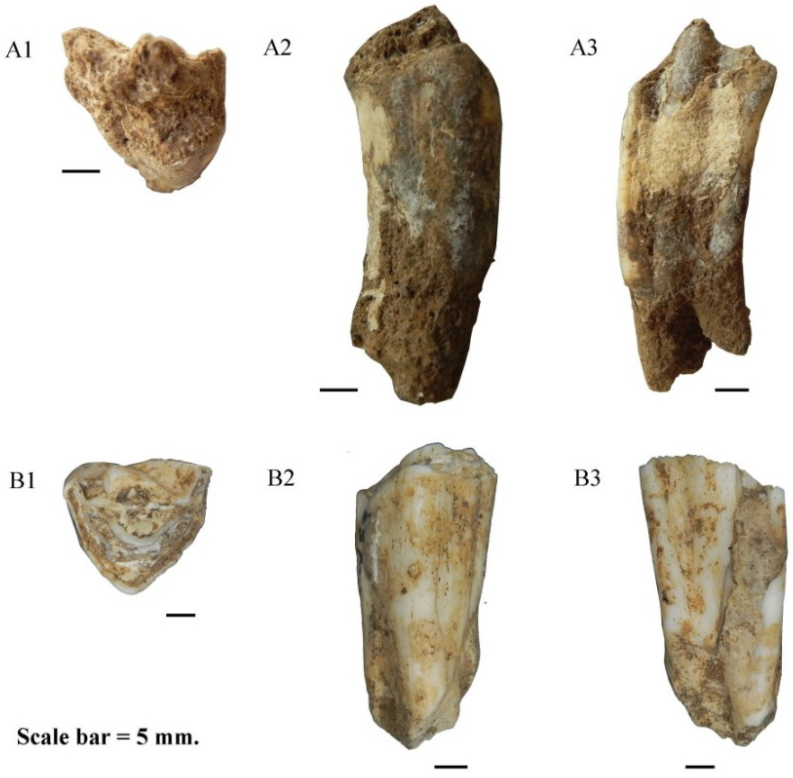


Figure 4.37 Upper P3 of *Bubalus arnee* A1-3) Occlusal, lingual, and labial views of a right P3 (A1538 in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left P3 (SW59) from Tham Prakai Phet

P4: In occlusal view, the tooth is more symmetric and present a triangular. The tooth is larger than P3, all conids and styles are strongly marked. The fossa is a large-U-shape with two lateral folds pinched at the middle in worn tooth. In labial view, the wall is strongly marked. Labial cones locate at the center of the tooth. The labial cone is strongly sharp in early worn tooth (SE47) and being rounded with the use of the crown (in TPKPSE198) (Table 4.39, Figure 4.38).

Table 4.39 Upper P4 measurements of *Bubalus arnee* (mm)

Localities		**Measurements**			
		1	**2**	**3**	**5**
Tham Lod Rockshelter	n	1	1	1	1
	Mean	20.80	19.34	20.13	21.13
Tham Prakai Phet	n	2	2	2	2
	Max	2	2	2	2
	Min	23.7	18.95	23.33	23.54
	Mean	18.21	17.15	21.58	22.09
	SD	20.96	18.05	22.46	22.82

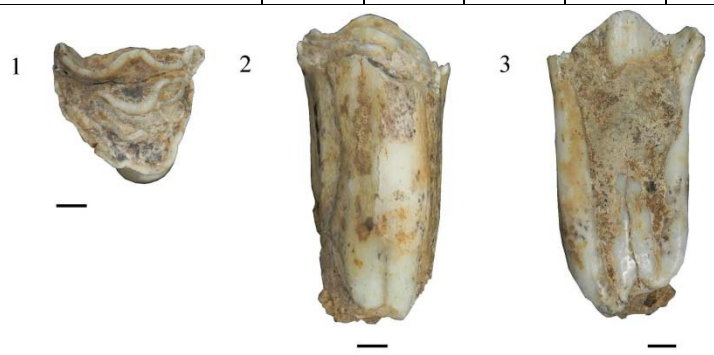


Figure 4.38 A left P4 (TPKPSE47) of *Bubalus arnee* from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views, scale bae = 5 mm

M1: The tooth is strongly robust, the anterior lobe is smaller than the posterior one**,** the parastyle and the mesostyle are marked, the metastyle is often lost by abrasion. Labial cones are robusts and rounded. Fossa have a large U-shaped. The posterior fossa has a large fold, many enamel island occurs between the lobes, the paracone and the hypocone are strongly rounded. The entostylid is conect to between the protoconid and the hypoconid. The entostyle is often lost. In labial view, the tooth present a weak dilation at the top, all styles are marked, conids are strongly developed. In lingual view, the entostyle is also deep-rooted between the paracone and the hypoconid. No grooves

on protocone and hypocone can be observed. In mesial and distal view, the base is slightly larger than the top (Table 4.40, Figure 4.39)

Table 4.40 Upper M1 measurements of *Bubalus aree* from Tham Lod Rockshelter (mm)

	Measurements					**Entostyle**	
	1	**2**	**3**	**5**	**7**	**Length**	**Number of lobe**
N	2	2	2	2	2	2	
Max	31.26	31.17	23.93	23.76	28.52	4.81	1
Min	27.37	26.34	22.57	23.64	27.52	4.57	1
Mean	29.32	28.76	23.25	23.70	28.02	4.69	
SD.	2.75	3.42	0.96	0.08	0.71	0.17	

Figure 4.37 A left M1 (TLA2274 in Area 1) of *Bubalus arnee* from Tham Lod Rockshelter 1-3) Occlusal, lingual, and labial views

M2: The tooth is similar to M1, it present a strongly robust developed styles and cones. The metastyle is less marked than other styles, fossas are marked, anterior fossa has an elongated fold, the entostylid is marked and complicated, the labial side is strongly rounded. No groove in labial side. M2 is larger than M1. (Table 4.41).

Table 4.41 Upper M2 measurements of *Bubalus arnee* (mm)

	Measurements					**Entostyle**	
	1	**2**	**3**	**5**	**7**	**Length**	**Number of lobe**
N	3	2	3	3	2	2	
Max	32.82	34.54	24.25	26.07	26.72	5.69	1
Min	30.22	32.05	15.89	15.77	25.90	5.37	1
Mean	31.77	33.30	20.79	20.36	26.31	5.53	
SD	1.37	1.76	4.36	5.24	0.58	0.23	

M3: The tooth morphology is similar to M1 and M2. All fossa has fold especially posterior cone has extended fold. In occlusal view, metastylar wing is less developed than other styles but in labial view, the metastylar wing is larger than the other style (Table 4.42, Figure 4.40).

Table 4.42 Upper M3 measurements of *Bubalus arnee* (mm)

Localities		**Measurements**					**Entostyle**	
		1	**2**	**3**	**5**	**7**	**Length**	**Number of lobe**
Tham Lod Rockshelter	n	1	1	1	2	1	1	
	Max	-	-	-	19.78	-	-	2
	Min	-	-	-	19.46	-	-	-
	Mean	31.86	37.59	23.21	19.62	23.15	6.48	
	SD	-	-	-	2	-	-	

Figure 4.40 A right M3 (A6744 in Area 1) of *Bubalus arnee* from Tham Lod Rockshelter 1-2) Occlusal and labial views, scale bae = 5 mm

Lower Dentition:

i1-2: The lower i1 is more robust the lower i2. In occlusal view, the width is larger than the length, and shows a rectangular outline in i1 and i2 but c shows rounded outline. In labial view, labial wall is rounded, occlusal edge is rounded. In lingual view, the mesial edge of i1 is rounded on the top and straight near the base, the top of the distal edge is rounded and points distally. i2 is more rounded than i1. A shallow basin occurs at the middle of the tooth (Table 4.43-5, Figure 4.41-42)

Table 4.43 Lower i1 measurements of *Bubalus arnee* (mm)

Localities		**Measurements**	
		1	**4**
Tham Lod Rockshelter	n	2	1
	Max	21.90	12.23
	Min	19.15	12.23
	Mean	20.53	12.23
	SD.	1.94	
Tham Prakai Phet	n	1	1
	Mean	15.95	12.39

Figure 4.41 Upper i1 of *B. arnee* A1-3) Labial and lingual, view of a left i1 (A776 in Area 2) from Tham Lod Rockshelter; B1-3) Labial and lingual, view of a leftt i1 (SE23) from Tham Prakai Phet

Table 4.44 Lower i2 measurements of *Bubalus arnee* from Tham Prakai Phet (mm)

	Measurements	
	1	4
n	2.00	2.00
Max	16.61	11.86
Min	15.01	9.37
Mean	15.81	10.615
SD	1.13	1.76

Figure 4.42 A left i2 (NW12) of *Bubalus arnee* from Tham Prakai Phet 1-2) Occlusal and labial views

Table 4.44 Lower c measurements of *Bubalus arnee* from Tham Lod Rockshelter (mm)

	Measurements	
	1	4
n	1	1
Mean	16	10.67

p3: In occlusal view, the tooth has a triangular outline. The protoconid is slightly flat. The hypoconid is weakly marked. The parastylid and the paraconid are slightly developed. The valley between the parastylid and the paraconid is shallow. The anterior valley is short and presents an U-outline. The metaconid is extended and bends backwards. The posterior valley is nearly enclosed. The entostyle and the entoconid are developed and elongated. The valley between the entostyle and the entoconid present a long U-shape outline. The hypoconid is not developed. In lingual view, lingual valley is present at the top of the crown (Table 4.46, Figure 4.43).

Table 4.46 Lower p3 measurements of *Bubalus arnee* from Tham Lod Rockshelter (mm)

	Measurements	
	1	3
n	1	1
Mean	23.22	12

Figure 4.43 A right p3 (A5236 in Area 1) of *Bubalus arnee* from Tham lod 1-3) Occlusal, labial, and lingual views

m1-m2: In occlusal view, the teeth show diamond-like outline, the anterior lobe is as large as the posterior one, the entostylid is more marked than the parastylid. The metastylid is present. In m2, stylids are more marked than in m1. Both lingual conides are developed, fossa show a V-shape outline.. Labial conids are rounded. The entostylid is developed between the lobes. In labial side, the entostyle is deep rooted between protoconid and hypoconid. No groove occurs on the protoconid and the hypoconid. In lingual view, lingual conids are marked. Both parastylid and entostylid are developed along the tooth. The metastylid is developed only in the top. The lingual valley in m1 is narrower than that of m2. The size of m1 is smaller than m2 (Table 4.47-8, Figure 4.44-5).

Table 4.47 Lower m1 measurements of *Bubalus arnee* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	1	1	1	-	-
	Mean	30.31	25.79	15.67	-	-
Tham Prakai Phet	n	-	-	1	-	-
	Mean	-	-	13.16	-	-

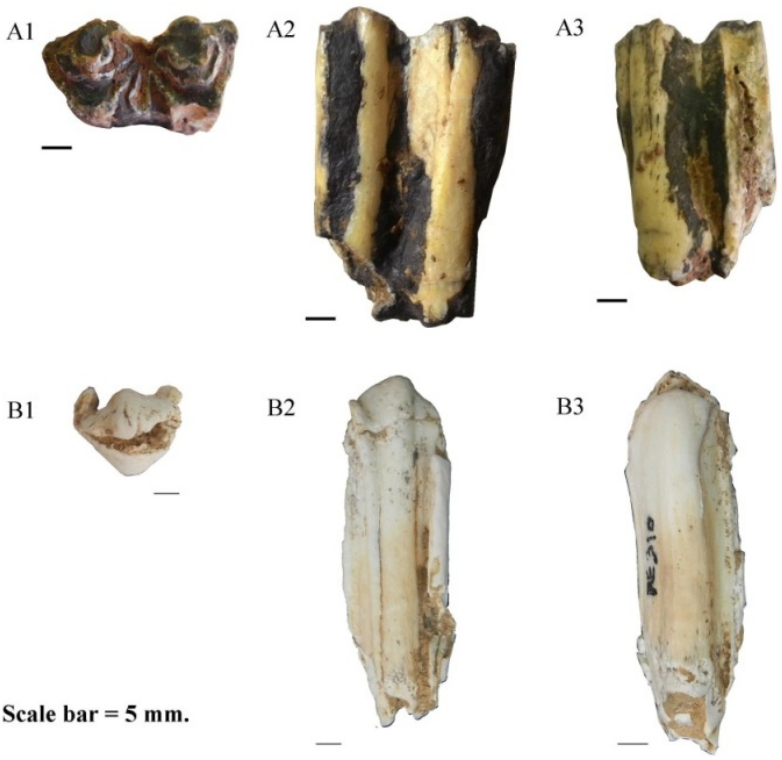


Figure 4.44 Lower m1 of *B. arnee* A1-3) Occlusal, lingual, and labial views of a left m1 (A2273 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a broken left m1 (NE310) from Tham Prakai Phet

Table 4.48 Lower m2 measurements of *B. arnee* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	2	1	1	2	1
	Max	33.15	18.70	19.56	19.46	19.20
	Min	30.61	18.70	19.56	16.74	19.20
	Mean	31.88	18.70	19.56	18.10	19.20
	SD.	1.80			1.92	
Tham Prakai Phet	n	3	2	3	3	2
	Max	33.26	30.81	20.22	19.73	21.31
	Min	30.78	27.12	17.60	18.05	19.31
	Mean	31.80	28.97	18.66	18.98	20.31
	SD.	1.30	2.61	1.38	0.85	1.41

Figure 4.45 Lower m2 of *B. arnee* A1-3) Occlusal, lingual, and labial views of a left m2 (A2269 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left m2 (NE283) from Tham Prakai Phet

m3: In occlusal view, the outline of the tooth is a diamond-like shape. The anterior lobe is larger than the posterior one. The metaconid is larger than the entoconid. The parastyle is marked and perpendicaular to the mesio-distal axis, the metastylid is developed and straight, the entostylid is absent, the entoconulid is developed and perpendicular to the mesio-distal axis of the crown. The entoconulid is strongly prominent. The hypoconid is rounded. A vertical ridge occurs at the distal side. In lingual view, all stylids and conids are strongly prominent along the tooth. The top is dilated and being pintched at the base. In lingual view, the third lobe is curved forwards (Table 4.49, Figure 4.46).

Table 4.49 Lower m3 measurements of *B. arnee* (mm)

Localities		Measurements					
		1	**2**	**3**	**4**	**5**	**6**
Tham Lod Rockshelter	N	5	2	5	5	4	5
	Max	38.23	42.45	16.60	14.06	7.33	17.66
	Min	31.25	39.52	12.00	11.96	4.75	14.88
	Mean	35.26	40.99	13.79	12.92	6.11	16.23
	SD.	2.68	2.07	1.85	0.82	1.12	1.02
Tham Prakai Phet	N	9	8	10	11	10	9
	Max	44.89	45.95	15.49	16.96	8.85	19.6
	Min	36.42	35.87	12.71	11.71	5.09	15.2
	Mean	40.23	41.01	14.43	14.49	6.86	17.82
	SD.	2.59	3.08	0.95	1.43	1.09	1.55

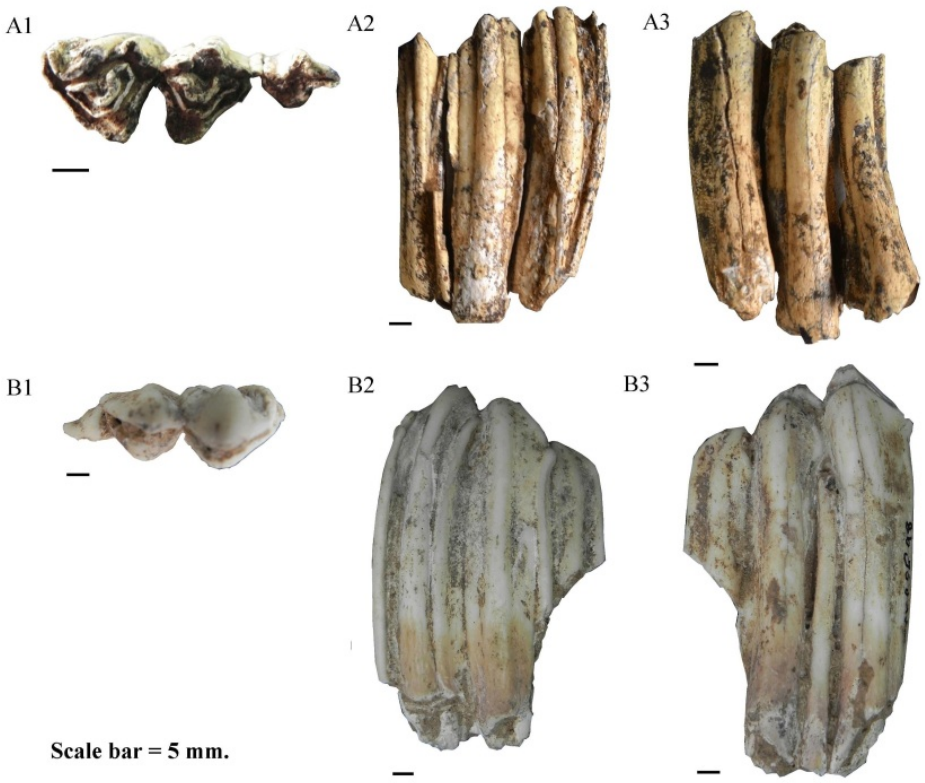


Figure 4.46 Lower m3 of *B. arnee* A1-3) Occlusal, lingual, and labial views of a left m3 (A2265-7 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right m3 (NW152) from Tham Prakai Phet.

4.1.2 Discussion of Bovinae

Bos gaurus

In upper DP3 and DP4, the metastyle is developed as well as the other styles, like the describtion of upper molar of *B. gaurus* (Thein, 1974) and is similar to the recent specimens (Filoux, per. com.), the DP3 shows a very prominent parastyle, a rounded protocone and the hypocone, and very marked styles and cones in labial view. Unlike in *B. javanicus*, all styles and cones are less remarkable, with moderated marked parastyle, flat protocone, sharp hypocone and weak prominent metacone. Moreover, the size is larger than *B. javanicus*.

The P2 presents an elongated parastyle but is less developed than *B. sauveli* and *Bubalus arnee* (Thein, 1974). The labial cone strongly bends mesially. The metastyle is marked and elongated. Unlike in *B. javanicus*, it presents a less developed metastyle (Thein, 1974).

In upper P3 and P4, teeth show bilobation in the lingual side, like in *Bos* (Thein, 1974). Unlike in *Bubalus arnee*, no bilobation is present in any side of the tooth (Thein, 1974). Moreover the teeth present a more symmetric outline than other *Bos* which is closed to *B. gaurus*. No folds appear on the fossa, unlike in *B. javanicus*, that present an elongated fold in the fossa (Thein, 1974).

On upper molar, the metastyle is well developed like the other styles. The same observation can be made for *Bos sauveli* (Thein, 1974), but not in *B. javanicus*, for which the metastyle is clearly weaker than other styles (Thein, 1974). Like in general *Bos*, the entostyle form the protocone and occurrence two lateral groove on both protocone and hypocone surface (Thein, 1974, Ibrahim, 2013). The entostyle is connected to protocone, unlike in *Bubalus. arnee*, that of *B. arnee* conect between protocone and hypocone (Thein, 1974). It is often strongly developed and display two lobes, like *B. gaurus*. Unlike in *B. javanicus* and *B. sauveli*, the tooth has weaker development (Coolidge, 1940, Thein, 1974). Lingual cones are shape, unlike in *B. javanicus*, lingual cones are more rounded. In M1, the anterior lobe often is as width as the posterior one like *B. gaurus*. Unlike in *B. javanicus* and *B. sauveli*, the anterior is smaller than the posterior one (Thein, 1974). In M2, the anerior lobe often larger than the posterior one, like *B. gaurus*, *B. javanicus*, and *B. sauveli*.

The lower p2 has a clearly developed stylids, conids and valleys like in *B. sauveli* and *Bubalus arnee* (Thein, 1974). *Bos sauveli* has a more maked hypoconid and more longated metaconid. *Bubalus arnee* has more marked lingual style than other (Thein, 1974). Unlike in *B. javanicus*, the tooth has less developed (Thein, 1974). In lingual or labial view, the mesial side of tooth inclines backwards unlike in *B. javanicus*, the mesial side is more straigth.

In lower p3 and p4, the tooth has rounded metaconid, an enclosed posterior valley, and more strongly hypoconid like in *B. gaurus*. Unlike in *Bos javanicus*, the tooth has weaker stylid, conid, and valley (Thein, 1974). In all valleys, the top is as wide as the base, unlike in *B. javanicus*, the top is larger than the base. In *B. sauveli*, the tooth has an elongated metaconid (Thein, 1974) and usually completely enclosed posterior valley. Unlike in *Bubalus bubalis*, the tooth has weakly development of metaconid, protoconid, and lingual valley (Thein, 1974).

In lower molar, an ectostylid is present, and two lateral grooves on both protoconid and hypoconid are marked which are generally found in *Bos* (Thein, 1974, Filoux *et al.*, 2015). The tooth has a U-shape valley between metaconid and entoconid, like in *Bos gaurus* and *B. sauveli*. Unlike in *B. javanicus*, they have wide and flat valley. The metaconid is marked along the tooth, unlike *B. javanicus* and *B. sauveli*, the metaconid is absent or weakly developed. In m3, the entostylid is more developed than *B. javanicus* and *B. sauveli*. The vertical rib at the distal side of the third lob bends distro-lingually. Unlike in *B. gaurus*, the tooth inclined distally. While in *B. sauveli*, vertical ribs are very weak or absent.

Bos javanicus

In DP3 and DP4, the development of the metastyle is weaker than other styles, following the describtion of upper molar of *B. javanicus* (Thein, 1974). In DP3, all styles and cones are less remarkable, a parastyle morderatly marked, a flat protocone, a sharp hypocone, and a weak prominent metacone which is different from *B. gaurus*. The dimensions of these specimens are smaller than *B. gaurus*.

In upper P2: the tooth presents a parastyle less developed than speciemens of *B. gaurus*, and *B. sauveli* (Thein, 1974). The labial cone is less developed than *B. gaurus*.

In upper P3 and P4, the tooth also shows lingual bilobation which is similar to other *Bos* (Thein, 1974). But the bilobation is more remarkable than *B. gaurus*. The tooth presents an asymmetric outline. Some specimens show a small fold and two fossas, unlike in description of *B. javanicus* (Thein, 1974), extended fold was descripted.

In upper molar, the metastyle is clearly less marked than other styles like in *B. javanicus* (Thein, 1974), unlike in *B. gaurus* and *B. sauveli*. The tooth is similar to general discrption of *Bos* (Thein, 1974, Ibrahim, 2013), the entostyle is fused to the protocone and two lateral grooves on both protocone and hypocone surface can be observed. The entostyle shows 1 to 3 lobes but it is less developed than *B. gaurus*, like in *B. javanicus* and *B. sauveli* (Coolidge, 1940, Thein, 1974). Lingual cones are rounded, which is different from *B. gaurus*. In M1, the anterior lobe is smaller than the posterior one like *B. javanicus* and *B. sauveli* (Thein, 1974). In M2, the tooth outline has rectanangular like *B. gaurus* and *B. javanicus* (Coolidge, 1940).

In lower p2, the tooth has less developed stylid than *B. gaurus*, *B. sauveli* and *Bubalus bubalis* (Thein, 1974). The mesial side is more straigth in lateral view. Unlike in *B. gaurus*, the mesial side of tooth inclines backwards

In lower p3 and p4, the tooth has less daceloped in both stylids and conids associated with constant width valley, like in *B. javanicus* (Thein, 1974). Unlike in *B. gaurus*, the tooth has a remarkable rounded metaconid, and more strongly hypoconid. In *B. sauveli*, the tooth has an elongated metaconid (Thein, 1974). In advance wearing stage, the posterior valley of *B. gaurus*, and *B. sauveli* is enclosed. But that of *B. javanicus* is marked along the tooth (Thein, 1974).

In lower molar, the ectostylid is fromed from the hypoconid. Two lateral grooves on both lingual side present, like in other *Bos* (Thein, 1974, Filoux *et al.*, 2015). The tooth has a wide and flat U-shape valley between the metaconid and the entoconid. Unlike in *B. gaurus* and *B. sauveli*, they show V-shape outline. For the m3, the entostylid is less developed than the entostylid of *B. gaurus*. The vertical rib at the distal side of the third lob bends distro-lingually

Bos* cf. *sauveli

The upper molar of *Bos sauveli* show a metastyle well developed as other styles like in *B. gaurus*, and *Bubalus arnee* (Thein, 1974). It is different for *B. javanicus*

of which metastylid is the smallest style. Like in all *Bos species*, the entostyle is developed from the protocone and has two lobes (Thein, 1974, Ibrahim, 2013). The entostyle is weaky developed like *B. javanicus* and *B. sauveli* (Coolidge, 1940, Thein, 1974). Lingual cones are rounded, like in *B. javanicus* and *B. sauveli*. In M2, the outline at base is closed to square outlike like *B. sauveli* (Coolidge, 1940). In M 3, the anterior lobe is larger than the posterior one. The tooth has a very marked parastyle like *B. sauveli*, unlike in *B. gaurus* and *B. javanicus* (Thein, 1974). The tooth has a weak developed entostyle (only one lobe) unlike in descriptionion of *B. sauveli* in thein (1974), the tooth shows bilobed entostyle.

In both lower p3 and p4, the tooth show extended metaconids which enclosed to posterior valley on the top on the tooth, like in *Bos sauveli* (Thein, 1974). Unlike in *B. gaurus* and *B. javanicus*, they show less elongated mesostylid, and a subtriangular posterior outline valley (Thein, 1974). Even if, the posterior valley in *B. gaurus* is clossed but it is present in only advance stage.

Bubalus arnee

The upper premolars have a symmetric pentagonal-like shape like in *Bos gaurus*. Fossa is enclosed, unlike in *Bos*, it opens in the distal side of the top of the crown. No any fossete occurrence.

In upper molar and lower molar, cones and styles are massive, the entostyle formed between lobes, no grooves can be observed on the lingual side like *Bubalus arnee* following Thein (1974), Tougard (1996), Bacon *et. al.* (2011), Filoux, *et. al.* (2015).

Lower incisor, the tooth is straight and robust, present a rounded occlusal edge, unlike in *Bos*, the tooth is slender, and bends mesially.

Lower p3, the tooth has extended metaconid, the absence of hypoconid and lingual valley, weak development of protoconid, almost enclosing posterior valley. Like in *Bos sauveli*, the tooth has elongated metaconid and complete enclosing posterior valley, however, *B. sauveli* has more marked labial side (Thein, 1974). Unlike in *B. gaurus* and *B. javanicus*, short metaconid, U-shape posterior valley, very marked hypoconid and lingual valley (Thein, 1974).

4.2. Caprinae

4.2.1 Systematic palaeontology of Caprinae

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

Family: Bovidae Gray, 1821

Subfamily: Caprinea Gray, 1821

Tribe Ovibovini Gray, 1821

Genus: *Capricornis* Ogilby, 1836

Species: *Capricornis sumatraensis* (Bechstein, 1799)

Localities: Tham Lod Rockshelter, Tham Prakai Phet, Tham Rak Sai

Material: Tham Lod Rockshelter: The collection is composed of 36 specimens: 3 M1, 7 M2, 4 M3, 3 p4, 3 m1, 12 m2, and 4 m3.

Tham Prakai Phet: Totally 81 specimens with 1 DP4, 4 P3, 6 P4, 6 M1, 10 M2, 5 M3, 3 p3, 7 p4, 10 m1, 13 m2, and 11 lower m3.

Tham Rak Sai: Totally 3 specimens consist of 1 M1, 1 M2, and 1 M3.

DP4: In occlusal view, the anterior lobe is a triangular shape. The posterior lobe has a pentagonal shape. Labial styles and cones are marked. The protocone and hypocone bend in the same direction. The protocone is more extended than the hypocone. In labial view, the dilation of the crown is well marked at top, clearly less at the base. The paracone and the metacone are very prominent. Styles are developed from the top to the base. In lingual view, cones are pinched at the base (Table 4.50 and Figure 4.47).

Table 4.50 Upper DP4 measurements of *Capricornis sumatraensis* from Tham Prakai Phet

	Measurements						
	1	**2**	**3**	**4**	**5**	**6**	**7**
N	1	1	1	1	1	1	1
Mean	17.51	14.97	12.18	11.66	11.23	10.29	13.46

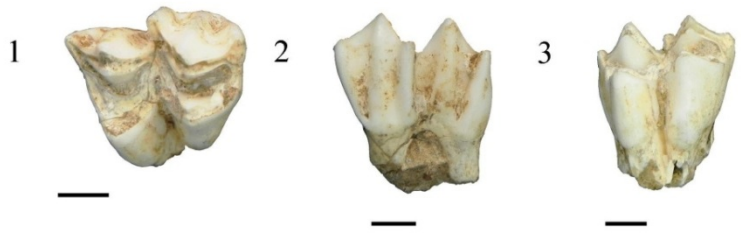


Figure 4.47 Upper left DP4 (TPKP SW54) of *Capricornis sumatraensis* from Tham Prakai Phet; 1-3) occlusal, labial, and lingual views

P2: The tooth is a trapezoid shape; the labial side is larger than the lingual one. In occlusal view, the tooth is compressed labial-lingually. The parastyle is less marked than the metastyle. The paracone is very marked and clearly closed to the parastyle. The lingual edge has the bilobation which located near the mesial edge. In labial view, the tooth is curved distally. The paracone is strongly marked and located near the parastyle. The top of crown is larger than base. The bilobation occurs at the lingual side (Table 4.51 and Figure 4.48).

Table 4.51 Upper P2 measurements of *Capricornis sumatraensis* in Tham Prakai Phet

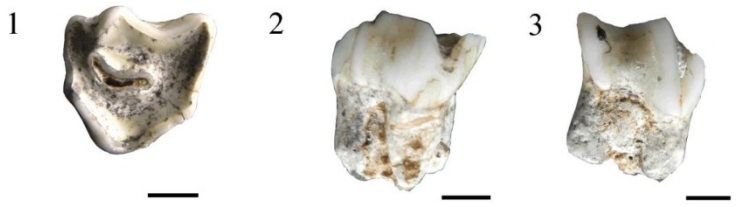
	Measurements			
	1	**2**	**3**	**4**
n	4	4	4	4
Max	13.91	12.95	10.33	11.65
Min	11.80	10.88	9.71	10.14
Mean	12.52	11.63	10.14	10.81
SD	0.99	0.94	0.29	0.63

Figure 4.48 A lower a right P2 (TPKP SW210) of *Capricornis sumatraensis* in Tham Prakai Phet; 1-3) Occlusal, lingual, and labial view.

P3: The tooth present a trapezoid shape, like the P2. However, it is larger than P2. The bilobation cannot be observed. In occlusal view, labial styles are marked. The parastyle is less prominent than the metastyle. The paracone is slightly marked and clearly closed to the parastyle like that of the P2. The lingual side is a sub-angualr shape. In labial view, styles are marked along the tooth, the paracone is located near the parastyle, the top of crown is larger than the base (Table 4.52 and Figure 4.49).

Table 4.52 Upper P3 measurements of *Capricornis sumatraensis* from Tham Prakai Phet

	Measurements				
	1	**2**	**3**	**4**	**5**
n	6	6	5	5	5
Max	13.90	12.56	14.13	13.32	14.10
Min	10.27	9.61	11.84	10.83	11.42
Mean	12.20	11.13	12.89	12.08	12.94
SD	1.60	1.27	0.84	0.93	1.06



Scale bar = 5 mm.

Figure 4.49 A upper left P3 (TPKPSE211) of *Capricornis sumatraensis* from Tham Prakai Phet: 1-3) occlusal, labial, and lingual views.

P4: The tooth present a trapezoid shape in early wearing stage and became a rectangle (width is larger than length) in an advance wearing stage. In occlusal view, labial styles are marked. The parastyle is weaker than the metastyle. The paracone is weakly marked and locates at the middle of the tooth. The protocone is located near diatal side. The mesio-labially corner is flat. In labial view, styles and cone are marked along the tooth (Table 4.52 and Figure 4.50).

Table 4.53 Upper P4 measurements of *Capricornis sumatraensis* from Tham Prakai Phet

	Measurements				
	1	**2**	**3**	**4**	**5**
Number	3	3	3	3	3
Max	13.72	12.13	14.58	13.49	14.94
Min	11.28	10.03	11.89	10.72	11.18
Mean	12.67	11.18	12.94	11.77	13.12
SD	1.26	1.07	1.44	1.50	1.88

Figure 4.50 A upper left P4 (TPKP SE144) of *Capricornis sumatraensis* from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views.

M1: The tooth is clearly hypsodont which is clearly smaller than M2. In occlusal view, the anterior lobe is slightly wider and presents a more triangular outline than the posterior lobe, labial styles are well marked, the mesostyle is more developed than the other ones. The paracone and the metacone are poorly prominent. The protocone and hypoconeis are U-shaped. On some worn teeth from Tham Prakai Phet and Tham Rak Sai, fossete such as TPKPNE113, TPKPNE269, TPKPNE277, TPKPNW3, TPKPSW48, and TR4, occurs near the posterior fossa which presents a semicircular or ovule shape. In labial view, the top is larger than the base. The distal edge of the crown is concave. In lingual view, no entostyle occurs at the base. In distal view, a shallow groove exists along the tooth (Table 4.54 and Figure 4.51).

Table 4.54 Upper M1 measurements of *C. sumatraensis* (mm)

Localities		**Measurements**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Tham Lod Rockshelter	n	2	2	2	2	3	2	2
	Max	17.09	14.16	11.06	9.20	10.37	9.34	14.92
	Min	16.04	13.52	10.29	8.53	9.12	8.04	12.79
	Mean	16.57	13.84	10.68	8.87	9.58	8.69	13.86
	SD.	0.74	0.45	0.54	0.47	0.68	0.92	1.51
Tham Prakai Phet	n	5	5	4	4	5	5	5
	Max	18.78	16.38	14.24	14.00	13.91	13.43	18.22
	Min	16.15	15.12	12.27	12.02	11.39	10.84	16.15
	Mean	17.34	15.90	13.48	13.08	13.05	12.41	17.11
	SD.	0.95	0.49	0.94	0.82	1.00	1.02	0.85
Tham Rak Sai	n	2	2	2	2	2	2	2
	Max	14.25	13.25	11.46	11.95	9.82	8.97	13.09
	Min	14.00	11.24	9.47	8.19	7.98	6.87	11.50
	Mean	14.13	12.25	10.47	10.07	8.90	7.92	12.30
	SD.	0.18	1.42	1.41	2.66	1.30	1.48	1.12

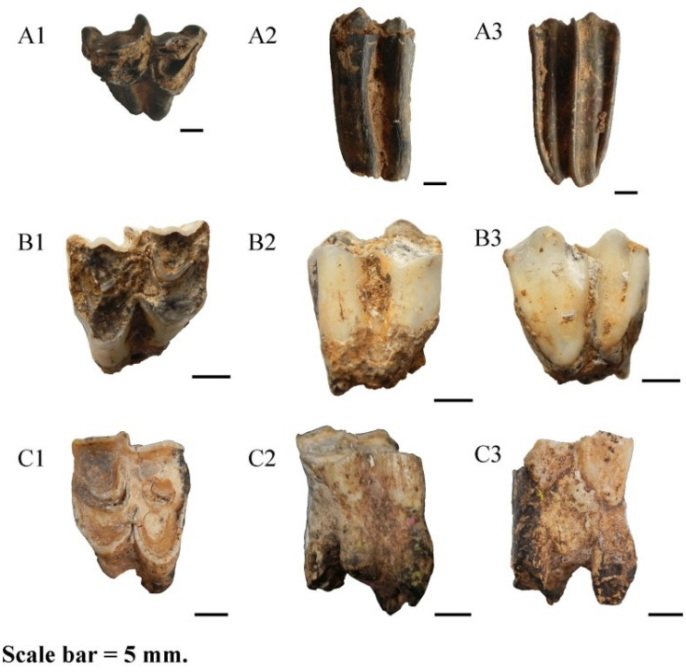


Figure 4.51 Upper right M1 of *Capricornis sumatraensis* from Tham Lod Rockshelter A1-3) Occlusal, lingual, and labial views (TLA3452 in Area 1) from Tham Lod Rockshelter; B1-3) Upper left M1 from Tham Prakai Phet, occlusal, lingual, and labial (TPKPNE269), C1-3) Upper right M1 from Tham Rak Sai (TR8) occlusal, lingual, and labial views

M2: The tooth present in occlusal view, an anterior lobe with a clearly wider and more triangular shape than the posterior lobe, the posterior lobe show a pentagonal outline. The paracone and the metacone are slightly marked, the mesostyle is more developed than the other styles. The outline of lingual part is U-shape, unlike in M1, that of M1 is sharper. The hypocone is clearly more rounded than the protocone. There is a tiny rounded fosseta between lobes from worn tooth such as TLA7361, TPKPNE6.1, TPKPNW70, TPKPNW196, TPKPSW19, TPKP73, and TR6. In labial view, the dilation of the crown is less important than M1. The interstyle surface in the anterior lobe is clearly narrower than that of the posterior one, unlike in M1, the anterior lobe is larger. In distal view, a shallow groove is present from the top to the base (Table 4.55 and Figure 4.52).

Table 4.55 Upper M2 measurements of *C. sumatraensis* (mm)

Localities		**Measurements**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Tham Lod Rockshelter	n	5	3	2	2	3	4	2
	Max	20.98	17.38	14.35	12.07	11.60	11.20	17.83
	Min	15.17	13.01	12.84	12.02	11.49	9.72	16.18
	Mean	18.40	15.36	13.60	12.05	11.55	10.37	17.01
	SD.	2.44	2.20	1.07	0.04	0.06	0.68	1.17
Tham Prakai Phet	n	10	10	7	7	9	9	8
	Max	21.92	20.35	18.14	17.39	18.66	17.64	22.61
	Min	18.20	18.07	15.12	13.54	10.98	10.57	17.04
	Mean	19.84	19.00	16.60	15.29	14.32	13.45	19.68
	SD.	1.04	0.70	1.35	1.52	2.22	2.07	2.20
Tham Rak Sai	n	1	1	1	1	0	0	1
	Mean	17.93	16.90	16.22	15.74	-	-	16.20

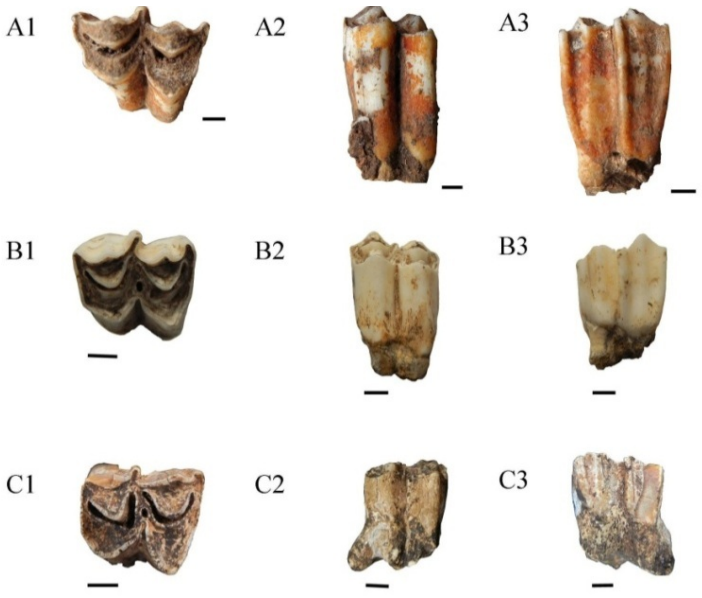


Figure 4.52 Upper M2 of *Capricornis sumatraensis*: A1-3) from Tham Lod Rockshelter (A4208 in Area 1), occlusal, lingual, and labial views; B1-3) from Tham Prakai Phet (TPKP NW70), occlusal, lingual, and labial views, C1-3) from Tham Rak Sai (TR6), occlusal, lingual, and labial views.

M3: In occlusal view, the outline of the anterior lobe is a triangular shape, the posterior lobe has a pentagonal shape, labial cones are weakly prominent. The mesostyle is marked and bend forwards. The metastylar wing and the parastyle are also well developed and perpendicular to the mesio-distal axis. The lingual edge is a U-shape. The angle of the hypocone is more open than that of the protocone. The lingual valley between prorocone and hypocone is wider than that of M1 and M2. Some teeth such as TLA472, TLA7483, TPKPNW123, TPKPSW106, and TR5 present semicular or ovule fosseta between lobes which are correlated to worn to advanced worn stage of the tooth. In labial view, the crown is wider at the base. The interstylar length of the anterior lobe is narrower than that of the posterior one. In lingual view, the metacone is curved at the base, the metastylar wing at the top is less expands than at the base, the distal edge of metastylar wing is straight. In distal view, a shallow groove is marked and located after the metastylar wing (Table 4.56 and Figure 4.53).

In some specimens of Tham Prakai Phet such as TPKPSW52 and TPKPNE192 present more prominent labial cones and styles especially metastylar wing than other specimen in the same sie and other site.

. Table 4.56 Upper M3 measurements of *Capricornis sumatraensis* (mm)

Localities		Measurements											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Tham Lod Rock shelter	N	3	3	3	3	3	3	3	2	2	2	2	2
	Max	24.47	23.72	16.79	16.27	14.48	13.80	17.05	14.04	7.52	8.06	20.57	20.62
	Min	20.29	21.44	13.83	12.38	11.71	10.54	15.72	12.94	6.42	7.86	19.24	20.12
	Mean	22.40	22.64	15.36	14.96	12.95	11.87	16.37	13.49	6.97	7.96	19.91	20.37
	SD	2.09	1.15	1.48	2.24	1.41	1.71	0.67	0.78	0.78	0.14	0.94	0.35
Tham Prakai Phet	N	5	5	5	5	5	5	5	5	5	5	5	5
	Max	22.93	21.84	18.50	17.76	16.19	15.11	16.86	15.66	7.08	8.19	19.80	19.33
	Min	19.52	20.45	11.11	11.00	10.84	9.51	10.81	13.79	6.62	6.69	19.14	18.03
	Mean	21.18	21.13	14.20	13.39	14.00	12.24	14.13	14.89	6.89	7.61	19.44	18.72
	SD	1.34	0.50	2.69	2.59	2.47	2.09	2.49	0.81	0.18	0.64	0.24	0.60
Tham Rak Sai	N	1	1	1	1	1	1	1	1	1	1	1	1
		22.64	22.52	12.99	11.33	12.58	10.74	18.85	16.03	6.96	6.55	21.79	20.76

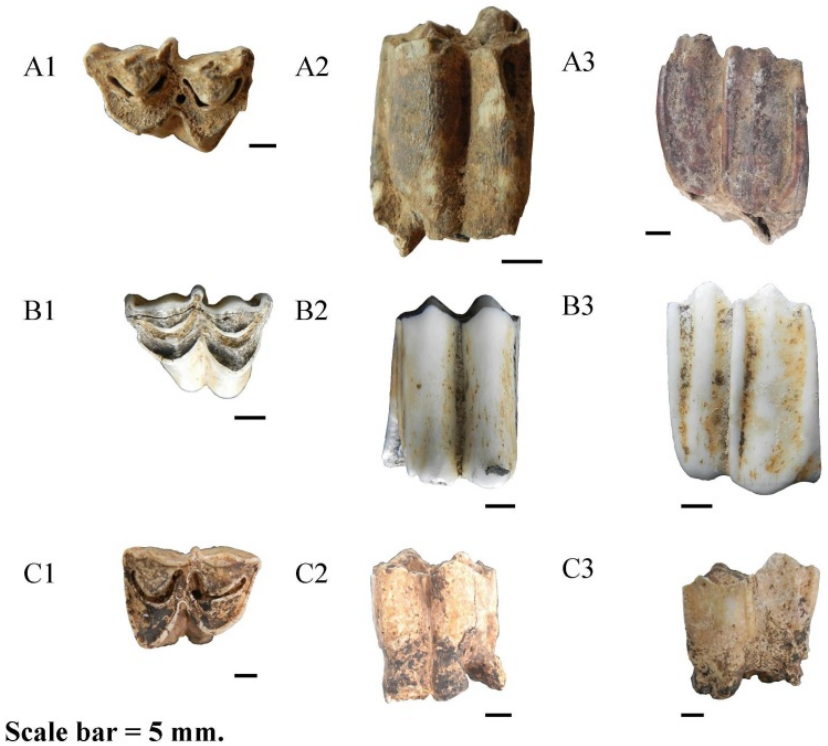


Figure 4.53 Upper M3 of *Capricornis sumatraensis*: A1-3) Occlusal, lingual, and labial views of a right M3 (A472 in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right M3 (TPKP NW70) from Tham Prakai Phet, C1-3) Occlusal, lingual, and labial views of a left M3 (TR5) from Tham Rak Sai.

Lower dentition:

dp 4: The tooth present three-lobes: the first lob is the smallest, and the third one is the largest. Outline of all lobes are triangular. In occlusal view, lingual conids are marked, the parastylid and the entostylid are also prominent. The metastylid has a weak development as a small rib. Labial conids are sharp, two ectostylids presented between labial conids, the distal wall is flat. In lingual view, the top of the tooth is larger than the base, both conids and stylids can be observed along the crown (Table 4.57 and Figure 4.54).

Table 4.57 Upper dp4 measurements of *Capricornis sumatraensis* from Tham Prakai Phet

	Measurements					
	1	2	3	4	5	6
N	2	2	2	2	2	2
Max	21.91	19.16	7.01	9.24	9.54	10.05
Min	19.91	16.75	6.76	8.58	9.42	9.74
Mean	20.91	17.96	6.89	8.91	9.48	9.90
SD	1.41	1.70	0.18	0.47	0.08	0.22

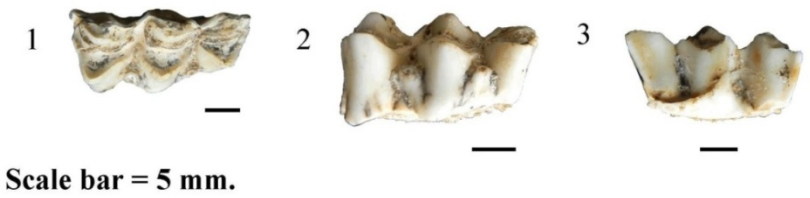


Figure 4.54 A lower right dp4 (TPKP SE167) of *Capricornis sumatraensis* from Tham Prakai Phet; 1-3) occlusal, labial, and lingual views.

p3: The tooth is a triangular-like shape. In occlusal view, the paraconid often fuses to the parastylid and inclines mesially. The anterior valley exhibits a wide V-shape. The metaconid is weakly marked and incline backwards. In advance worn stage, it is usually merged to the entoconid and the entostylid which associated to enclosing of the posterior valley. The protoconid is curved. The hypoconid is weakly prominent. The labial valley (between protoconid and hypoconid) is shallow. The distal wall slightly inclines backwards. In labial view, the anterior valley is marked at the top and being lost at the base. The posterior valley is marked along the tooth (Table 4.57 and Figure 4.55).

Table 4.58 Lower p3 measurements of *Capricornis sumatraensis* from Tham Prakai Phet

	Measurements				
	1	**2**	**3**	**4**	**5**
n	3	3	3	3	2
Max	13.78	13.47	9.11	9.13	3.82
Min	11.91	11.26	8.12	8.15	2.43
Mean	13.12	12.70	8.67	8.49	3.13
SD	1.05	1.25	0.50	0.56	0.98

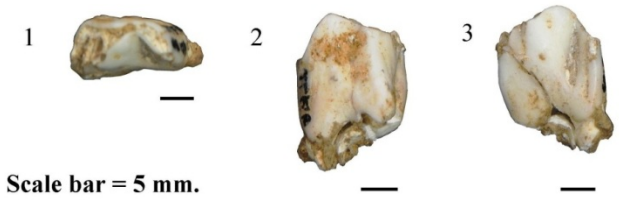


Figure 4.55 A lower left p3 (TPKP NE123) of *Capricornis sumatraensis* from Tham Prakai Phet 1-3) Occlusal, labial, and lingual views.

p4: The tooth has a strong bilobation (molarized). In occlusal view, the anterior lobe is longer than the posterior one and clearly separated by two opposite deep lingual and labial valleys. The metaconid is nearly flat, the parastylid is marked, the entostylid is weak, the anterior fossa is more mesio-distally elongated than the posterior one, the posterior fossa bend disto-lingually, the mesio-labial corner of the crown exibits an open angle and a slightly rounded face. The protoconid and the hypoconid are sharp and show open angles. In lingual view, styles present on the upper part. The lingual groove is less marked than the labial one (Table 4.59 and Figure 4.56).

Table 4.59 Lower p4 measurements of *Capricornis sumatraensis* (mm)

Localities		Measurements				
		1	2	3	4	5
Tham Lod Rockshelter	n	3	3	3	3	3
	Max	17.77	16.64	9.70	9.06	10.27
	Min	15.69	14.38	8.70	7.86	8.41
	Mean	16.78	15.61	9.08	8.64	9.43
	SD	1.04	1.14	0.54	0.67	0.94
Tham Prakai Phat	n	6	6	6	7	7
	Max	16.92	16.03	10.80	8.95	10.59
	Min	13.57	12.73	9.00	7.16	8.65
	Mean	15.60	15.09	9.58	8.15	9.30
	SD	1.23	1.23	0.66	0.72	0.68

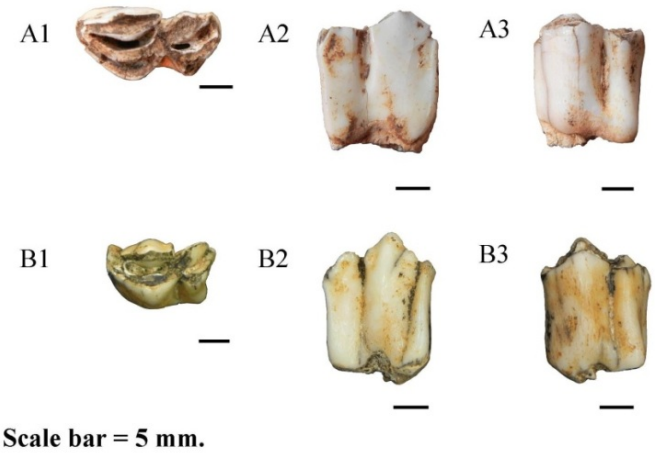


Figure 4.56 Lower p4 of *Capricornis sumatraensis*: A1-3) Occlusal, lingual, and labial views of a left p4 (TLA2363 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left p4 (TPKPNW95) from Tham Prakai Phet.

m1: The tooth is hypsodont. In occlusal view, the anterior lobe is wider than posterior one. The parastylid and the entostylid are weakly developed. The metastylid is rarely observed or developed as small rib, the metaconid and entoconid are wide and rounded. The caprine fold is weakly developed. The ectostylid often is absent, but only TPKP34 from Tham Prakai Phet is present. Labial conids are sharp in early wearing stage after that they became round in advance wearing stage. The protoconid is perpendicular to mesio-distal asix while the hypoconid bends backwards (Table 4.60 and Figure 4.57).

Table 4.60 Lower m1 measurements of *Capricornis sumatraensis* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	1	1	1	2	1
	Max	-	-	-	11.11	-
	Min	-	-	-	9.44	-
	Mean	15.42	12.63	10.66	10.28	10.25
	SD	-	-	-	1.18	-
Tham Prakai Phet	n	10	9	9	9	9
	Max	18.75	16.61	11.27	12.10	11.45
	Min	13.13	12.47	8.94	8.46	10.11
	Mean	16.36	14.79	10.00	10.07	11.15
	SD	2.07	1.36	0.77	1.19	0.42

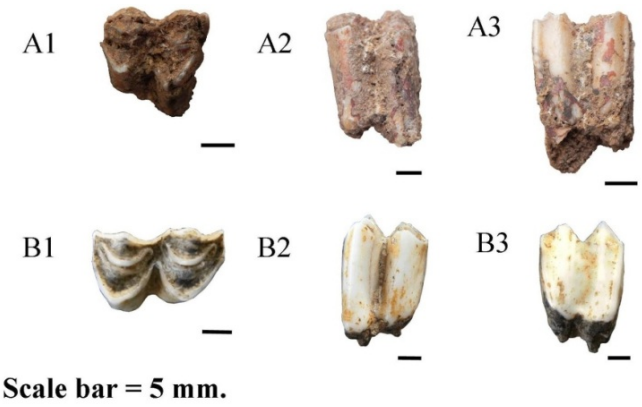


Figure 4.57 Lower m1 of *Capricornis sumatraensis*: A1-3) occlusal, labial, and lingual views of a left m1 (A7603 in Area 1) from Tham Lod Rockshelter; B1-3) occlusal, labial, and lingual views of a right m1 (TPKP SW211) from Tham Prakai Phet.

m2: In occlusal view, the anterior lobe has a pentagonal shape, the posterior one present a triangular shape. The parastylid and the entostylid are marked, the metastylid is extremely reduced as a small rib. Labial conids are sharp in early wearing stage and became rounded in advance worn tooth. In lingual view, all conids and stylids exist along the tooth. The top is slightly larger than the base. The ectostylid usually is absent except on some specimens from Tham Prakai Phet such as TPKPSW173 and TPKPSE221 can be observed. In labial view, both the protoconid and the hypoconid are parallel. The tooth is larger than m1. Both anterior and posterior lobes are less perpendicular to the mesio-distal axis than m1. The base of the tooth is larger than that of m1 (Table 4.61 and Figure 4.58).

Table 4.61 Lower m2 measurements of *Capricornis sumatraensis* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	11	7	11	8	5
	Max	21.02	18.23	12.05	12.88	13.45
	Min	17.23	15.81	9.57	10.01	11.54
	Mean	18.77	17.02	10.70	10.94	12.31
	SD	1.32	0.79	0.66	0.94	0.70
Tham Prakai Phet	n	11	11	9	12	12
	Max	19.56	19.85	12.44	13.11	16.61
	Min	15.29	13.56	8.88	8.06	9.26
	Mean	18.41	17.52	10.78	10.79	12.46
	SD	1.27	1.56	1.11	1.36	1.70

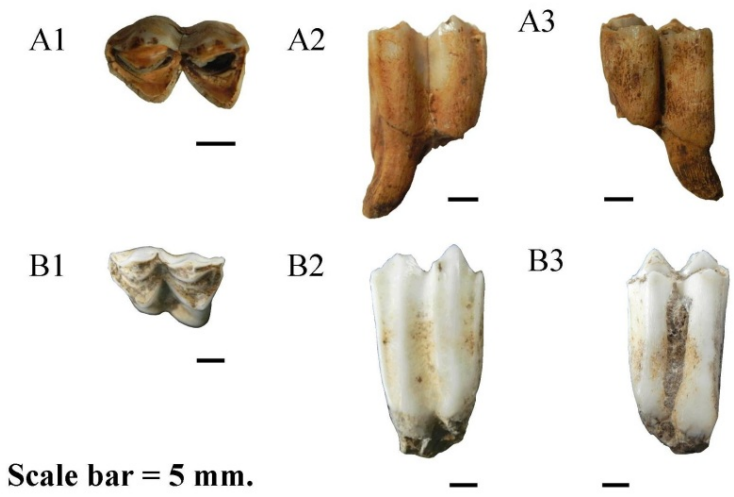


Figure 4.58 Lower m2 of *Capricornis sumatraensis*: A1-3) Occlusal, lingual, and labial views of a left m2 (A144 in Area 2) from Tham Lod Rockshelter; B1-3) occlusal, lingual, and labial views of a left m2 (TPKP 50) from Tham Prakai Phet

m3: In occlusal view, both anterior and posterior lobes show pentagonal shape. The anterior lobe is as large as the posterior one. The parastylid is marked. The metastylid exists as a small rib. In some specimens such as TLA1015, TLA507, TPKPNW181, lingual style of them is more marked than other specimens. Both the metaconid and the entoconid are slightly marked, except TPKPNE85, TPKPNW181, is more prominent. The protoconid is rounded. The hypoconid is sharp. They bends backwards. The labial valley between the hypoconid and hypoconulid is dilated and rounded. The third lobe exhibits a semi-circle shape: flated entoconulid and rounded hypoconulid, but in some specimens such as TPKP49, the entoconulid is markeed on the top of the tooth; and NW181, the hypoconulid is sharp. In some advance worn tooth such as SW1, the third lobe is clearly more elongated than other specimens. In lingual view, both conids and stylids are marked from the top to the base. A metastylid rib is present from the top to the base of the crown (Table 4.62 and Figure 4.59).

Table 4.62 Lower m3 measurements of *Capricornis sumatraensis* from Tham Prakai Phet

Localities		Measurements					
		1	**2**	**3**	**4**	**5**	**6**
Tham Lod Rockshelter	N	2	1	3	3	1	1
	Max	28.47	28.92	12.13	11.70	6.15	12.22
	Min	24.52	28.92	10.29	10.17	6.15	12.22
	Mean	26.50	28.92	11.18	11.15	6.15	12.22
	SD	2.79	-	0.92	0.85	-	-
Tham Prakai Phet	N	7	7	7	9	9	8
	Max	29.60	29.15	14.01	13.07	7.99	13.92
	Min	25.61	26.82	9.77	9.09	5.16	11.12
	Mean	28.05	27.86	11.56	10.86	6.32	12.42
	SD	1.46	0.79	1.63	1.31	1.01	1.11

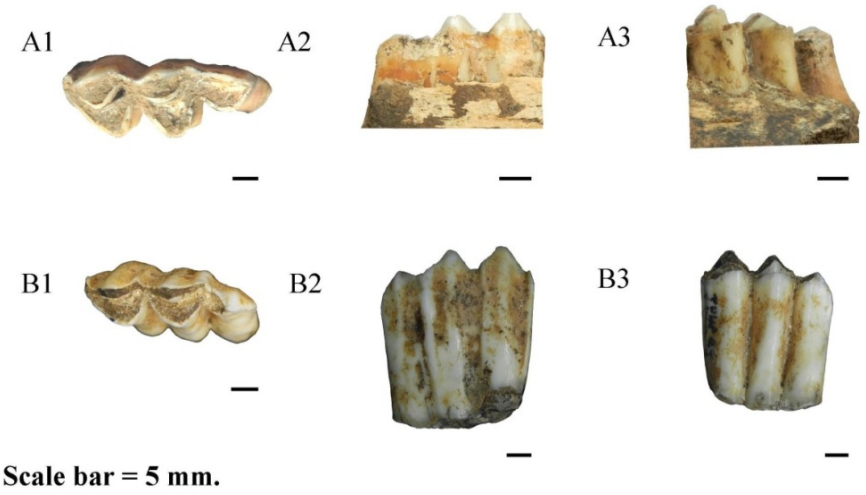


Figure 4.59 Lower m3 of *Capricornis sumatraensis* A1-3) Occlusal, lingual, and labial views of a left m3 (A1015b in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left m3 (TPKP 49) from Tham Prakai Phet.

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

Family: Bovidae Gray, 1821

Subfamily: Caprinea Gray, 1821

Tribe Ovibovini Gray, 1821

Genus: *Capricornis* Ogilby, 1836

Species: *Capricornis milneedwardsii* David, 1869

Tham Prakai Phet: 22 teeth corresponding to 1 P3, 1 P4, 3 M2, 3 M3, 1 dp4, 1 p2, 1 p3, 2 p4, and 1 m2.

Description of the material:

Upper dentition:

P3: The tooth has a trapezoid shape. In occlusal view, the tooth is compressed labial-lingually. The parastyle is less prominent than the metastyle. The paracone is marked and clearly closed to the parastyle. There is bilobation at lingual side. The protocone is more marked the than the hypocone. Both mesial and distal sides are rounded. In labial view, the tooth is straight, styles are strongly prominent along the tooth, the paracone is located near the parastyle, the top of crown is slightly larger than the base. In the lingual view, a groove (between the protocone and hypocone) at a disto-lingual corner occurs from the top to the base (Table 4.63 and Figure 4.60).

Table 4.63 Upper P3 measurements of *Capricornis milneedwardsii* from Tham Prakai Phet

	Measurements				
	1	**2**	**3**	**4**	**5**
n	1	1	1	1	1
Mean	14.10	13.07	12.35	-	13.99

Figure 4.60 Upper left P3 (TPKP NE135) of *Capricornis milneedwardsii* from Tham Prakai Phet; 1-3 Occlusal, lingual, and labial views.

P4: The tooth has an asymmetric trapezoid shape but the mesial side is larger than the distal one, unlike in P3, the labial side is larger than the lingual one. No bilobation present. The parastyle which is more marked than that of P3, is alos as well as the metastyle. The paracone is weakly marked and slightly closed to the parastyle. The protocone is rounded and located near the mesial side. In labial view, styles and cones are marked. The parastyle is large at the base and small at the top. The metastyle is slightly straight along the tooth. The paracone is often curved and closed to the metastyle at the base. The tooth is wide at the top and narrow at the base (Table 4.64 and Figure 4.61).

Table 4.64 Upper P4 measurements of *Capricornis milneedwardsii* from Tham Prakai Phet

	Measurements				
	1	**2**	**3**	**4**	**5**
n	2	2	2	2	1
Mean	14.60	13.57	13.28	10.87	15.64

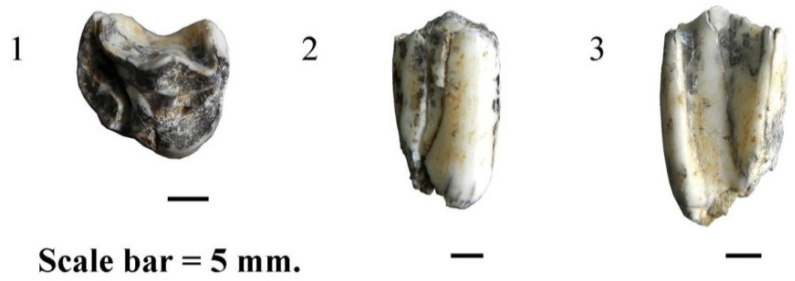


Figure 4.61 An Upper a right P4 (TPKP NE249) of *Capricornis milneedwardsii* from Tham Prakai Phet; 1-3 Occlusal, lingual, and labial views.

M2: The anterior lobe is narrower and wider than the posterior one. In occlusal view, outline of lobes have a pentagonal shape, both labial cones and styles are prominent, the mesostyle is very marked which is influenced by the week development of the metacone, the protocone is clearly sharper than the hypocone, lingual cones bends lingually, the fossete occurs between lobs. In labial view, styles are prominent and straight along the tooth, the paracone is close to the parastyle at the base. Length at the

top is slightly smaller than the length at the base. In lingual view, a narrow groove can be observed by touching (Table 4.65 and Figure 4.62).

Table 4.65 Upper M2 measurements of *Capricornis milneedwardsii* from Tham Prakai Phet

	Measurements						
	1	**2**	**3**	**4**	**5**	**6**	**7**
n	3	3	2	2	3	3	2
Max	20.53	21.37	16.32	15.39	15.07	14.06	19.52
Min	20.24	19.52	16.27	14.18	13.68	11.32	18.49
Mean	20.41	20.59	16.30	14.79	14.28	13.06	19.01
SD	0.15	0.96	0.04	0.86	0.71	1.51	0.73

Figure 4.62 Upper left M2 (TPKP NW115) of *Capricornis milneedwardsii* from Tham Prakai Phet; 1-3) Occlusal, lingual, and labial views

M3: In occlusal view the tooth, labial lobes show pentagonal-like outline, styles are marked, the paracone and the metacone are prominent, the protocone is shaper than the hypocone, lingual cones are perpendicular to mesio-distal axis in occlusal view. In labial view, all styles are marked especially in TPKPSW191, the paracone bends the parstyle at the base, the metastylar wing straight along the tooth, the inner edge of the metastylar convergent to the metacone at the base, the length of top is as well as that of the base. Interstylar width of anterior lobe is as well as that of posterior one. In lingual view, the protocone and the hypocone are parallel along the crown. The entostyle can be developed between lingual cones (such as TPKPSW191). The metastylar wing is wider at the base and well marked (Table 4.66 and Figure 4.63).

Table 4.66 Upper M3 measurements of *Capricornis milneedwardsii* from Tham Prakai Phet

	Measurements											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
n	3	3	2	3	2	3	3	3	3	3	3	3
Max	22.64	25.60	14.96	14.48	12.58	11.43	18.85	20.28	6.96	7.89	21.79	22.65
Min	21.05	22.52	12.99	11.33	12.31	10.74	16.88	15.44	6.71	6.55	19.60	18.90
Mean	21.90	24.27	13.98	13.38	12.45	11.11	17.79	17.25	6.83	7.21	20.57	20.77
SD	0.80	1.58	1.39	1.78	0.19	0.35	0.99	2.64	0.13	0.67	1.12	1.88

Figure 4.63 Upper left M3 (TPKPNE278) of *Capricornis milneedwardsii* from Tham Prakai Phet; 1-3) Occlusal, lingual, and labial views

Lower dentition:

dp 4: The tooth present three-lobes. The first lob is the smallest and the third one is the largest. The outline of three lobes is a triangular shape. The crown is low and slender. In occlusal view, lingual conids are marked, the parastylid and the entostylid are prominent, the metastylid show a strong development as a marked vertical rib. Two basal pillars: anterior ectostylids and ectostylids presented between labial conids. The distal wall is flat. In lingual view, the top of the crown is larger than the base, conids and stylids are very marked along the crown (Table 4.67 and Figure 4.64).

Table 4.67 Lower dp4 measurements of *Capricornis milneedwardsii* from Tham Prakai Phet

	Measurements					
	1	**2**	**3**	**4**	**5**	**6**
Number	1	1	1	1	1	1
Mean	22.26	20.99	6.63	8.92	9.10	10.62

Figure 4.64 Upper left dp4 (TPKPNE5) of *Capricornis milneedwardsii* from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views

p2: The tooth has a trigular-like shape. In occlusal view, the parastylid is marked, the paraconid is absent, the anterior valley has an U-shape, the metaconid and the entoconid are marked, the entostylid is absent, the posterior valley is a V-shape, both the protoconid and the hypoconid are rounded. In lingual view, the parastyle is marked along the tooth, the anterior valley and the posterior valley are enclosed at the base, the metaconid and the entoconid can be observed. In the distal view, a wall is slightly flat (Table 4.68 and Figure 4.65).

Table 4.68 Lower p2 measurements of *Capricornis milneedwardsii* from Tham Prakai Phet

	Measurements				
	1	**2**	**3**	**4**	**5**
Number	1	1	1	1	1
Mean	11.45	9.80	6.64	6.00	2.78

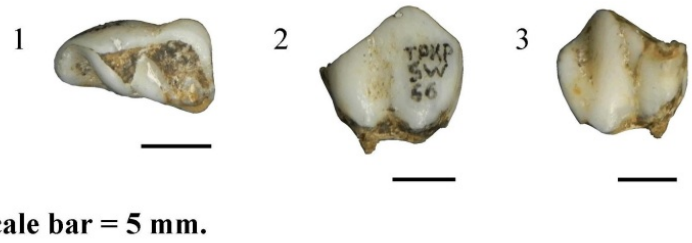


Figure 4.65 Upper right p2 (TPKPSW66) of *Capricornis milneedwardsii* from Tham Prakai Phet; 1-3) Occlusal, labial, and lingual views

p3: The tooth has a triangular shape. In occlusal view, the parastylid often fuses to the paraconid and inclines mesially, the anterior valley has a wide V-shape, the metaconid is weakly prominent, the entoconid and the entostylid trend to be merging in an advance stage, the posterior valley also tend to enclosing, the protoconid is strongly

curved, the labial valley is shallow, the hypoconid is weak, the distal edge inclines backwards. In lingual view, the anterior valley is marked and wide, being lost at the base, the posterior valley is enclosed at the middle, the metaconid and entoconid are merged after the middle. In labial view, the valley is weak. In distal view, the groove exists along the tooth (Table 4.69 and Figure 4.66).

Table 4.69 Lower p3 measurements of *Capricornis milneedwardsii* from Tham Prakai Phet

	Measurements				
	1	**2**	**3**	**4**	**5**
N	1	1	1	1	1
Mean	14.79	14.51	10.02	9.10	-

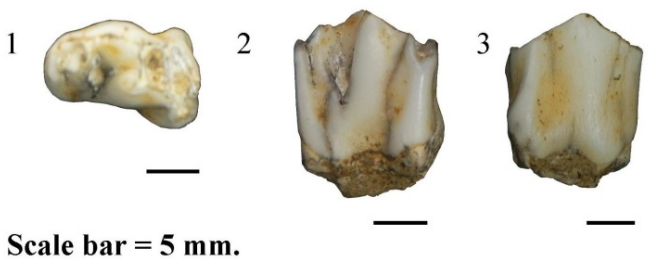


Figure 4.66 An upper right p3 (TPKPSW203) of *Capricornis milneedwardsii* from Tham Prakai Phet 1-3) Occlusal, lingual, and labial views

p4: The tooth shows a bilobation (molarized) due to the two deep opposite valleys. In occlusal view, the outline of both anterior and posterior lobe is a trapezoidal, the anterior one is wide and perpendicular to the mesio-distal axis of the tooth, the posterior one is inclined disto-lingually, the parastylid is marked, the metaconid is very marked and associated with a well developed metastylid, the entoconid is sharp, a lingual valley is more deep than the labial valley, both the mesial and distal faces are rounded. In TPKPNW72, the outline of both two fossa is an U-shape, while that in TPKPNW154 is a line shape. In lingual view, the groove is very deep, all lingual stylids and the entoconid are marked along the tooth. In labial view, the labial groove is marked from the top to the base (Table 4.70 and Figure 4.67).

Table 4.70 Lower p4 measurements of *Capricornis milneedwardsii* from Tham Prakai Phet

	Measurements				
	1	**2**	**3**	**4**	**5**
n	2	2	2	2	2
Max	16.77	16.85	9.60	8.52	9.58
Min	16.04	15.32	9.50	7.56	9.21
Mean	16.41	16.09	9.55	8.04	9.40
SD	0.52	1.08	0.07	0.68	0.26

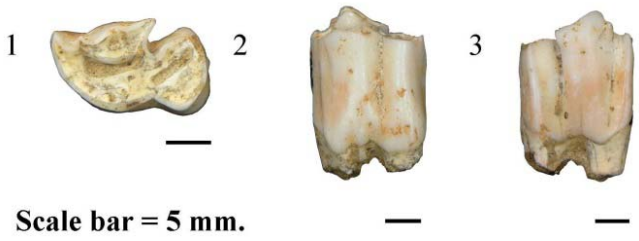


Figure 4.67 A lower left p4 (TPKPNW154) of *Capricornis milneedwardsii* from Tham Prakai Phet: 1-3) Occlusal, labial view, and lingual views

Lower m2: The anterior lobe has an asymetry shape, while the posterior one shows a symmetric pentagonal shape. In occlusal view, almost lingual stylids are slightly developed, except the metastylid, it is very developed. Both lingual conids are strongly. The hypoconid is sharper and more extended than the protoconid. In lingual view, both conids and stylids are prominent along the tooth, especially metaconid, it become a semi-circular shape and associated with merging to metastylid after the middle of the tooth. The top is more dilated than the base. In labial view, the protoconid and the hypoconid are parallel, like in the m1, no ectostylid is observed (Table 4.71 and Figure 4.68).

Table 4.71 Lower m2 measurements of *Capricornis milneedwardsii* from Tham Prakai Phet

	Measurements				
	1	**2**	**3**	**4**	**5**
Number	1	1	1	1	1
Mean	20.42	18.64	11.08	11.09	13.82

Figure 4.68 Lower left m2 (TPKPNE66) of *Capricornis milneedwardsii* from Tham Prakai Phet: 1-3) Occlusal, lingual, and labial views

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

Family: Bovidae Gray, 1821

Subfamily: Caprinea Gray, 1821

Tribe Ovibovini Gray, 1821

Genus: *Naemorhedus* Smith, 1827

***Naemorhedus griseus* Milne-Edwards, 1871**

Localities: Tham lod Rockshelter, Tham Prakai Phet, and Tham Rak Sai

Material: Tham lod Rockshelter totally 148 specimens consist of 1 DP2, 1 P3, 6 P4, 22 M1, 18 M2, 23 M3, 5 p3, 6 p4, 15 m1, 25 m2, and 26 m3.

Tham Prakai Phet Totally 7 specimens consist of 1 DP4, 2 P3, 2 M3, and 2 m3.

Tham Rak Sai: Totally 12 specimens consist of 1 DP4, 1 M1, 1 M3, 1 dp4, 1 p3, 2 m1, 2 m2, and 3 m3.

Upper dentition

DP2: In occlusal view, the outline of the tooth is a trapezoidal shape with two opposite shallow valleys, the parastyle is developed, the metastyle is weakly prominent, the paracone is more marked than the metacone. In labial view, the paracone is very marked. In lingual view, the crown curved distally. In both mesial and distal view, the tooth shows shallow grooves from the top to the base (Table 4.72 and Figure 4.70).

Table 4.72 DP2 measurements of *Naemoredus griseus* from Tham Lod Rockshelter

	Measurements			
	1	**2**	**3**	**4**
n	1	-	1	-
Mean	9.18	-	7.11	-

Scale bar = 5 mm.

Figure 4.70 A lower rigth DP2 (TLA2133 in Area 1) of *N. griseus* from Tham Lod Rockshelter: 1-3) Occlusal, lingual, and labial views

DP4: The tooth is a molarized brachyodont. Both anterior and posterior lobes are pentagonal shape. In occlusal view, labial styles and cones are weakly marked. The protocone exhibits open angle which is clearly distance from the hypocone. In labial view, both styles and cones are marked along the tooth, the top of the tooth is wider than the base (Table 4.73 and Figure 4.71).

Table 4.73 Upper DP4 measurements of *Naemorhedus griseus* from Tham Prakai Phet

Localities		**Measurements**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Tham Prakai Phet	N	1	1	1	1	1	1	1
	Mean	14.42	-	-	9.21	13.16	-	-
Tham Rak Sai	N	1	1	-	-	1	1	1
	Mean	12.62	10.04	-	-	8.76	7.65	13.58

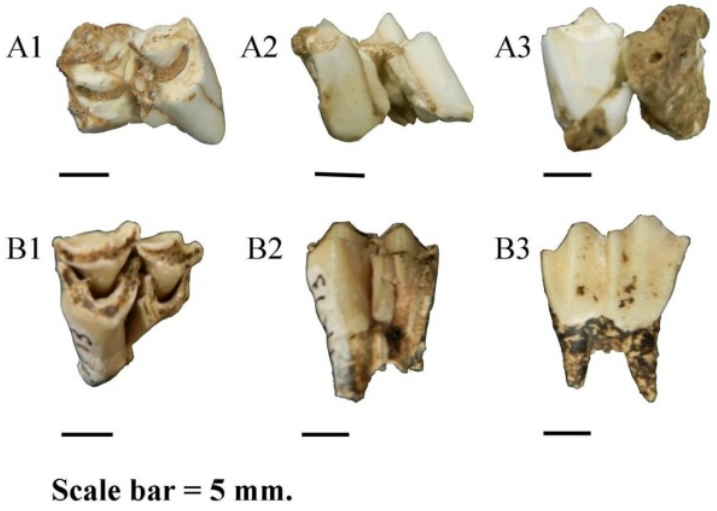


Figure 4.71 Upper DP4 of *N. griseus*: A1-3) Occlusal, lingual, and labial views of a left DP4 (TPKPSW14) from Tham Prakai Phet; B1-3) occlusal, lingual, and labial views of a right DP4 (TR13) from Tham Rak Sai

P3: In occlusal view, the tooth exhibits pentagonal outline and is slightly compressed labio-lingually, the parastyle is slightly marked and perpendicular to the mesio-distal axis of the tooth. The metastyle is larger than the parastyle and bend backwards. The protocone is slightly sharp and bend forwards. In labial view, the paracone clearly located near the parastyle, the parastyle and the metastyle are developed along the crown, the width of the tooth is decrese from the top to the base (Table 4.74 and Figure 4.72).

Table 4.74 Upper P3 measurements of *Naemoredus griseus*

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	1	-	1	1	1
	Mean	8.99	-	9.97	9.12	10.12
Tham Prakai Phet	N	2	2	2	-	2
	Max	10.44	9.53	9.87	-	8.54
	Min	10.05	9.31	9.23	-	8.21
	Mean	10.25	9.42	9.55	-	8.38
	SD	0.28	0.16	0.45	-	0.23

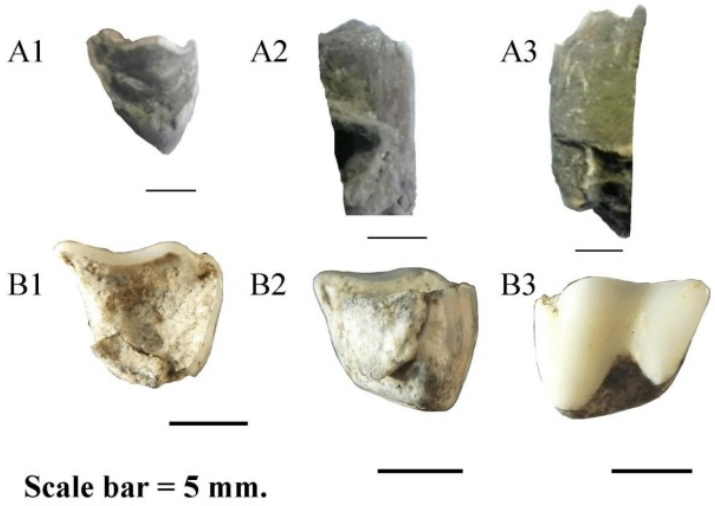


Figure 4.72 Upper right P3 of *N. griseus*: A1-3) Occlusal, lingual, and labial views of a right P3 (A1994a in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right P3 (TPKP SE93) from Tham Prakai Phet.

P4: In occlusal view, the outline of the crown is a pentagonal shape, the parastylid and the metastylid are marked and perpendicular to the mesio-distal axis, the protoconid is sub-angular outline which bends mesially. In labial view, the labial cone is centered between the parastylid and the metastylid, the dilation of the crown is more important than that of P3 (Table 4.75 and Figure 4.73).

Table 4.75 Upper P4 measurements of *Naemoredus griseus*from Tham Lod Rockshelter

	Measurements				
	1	**2**	**3**	**4**	**5**
n	9	7	8	7	7
Max	16.76	14.09	11.27	12.10	11.45
Min	8.60	7.48	8.28	7.53	8.19
Mean	11.87	10.28	9.81	9.69	10.03
SD	2.99	3.05	1.13	1.61	1.35

Figure 4.73 A left P4 (TLA7431 in Area 1) of *N. griseus* from Tham Lod Rockshelter: 1-3) Occlusal, lingual, and labial views

M1: In occlusal view, the anterior lobe exhibits a triangular shape, the posterior one shows a pentagonal shape. The parastyle and the mesostyle are developed which bend forwards. The metastyle is weakly prominent and bend backward. Both labial cones are developed especially the metacone. The protocone is sharped. The hypocone is rounded. The protocone is wider than the hypocone. The lingual valley between lingual lobes is narrow. In labial view, the crown is strongly pinched at the base, the mesostyle and the parastyle are marked. (Table 4.76 and Figure 4.74).

Table 4.76 Upper M1 measurements of *Naemoredus griseus*

Localities		**Measurements**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Tham Lod Rockshelter	N	19	17	17	17	17	15	12
	Max	14.74	12.79	12.30	12.12	10.84	12.78	14.40
	Min	10.32	9.33	7.38	7.58	6.64	6.74	9.25
	Mean	13.07	11.01	10.25	9.74	9.09	9.17	12.28
	SD	1.03	1.01	1.29	1.27	1.15	1.57	1.36
Tham Rak Sai	n	1	1	1	1	1	1	1
	Mean	14.58	14.31	15.55	15.28	14.77	14.71	16.14

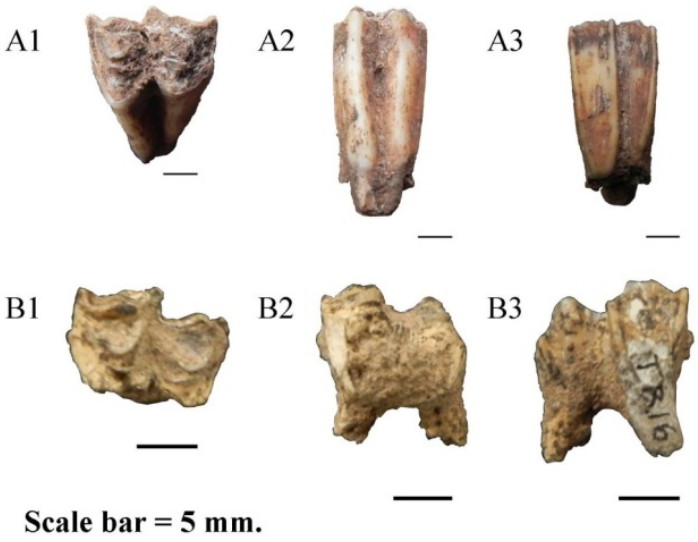


Figure 4.74 Upper let M1 of *N. griseus*: A1-3) Occlusal, lingual, and labial views of a rigth M1 (TLA4792 in Area 1) from Tham Lod Rockshelter; B1-3) Oocclusal, lingual, and labial views of a right M1 (TR16) from Tham Rak Sai

M2: In occlusal view, like in the upper M1, the anterior lobe has a triangular shape, the posterior one shows a pentagonal shape. The metacone is more marked than the paracone, the mesostyle and the parastyle are prominent and bend forwards. The metastyle is smaller than that of M1, and bend distally. The protocone is sharper than the hypocone and bend slightly mesially, the hypocone is perpendicular to the mesio-distal axis of the crown. The valley between lingual cone is V-shape and wider than that of M1. In labial view, the base of the crown is less pinched than M1, the metastyle is weaker than other style. The interstyle surface of both lobe are not clearly different, unlike in M1, the interstyle surface of anterior lobe is larger than that of posterior one. In lingual view, lingual cones are more pararell than those of M1. The dimesions of M2 are larger than M1 (Table 4.77 and Figure 4.75).

Table 4.77 Upper M2 measurements of *Naemorhedus griseusl* from Tham Lod Rockshelter.

	Measurements						
	1	**2**	**3**	**4**	**5**	**6**	**7**
n	15	13	12	13	15	13	11
Max	15.87	14.67	12.46	11.99	15.67	10.74	15.51
Min	11.21	9.61	8.25	7.44	7.76	7.14	10.76
Mean	14.65	13.11	10.83	9.94	10.19	9.07	13.18
SD	1.16	1.43	1.27	1.27	1.86	0.97	1.43

Figure 4.75 A right M2 (TLA4543 in Area 1-3) of *N. griseus* from Tham Lod Rockshelter: 1-3) occlusal, lingual, and labial views

M3: In occlusal view, the anterior lobe is pentagonal shape, the posterior lobe exhibits a pentaonal-like or a triangular shape which is clearly smaller than the anterior one. The parastlye and the mesostyle are moderately developed. The metastylar wing is weak. The protocone is slightly sharper than the hypocone. Both protocone and hypocone are perpendicular to the mesio-distal axis of the crown. In the labial view, the dilation of crown is marked at the base due to the development of the metastylar wing. All styles are moderately developed. In the lingual view, the anterior lobe is larger than the posterior one. The metastylar wing is weakly developed and straight from the top to the base (Table 4.78 and Figure 4.76).

Table 4.78 M3 measurements of *N. griseusl* (mm)

Localities		Measurements											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Tham Lod Rock shelter	N	23	22	23	22	22	22	19	18	22	21	22	19
	Max	16.57	17.79	12.00	11.33	12.29	10.18	12.31	12.30	6.02	7.03	15.32	15.65
	Min	13.53	13.94	7.89	6.25	6.49	6.18	5.69	8.85	4.18	3.19	13.10	12.47
	Mean	14.97	15.52	9.68	8.80	8.78	7.83	10.08	10.03	5.19	5.42	14.00	14.12
	SD	0.84	1.06	0.86	1.09	1.52	1.08	2.32	1.09	0.52	0.86	0.57	0.90
Tham Prakai Phet	N	2	2	2	2	2	2	2	2	2	2	2	2
	Max	17.26	16.84	12.14	12.14	12.20	10.59	9.49	13.24	4.73	6.99	15.88	16.27
	Min	14.92	15.82	10.72	9.27	9.26	7.61	9.30	10.43	3.93	4.66	14.08	14.91
	Mean	16.09	16.33	11.43	10.71	10.73	9.10	9.40	11.84	4.33	5.83	14.98	15.59
	SD	1.65	0.72	1.00	2.03	2.08	2.11	0.13	1.99	0.57	1.65	1.27	0.96
Tham Rak Sai	N	1	1	-	-	-	-	-	-	1	1	-	1
	Mean	16.45	15.87	-	-	-	-	-	-	5.33	5.95	-	14.78

Figure 4.76 M3 of *N. griseus*: A1-3) Occlusal, lingual, and labial views of a left M3 (TLA235 in Area 2) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right M3 (TPKP45) from Tham Prakai Phet; C1-3) occlusal, lingual, and labial views of a left M3 from Tham Rak Sai (TR17).

Lower dentition

dp 4: The tooth presents the three-lobes form, the first lob is as wide as the second lob, and the third one is widest. The first and the second lobes are perpendiculat to the mesio-distal axis of the tooth, the third lobe bends backwards. The outline of all lobes is semi-triangular. In lingual view, a crown presents dilation at the base. The entoconid and the metaconid are marked. All styles are very weak (Table 4.79 and Figure 4.77).

Table 4.79 Lower dp4 measurements of *Naemorhedus griseus* from Tham Rak Sai.

	Measurements					
	1	2	3	4	5	6
n	1	1	1	1	1	1
Mean	14.93	12.88	7.07	6.99	5.88	-

Figure 4.77 A right dp4 (TR266) of *Naemorhedus griseus* from Tham Rak Sai: 1-3) occlusal, lingual, and labial views.

p3: In occlusal view, the crown exhibits a narrow triangular shape, the paraconid fuses to the parastylid and bends mesio-lingually. The anterior valley is a wide V-shape. The metaconid is weak and often merged to the entoconid. The metaconid corner is a right angle. The posterior valley is enclosed and lost at the base of the crown. The protoconid is curved. The valley between the hypocone and the protoconid is a shallow U-shape, the hypocone is morderately developed. In lingual view, the anterior groove is often reduced and became a small V-shape groove in worn teeth, the lingual wall is often flat. In labial view, the protoconid is rounded, the hypoconid is developed, a groove between the hypoconid and the protoconid presents along the crown (Table 4.80 and Figure 4.89).

Table 4.80 Lower p3 measurements of *Naemoredus griseus*from Tham Lod Rockshelter.

Localities		Measurements				
		1	2	3	4	5
Tham Lod Rockshelter	n	3	3	3	3	3
	Max	9.66	9.92	6.44	8.24	3.93
	Min	9.14	8.25	6.03	5.71	3.06
	Mean	9.41	8.82	6.21	6.82	3.56
	SD	0.26	0.95	0.62	1.29	0.45
Tham Rak Sai	n	1	1	1	1	1
	Mean	8.41	7.12	5.14	4.73	2.64

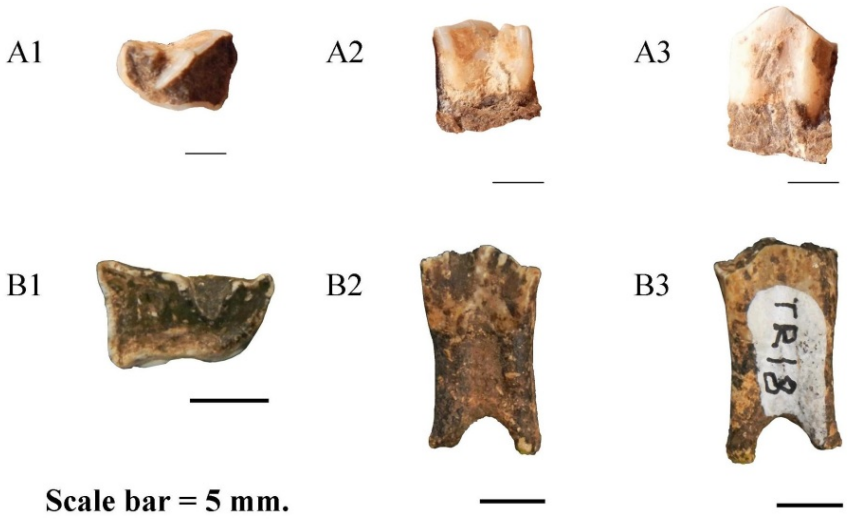


Figure 4.78 Lower p3 of *N. griseus*: A1-3) Occlusal, lingual, and labial views of a left p3 (TLA1102a in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a right p3 (TR18) from Tham Rak Sai

p4: The tooth presents weak bilobation (molarized), cones are sperated by two opposite shallow valleys. In occlusal view, the anterior cone is larger than the posterior one, the metaconid is prominent, the parastylid and the entostylid are moderatly developed, lingual valleys are weak and closed in worn tooth, the labial valley is shallow V-shape, the protoconid is rounded which is wider than the hypoconid, the hypoconid is sharpe. In lingual view, the metaconid is weakly rounded, the parastylid and the entostylid are prominent along the tooth. In labial view, the lingual groove is developed along crown (Table 4.81 and Figure 4.79).

Table 4.81 Lower p4 measurements of *Naemoredus griseus* Tham Lod Rockshelter.

	Measurements				
	1	**2**	**3**	**4**	**5**
n	6	4	5	5	4
Max	11.88	10.63	6.92	6.96	6.14
Min	9.97	9.16	6.00	5.83	5.55
Mean	11.17	10.03	6.55	6.11	5.85
SD	0.81	0.62	0.36	0.48	0.32

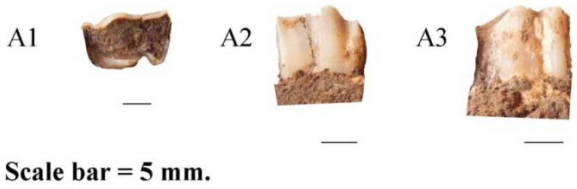


Figure 4.79 A left p4 (TLA1102b in Area 1) of *N. griseus* from Tham Lod Rockshelter: 1-3) occlusal, lingual, and labial views.

m1: The shape of the occlusal surface is influenced by wear. They are clearly hypsodont. In occlusal view, the anterior lobe is as large as the posterior one, lingual cones are prominent, the parastylid and the entostylid are weakly marked, the metastylid is absent, labial conids are sharp, the protoconid bend labially, the hypoconid bend backward, the caprine fold slightly presents, the outline of labial valley is deep and wide V-shape. In the lingual view, the metaconid and the entoconid are strongly rounded especially TLA3737, lingual styles are developed along the tooth (Table 4.82 and Figure 4.80).

Table 4.82 Lower m1 measurements of *Naemoredus griseus*in (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	15	12	14	13	10
	Max	14.13	13.02	8.67	8.55	8.82
	Min	10.72	7.21	6.52	6.50	3.41
	Mean	12.82	10.98	7.60	7.74	7.31
	SD	0.82	1.56	0.61	0.58	1.49
Tham Rak Sai	n	1	1	2	2	2
	Max	-	-	7.57	7.20	7.77
	Min	-	-	7.34	7.15	7.29
	Mean	13.59	10.97	7.46	7.18	7.53
	SD	-	-	0.16	0.04	0.34

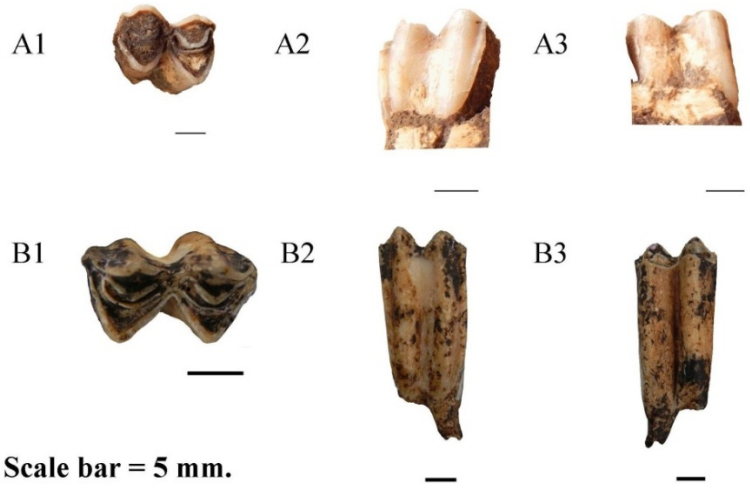


Figure 4.80 Lower m1 of *N. griseus*: A1-3) occlusal, lingual, and labial views of a left m1 (TLA1102c in Area 1) from Tham Lod Rockshelter; B1-3) occlusal, lingual, and labial views of a right m1 (TR9) from Tham Rak Sai

m2: In occlusal view, the anterior lobe is slightly smaller than the posterior one. Lingual conids are slightly developed. The metaconid is more marked than the entoconid. Lingual stylids are developed. The parastylid is more prominent than the entostylid. The metastylid is weakly developed, unlike in m1. The metastylid does not exhibit. The hypoconid bends more distally than the protoconid. In lingual view, the metastylid occurs only on the top of the crown. The size of tooth is larger than that of m1 (Table 4.83 and Figure 4.81).

In Tham Lod Rockshelter specimens, labial parts of the conid are rounded, and somes specimens present the entoconulid such as TLA577, TLA1654, TLA1175, TLA1184, TLA1920, TLA3054, and TLA4791). In Tham Rak Sai specimens, lingual stylids are slightly developed. Labial conids are sharp.

Table 4.83 Lower m2 measurements of *Naemoredus griseus*.

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	23	21	24	22	20
	Max	16.43	14.49	8.76	8.41	10.67
	Min	13.01	7.96	6.28	6.13	7.16
	Mean	14.44	12.21	7.57	7.38	8.29
	SD	0.86	1.43	0.63	0.66	0.77
Tham Rak Sai	n	2	2	2	2	2
	Max	13.95	13.50	8.14	8.05	7.96
	Min	13.02	10.53	8.01	7.66	7.62
	Mean	13.49	12.02	8.08	7.86	7.79
	SD	0.66	2.10	0.09	0.28	0.24

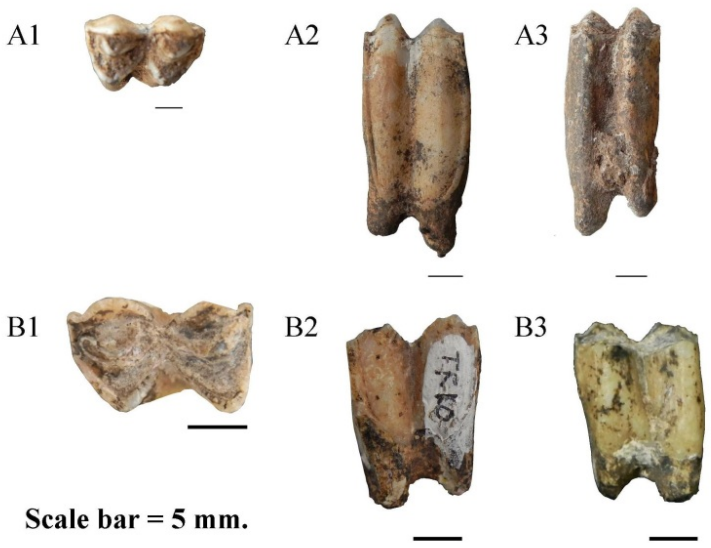


Figure 4.81 Lower m2 of *N. griseus*: A1-3) Occlusal, lingual, and labial views of a right m2 (TLA1744 in Area 1) from Tham Lod Rockshelter; B1-3) Occlusal, lingual, and labial views of a left m2 (TR10) from Tham Rak Sai

m3: In occlusal view, the anterior lobe is slightly smaller than the posterior one. Lingual conids are moderatly developed. The metaconid is larger than the entoconid. The parastylid is clearly marked. The entostylid is weakly developed. The protoconid is more rounded than the hypoconid. The outline of third lobe is semi-circular shape and point labio-distally. The entoconulid face represents shallow U-shape valley at the top of the tooth. The labial part of the crown is sharp. The hypoconulid

projects distally than the others. Some teeth (TLA1172, TLA3119, and TLA1289) present a third lobe with a flat entoconulid which point distally. Whereas in some teeth (TLA1604 and TLA2482), the entoconulid surface presents a V-shape valley at the top and inclined labio-distally. Only one specimen (TLA411) presents an entoconulid with a very tiny vertical rib on the most top of the crown which curve labio-distally (Table 4.84 and Figure 4.82).

Table 4.84 Lower m3 measurements of *Naemorhedus griseus* (mm)

Localities		**Measurements**					
		1	**2**	**3**	**4**	**5**	**6**
Tham Lod Rockshelter	n	18	16	21	26	19	17
	Max	22.36	22.65	9.86	9.53	5.27	9.97
	Min	16.25	16.59	5.40	4.11	1.70	7.59
	Mean	19.49	19.26	7.70	7.11	3.94	8.57
	SD	1.46	1.63	0.92	1.19	0.85	0.72
Tham Prakai Phet	n	1	1	2	2	1	2
	Max	-	-	8.18	7.44	-	8.28
	Min	-	-	7.60	7.21	-	8.08
	Mean	19.11	20.25	7.89	7.33	4.16	8.18
	SD	-	-	0.41	0.16	-	0.14
Tham Rak Sai	n	1	1	2	2	1	2
	Max	-	-	8.74	7.66	-	7.99
	Min	-	-	7.25	6.43	-	6.46
	Mean	19.62	19.14	8.00	7.05	4.42	7.23
	SD	-	-	1.05	0.87	-	1.08

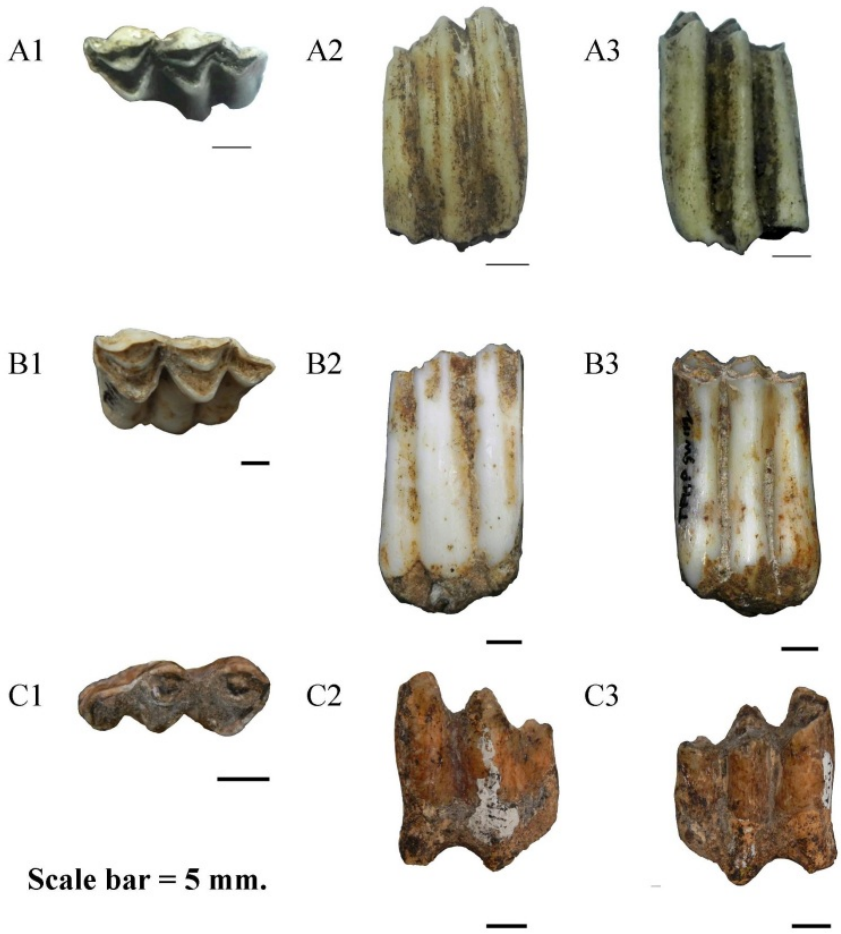


Figure 4.82 Lower m3 of *N. griseus*: A1-3) occlusal, lingual, and labial views of a left m3 (TLA1289 in Area 2) from Tham Lod Rockshelter; B1-3) occlusal, lingual, and labial views of a left m3 from Tham Prakai Phet (TPKPSW108); C1-3) occlusal, lingual, and labial views of a right m3 (TR10) from Tham Rak Sai

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

Family: Bovidae Gray, 1821

Subfamily: Caprinea Gray, 1821

Tribe Ovibovini Gray, 1821

Genus: *Naemorhedus* Smith, 1827

***Naemorhedus* cf. *goral* (Hardwicke, 1825)**

Localities: Tham Lod Rockshelter, Tham Prakai Phet, and Tham Rak Sai

Material: Tham Lod Rockshelter: 17 specimens (5 M2, 2 M3, 2 p3, 1 p4, 1 m1, 2 m2, and 4 m3).

Tham Prakai Phet: two specimens (1 M3 and 1 p3)

Upper dentition

M2: In occlusal view, the anterior lobe is an elongated triangular shape, the posterior lobe presents a pentagonal shape. Labial styles are developed. Especially the mesostyle, it is most prominent and perpendicular to the mesio-distal axis of the crown. The paracone is marked. The metacone is weakly developed. The protocone and the hypocone are shape and perpendicular to the mesio-distal axis. The valley between the protocone and hypocone is a V-shape and wide. In labial view, the top is as wide as the base. On the lingual side, the paracone is marked along the tooth, the metacone is flat (Table 4.85 and Figure 4.83).

Table 4.85 Upper M2 measurements of *Naemorhedus* cf. *goral* from Tham Lod Rockshelter

	Measurements						
	1	**2**	**3**	**4**	**5**	**6**	**7**
N	4	4	4	3	5	4	5
Max	14.57	13.60	10.34	9.74	10.63	9.83	13.35
Min	13.50	10.93	9.09	8.70	7.76	7.40	11.06
Mean	14.02	12.53	9.90	9.25	8.75	8.19	12.18
SD	0.45	1.16	0.58	0.52	1.18	1.14	1.01

Figure 4.83 A left upper M2 (TLA1102b in Area 1) of *N. cf. goral* in Tham Lod Rockshelter: 1-3) occlusal, lingual, and labial views

M3: In occlusal view, the anterior and the posterior lobes present a pentagonal shape. The posterior lobe is larger and more rounded than the anterior one. The parastyle is more marked than other styles. The metastylar wing is marked. The paracone is more developed than the metacone. The protocone and the hypocone are weakly sharp and perpendicular to the mesio-distal axis. In the labial view, the tooth clearly is curved backwards. The dilation of the crown is restricted to its top, being more diffuse distally at the base of the tooth. The metastylar wing is strongly developed at the base. The metacone is weakly developed or flat, unlike in the paracone, it is marked (Table 4.86 and Figure 4.84).

Table 4.86 Upper M3 measurements of *Naemorhedus* cf. *goral* from Tham Lod Rockshelter

Localities		Measurements											
		1	2	3	4	5	6	7	8	9	10	11	12
Tham Lod Rock shelter	n	2	2	1	1	1	1	1	1	2	2	2	2
	Max	14.53	18.14	-	-	-	-	-	-	5.34	5.63	13.62	16.13
	Min	13.10	16.13	-	-	-	-	-	-	5.12	5.43	13.18	14.36
	Mean	13.82	17.14	8.92	7.55	7.10	6.40	13.21	9.91	5.23	5.53	13.40	15.25
	SD	1.01	1.42	-	-	-	-	-	-	0.16	0.14	0.31	1.25
Tham Prakai Phet	n	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	15.75	17.49	10.15	8.76	11.85	8.20	7.33	10.09	5.09	5.11	14.22	16.44

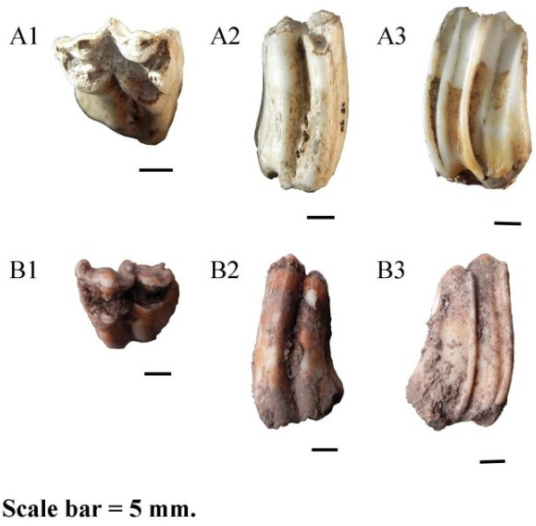


Figure 4.84 Upper M3 of *Naemorhedus* cf. *goral*: A1-3) occlusal, lingual, and labial views of a left M3 (TLA1921 in Area 1) from Tham Lod Rockshelter; B1-3) occlusal, lingual, and labial views of a right M3 (TPKPSW108) from Tham Prakai Phet

Lower dentition

p3: In occlusal view, the outline of the crown is triangular-like. The paraconid is fused to the parastylid and inclines forwards, the anterior valley is a wide U-shape. The metaconid is weak and inclines backwards which often merged to entoconid in an advance wearing stage. The posterior valley is enclosed, the protoconid is curved. The valley between the hypocone and the protoconid is a shallow U-shape, the hypocone is morderately developed. The distal face is flat and slightly perpendicular to the mesio-distal axis. In lingual view, the anterior valley is often reduced and became a shallow U-shape in worn teeth, the wall is often flat. In labial view, the hypoconid and a labial valley are developed along the crown (Table 4.87 and Figure 4.85).

Table 4.87 Lower p3 measurements of *Naemoredus* cf. *goral* (mm)

Localities		**Measurements**				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	2	2	2	2	1
	Max	9.76	9.61	6.27	6.41	-
	Min	9.35	8.93	6.23	5.54	-
	Mean	9.56	9.27	6.25	5.98	3.41
	SD	0.29	0.48	0.03	0.62	-
Tham Rak Sai	n	1	1	-	1	1
	Mean	9.50	8.33	-	5.52	3.53

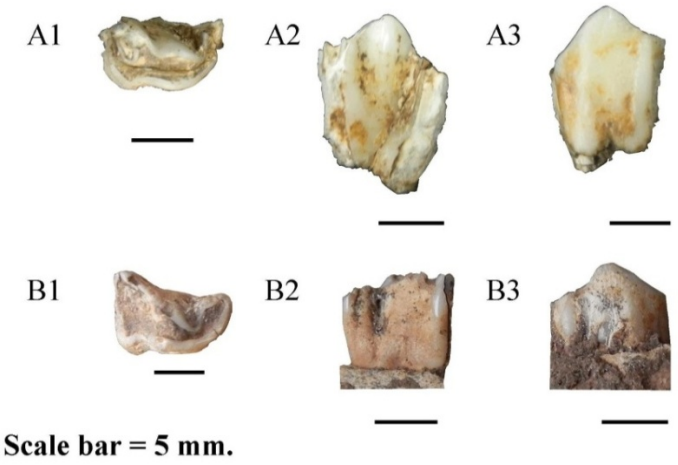


Figure 4.85 Lower p3 of *N.* cf. *goral* A1-3): occlusal, lingual, and labial views of a right p3 (TLA2132a in Area 1) from Tham Lod Rockshelter; B1-3) occlusal, lingual, and labial views of a left p3 (TPKPSE9) from Tham Prakai Phet.

p4: The tooth is molarized with two opposite shallow valleys: the lingual valleys is rarely marked, the labial valley is shallow V-shape. In occlusal view, the anterior cone is larger than the posterior one, the metaconid is prominent, the other stylids are moderatly developed, the protoconid and the hypoconid are rounded. The distal face is flat and slightly perpendicular to the mesio-distal axis. In lingual view, the wall of the metaconid is rounded, lingual valley is prominent along the tooth. In labial view, labial valley is developed from the top to the base (Table 4.88 and Figure 4.86).

Table 4.88 Lower p4 measurements of *Naemoredus* cf. *goral* from Tham Lod Rockshelter.

	Measurements			
	1	**2**	**3**	**4**
n	1	-	1	1
Mean	11.43	-	6.62	6.26

Figure 4.86 A right p4 (TLA2132b in Area 1) of *N.* cf. *goral* from Tham Lod Rockshelter: 1-3) occlusal, lingual, and labial views.

m1: In occlusal view, the anterior lobe is slightly wider than the posterior one, lingual cones are prominent, the parastylid and the entostylid are marked, the metastylid occurs from the top to the middle of the crown, labial cones are clearly sharp, the protoconid and the hypoconid bend distally, the caprine fold is slightly marked. In lingual view, the metaconid and the entoconid are marked, the parastylid and the entostylid are marked along the tooth, the top is wider than the base (Table 4.89 and Figure 4.87).

Table 4.89 Lower m1 measurements of *Naemorhedus* cf. *goral* from Tham Lod Rockshelter.

	Measurements				
	1	**2**	**3**	**4**	**5**
n	1	1	1	1	1
Mean	13.45	11.46	7.19	7.41	7.84

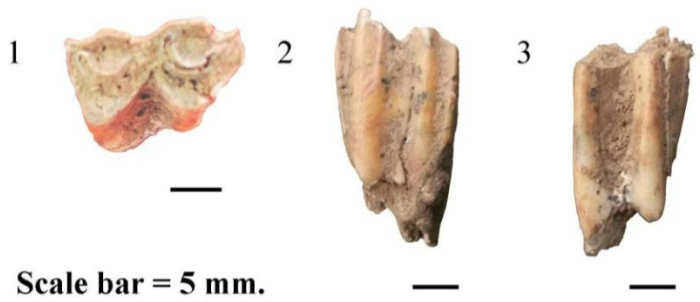


Figure 4.87 A right m1 (TLA791 in Area 1) of *N. goral* from Tham Lod Rockshelter: 1-3) occlusal, lingual, and labial views.

m2: In occlusal view, the anterior lobe is slightly larger than the posterior one, the metaconid is more prominent than the entoconid, the parastylid and the entostylid are developed, the metastylid developed and located at only the upper part, labial conids are sharp and bend lingually, the caprine fold is weak. In lingual view, almost conids and stylis present along the tooth, except the metastylid is developed at only the upper which is more marked than m1, the top of the tooth is more dilated than the base. The size of the tooth is larger than m1 (Table 4.90 and Figure 4.88).

Table 4.90 Lower m2 measurements of *Naemorhedus goral* (mm)

		Measurements				
		1	**2**	**3**	**4**	**5**
Tham Lod Rockshelter	n	2	2	2	2	2
	Max	16.38	14.03	7.57	7.26	8.25
	Min	14.28	13.23	6.96	7.25	8.15
	Mean	15.33	13.63	7.27	7.26	8.20
	SD	1.48	0.57	0.43	0.01	0.07

Figure 4.88 Lower m2 of *N goral*:A1-3) Occlusal, lingual, and labial views of a right m2 (A521 in Area 1) from Tham Lod Rockshelter

m3: In occlusal view, the metaconid is more prominent than the entoconid, the parastylid is marked, the entostylid is weakly developed, the metastylid is very weak, labial conids are sharp and bend distally, the third lobe point disto-lingually, the entoconulid show a vertical rib which bend distally, the hypoconulid is convex. The caprine fold is weak. In lingual view, the parastylid and metaconid are marked along the tooth, entoconulid exhibit a vertical rib at the upper part of. In labial view, the hypoconulid is sharp at the top and being rounded at the base of the crown (Table 4.91 and Figure 4.89).

Table 4.91 Lower m3 measurements of *Naemorhedus goral* (mm)

Localities		**Measurements**					
		1	**2**	**3**	**4**	**5**	**6**
Tham Lod Rockshelter	n	3	3	3	4	4	2
	Max	21.96	21.33	7.92	7.69	4.78	9.30
	Min	20.32	18.57	7.54	6.64	4.17	8.81
	Mean	21.07	20.08	7.74	7.26	4.50	9.06
	SD	0.83	1.40	0.19	0.46	0.27	0.35

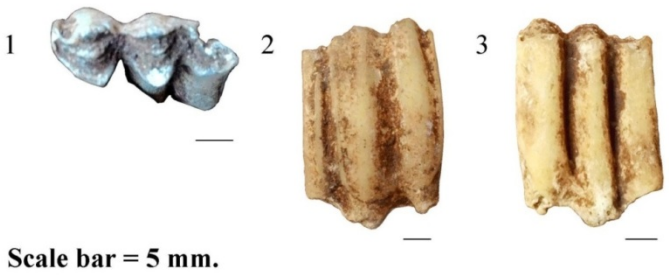


Figure 4.89 Lower m3 of *N* goral: A1-3): occlusal, lingual, and labial views of a left m3 (A7788 in Area 1) from Tham Lod Rockshelter.

4.2.2 Discusion of Caprinae

Capricornis sumtraensis

In DP4, the tooth is molarized and clear bilobation which present marked labial styles and cones, and rounded lingual cones, like *C. sumatraensis* (Guérin, 1966). Unlike in *C. milneedwardsii*, its tooth exhibits a rounded hypocone and more pinched lingual lobes. In *C. crispus*, labial styles and the metacone are weakly marked, and the hypocone is rounded (Filoux, 2015, Pers. Comn.).

In P2, the tooth has a trapezoid shape with developed labial styles and cone like in *Naemorhedus* and *Capricornis* (Guérin, 1966). In occlusal view, the tooth presents the paracone located near the parastylethe and the very marked hypocone, like in *C. sumatraensis* (Thein, 1974). It is different from *C. milneedwardsii* which exhibits a very strong labial style, labial-lingual compression, a marked protocone, and a bilobation at the lingual side (Filoux, 2015, Pers. Comn.). In *C. crispus*, the tooth is clearly compressed labial-lingually and show less developed labial style than *C. milneedwardsii*.

In P3, the metastyle is prominent parastyle, the paracone located near the parastyle, like in *C. sumatraensis* and *N. goral* (Guérin, 1966; Thein, 1974; Gliozzi and Malatesta, 1980). The outline of the tooth is more rounded than that of *C. milneedwardsii*. The tooth show more rounded outline, less marked labial cone and sharper lingual cone than *C. milneedwardsii* (Filoux, 2015, Pers. Comn.). The tooth is less rectangular than *Capricornis crispus* is (Natsume *et al.*, 2005).

In P4, the parastyle is as well as meatstyle, unlike in *N. goral* and *C. sumatraensis*, the parastyle is more marked than the metastyle (Guérin, 1966; Gliozzi and Malatesta, 1980). The labial side seem be sharper than those of *N. goral* and *C. crispus* (Guérin, 1966; Gliozzi and Malatesta, 1980; Natsume *et al.*, 2005). The paracone is distance from the parastyle, like in *C. sumatraensis* (Thein, 1974). But, the tooth is less depressed labio-lingually than *C. milneedwardsii* (Filoux, 2015, Pers. Comn.).

Upper molars are closed to *Capra* (Rivals, 2002), *Capriconisi* and *Naemorhedus* (Guérin, 1966; Thein, 1974; Gliozzi and Malatesta, 1980). Teeth present the developed mesostyle, the shaped paracone, and the rounded hypocone, like in Late Pleistocene *C. sumatraensis* (or *N. sumatraensis*) from Tam Hang (Bacon *et al.*, 2011), Duoi U'Oi (Bacon *et al.*, 2008), Tham Prakai Phet (Filoux *et al.*, 2015), Batu Caves (Ibrahim, 2013), Badak Cave C (Ibrahim, 2013), and recent *C. sumatraensis* (Guérin, 1966; Thein, 1974; Gliozzi and Malatesta, 1980). Unlike in other species, *Capra* and *Naemorhedus* show undeveloped mesostyle and more marked labial cone; *C. milneedwardsii* exhibits more developed mesostyle and more marked labial cones (Filoux, 2015, pers. comn.). Teeth are clearly larger than *C. crispus* (Natsume *et. al.*, 2005, 2006). All tooth in this research do not present entostyle, unlike in *C. sumatraensis* Lod in many sites such as Sumatra Island (Hooijer, 1958), Lang Trang cave (de Vos and Long, 1993), Batu Cave, Malaysia (Ibrahim, 2013), Lang Trang cave, ectostyle can be noticed (de Vos and Long, 1993).

In dp4, the first lobe is the smallest in width; the parastyle stylid and the entostylid are developed; labial conid is sharp, like in *C. sumatraensis* (Filoux, 2015, Pers. Comn.). But some *C. sumatraensis* is present a weak development of the parastylid and the entostylid and a rounded labial conid (Guérin, 1966).

In p3, the outline of the teeth is less rounded than *C. crispus* (Miura and Yasui, 1985; Natsume *et al.*, 2005). Lingual conids, the hypoconid, and the labial valley are weakly marked which is closed to *C. sumatraensis* (Thein, 1974). Unlike in *C. milneedwardsii*, lingual conids and labial face are strongly marked.

In p4, the tooth is a molarized, like the description in *Capra* (Halstead and Collins, 2002; Zeder and Pilaar, 2010; Gillis *et al.*, 2011) and *Naemorhedus* (Guérin, 1966; Gliozzi and Malatesta, 1980). The tooth shows a marked bilobation corresponding to two opposite deep valleys and weak lingual stylids, like in the recent *C. sumatraensis* (Thein, 1974; Gliozzi and Malatesta, 1980).

In lower molars, the metastyle exists as a small rib and caprine fold is weakly developed, like in Late Pleistocene *C. capricornis* from Tham Prakai Phet (Filoux *et al*, 2015), and Tam Hang (Bacon *et al.*, 2011). But it is different from Late Pleistocene *C. sumatraensis* from Tam Hang which presents well marked lingual stylids (Bacon *et al.*, 2011). Unlike in *Capra* (Halstead and Collins, 2002; Zeder and Pilaar, 2010; Gillis *et al.*, 2011) and *Naemorhedus* (Guérin, 1966; Gliozzi and Malatesta, 1980) show more developed capine fold and rarely occurrence of the mesostyle. In *C. crispus* and *C. milneedwardsii*, their metastylis have more marked (Natsume *et. al.*, 2005, 2006, 2008; Filoux, 2015, pers. comn.). In almost specimens, the ectostylid is absent, like in almost Pleistocene and recent *Capricornis*. Except a few specimens of m1 and m2 is similar to Lang Trang cave (de Vos and Long, 1993).

In bivariate diagram of the occlusal length vs. the occlusal width (Figure 4.90-5), overall Middle to Late Pleistocene *Capeiconsis sumatraensis* data are larger than the recent data, however, some smaller-size of Middle to Late Pleistocene are clearly overlap to the recent. Almost data of three study sites are overlap data of Middle to Late Pleistocene *C. sumatraensis* sites such as Lang Trang cave (de Vos and Long, 1993), Duoi U'Oi (Bacon *et al.*, 2008), Batu Caves (Ibrahim, 2013), Badak Cave C (Ibrahim, 2013) and larger than almost recent specimens (Hooijer, 1958; Thein, 1974; Gliozzi and Malatesta, 1980; Wattanapituksakul, 2006).

However, some specimens present range which is different from that of most specimens. M1 and m1 in Tham Lod Rockshelter; M1 in Tham Wiman Nakin; and M2 and M3 of Tham Rak Sai, almost of their data are intermediate between Middle to Late Pleistocene data and recent data. Only dimenssion of M1 of Tham Rak Sai is smaller

both Middle to Late Pleistocene data and recent data. Moreover, M1, M2 of Tham Lod Rockshelter are clearly narrower than those of Tham Prakai Phet and other Middle to Late Pleistocene sites. However, only a few numbers of these specimens due to is preserved in good condition, can be use in analysis.

In accordance to the average ratio (Figure 4.96-100), all sites in this study show consistent curve in the average measurement ratio. Besides that M1 and M2 is curved of Tham Lod Rockshelter are smaller and not responding to Tham Prakai Phet and Tham Rak Sai.

Capricornis milneedwardsii

In P3, the outline is trapezoidal, the paracone occurred near the parastyle, and the bilobation at lingual side, like in *C. sumatraensis* (Guérin, 1966; Thein, 1974). But the tooth presents more marked metastyle, and more compressed labial-lingually.

In P4, the tooth shows an asymmetric form with a very marked parastyle where for *C. sumatraensis* and *Naemorhedus goral*, the tooth present a symmetric outline with a well development of metastyle (Guérin, 1966; Thein, 1974).

In upper molars, the mesostyle and the paracone are more marked than Pleistocene *C. sumatraensis* from Tham Prakai Phet (Filoux *et al.*, 2015), Tam Hang (Bacon *et al.*, 2011), Duoi U'Oi (Bacon *et al.*, 2008), Batu Caves (Ibrahim, 2013), Badak Cave C (Ibrahim, 2013), and recent *C. sumatraensis* (Guérin, 1966; Thein, 1974; Gliozzi and Malatesta, 1980).

In dp4, the tooth present the first lobe being the smallest lobe in width, developed lingual stylids and shaped conids, like in *C. sumatraensis*. However, lingual stylids are more marked than *C. sumatraensis* especially the metastylid.

The p3 presents a rounded outline, unlike in *C. crispus*, it is exhibits a shape outline (Miura and Yasui, 1985; Natsume *et al.*, 2005). The tooth shows the development in anterior valley, face in both lingual and labial which is different form *C. sumatraensis*.

The p4 presents a strong marked lingual side and the occurrence of the metastylid (Filoux, 2015, Pers Comn.), which is not observed on that of *C. sumatraensis* (Guérin, 1966; Thein, 1974; Gliozzi and Malatesta, 1980)

The lower molar, the metastylid is developed as a tiny rib along the tooth, which is more marked than *C. sumatraensis* from Tham Prakai Phet (Filoux *et al*, 2015), Tam Hang (Bacon *et al.*, 2011) and also in *C. crispus* (Natsume *et. al.*, 2005, 2006, 2008; Filoux, 2015, pers. comn.).

Althought, these *C. milneedwardsii* specimens were preserved in only Tham Prakai Phet, their dental size can be help to identified as well as their detal characteristic. In the occlusal length against the occlusal width analysis, *C. milneedwardsii* specimens are ploted in ranges of the Middle-Late Pleistocene *C. sumatraensis* specimens such as Lang Trang cave (de Vos and Long, 1993), Duoi U'Oi (Bacon *et al.*, 2008), Batu Caves (Ibrahim, 2013), Badak Cave C (Ibrahim, 2013); and larger than the recent *C. sumatraensis* teeth (Hooijer, 1958; Thein, 1974; Gliozzi and Malatesta, 1980; Wattanapituksakul, 2006) and the extent *C. milneedwardsii* (Chang, 2001) (Figure 4.101-2, and 4.104).

In ratio diagram of dental average dimension, all *C. milneedwardsii* ratio is corrspoding to *C. sumatraensis*. However, teeth are clearly larger than *C. sumatraensis* of Tham Lod Rockshelter, Than Prakai Phet, and Tham Rak Sai in this study (Figure 4.107-8, and 4.110.).

Naemorhedus griseus

The *Naemorhedus* DP2 present trapezoidal form with two bilobation which is similar to the one observed on *Capricornis sumatraensis* (Guérin, 1966) and *N. griseus*. However, labial styles are less developed than *Capricornis*, like in *N. griseus*. The dental size is smaller than *Capricornis* specimens.

DP4 shows the typical characteristic of *Naemorhedus*: a molarized brachyodont, a weak developed labial wall, and a sharped hypocone.

In P3, the metastyle is prominent parastyle, the paracone located near the parastyle, like in *C. sumatraensis* and *N. goral* (Guérin, 1966; Thein, 1974; Gliozzi and Malatesta, 1980) and *C. milneedwardsii*. The outline of the tooth is pentagonal form, no any bilobation present. Unlike in *C. sumatraensis* (Guérin, 1966; Thein, 1974), the tooth exhibits trapezoidal outline. And the tooth is also different from *C. milneedwardsii* and *N. goral* (Guérin, 1966; Gliozzi and Malatesta, 1980) of which outline are more rounded.

The shape of the P4 is similar to *Capricornis* which shows developed parastyle and sub-angular labial cone (Thein, 1974; Gliozzi and Malatesta, 1980). Unlike in *N. goral* (Guérin, 1966; Gliozzi and Malatesta, 1980) and *C. crispus* (Natsume *et al.*, 2005), the protocone presents more rounded outline. But *C. sumatraensis* shows more developed parastyle and sharper labial lobe (Thein, 1974; Gliozzi and Malatesta, 1980). And the tooth is less depressed labio-lingually than *C. milneedwardsii* (Filoux, 2015, Pers. Comn.).

In upper molars, the base is pinched like *Capricornis* and *Naemorhedus* (Guérin, 1966; Gliozzi and Malatesta, 1980), but wider than that of *Capra* (Rivals, 2002). Teeth present weakly or morderatly developed mesostyle, unlike *N. goral* and *C. sumatraensis*, the mesostyle is strongly prominent than other styles (Guérin, 1966; Gliozzi and Malatesta, 1980). In labial view, the metacone is clearly prominent, unlike in *N.* cf. *goral*, the metacone is weakly marked.

The dp4 has smaller dimension than *C. sumatraensis* and *C. milneedwardsii*. The width of the first lobe is as well as the second one. Unlike in *C. sumatraensis* and *C. milneedwardsii*, the first lobe is narrowest. Lingual stylids are less marked than *C. milneedwardsii* especially the metastylid, unlike in *C. sumatraensis*.

The p3 present a weak metaconid (often merged to entoconid) and a rounded mesio-labial corner of protoconid, like in *Capricornis sumatraensis* (Thein, 1974). The tooth exhibits developed labial valley which is similar to *Naemorhedus goral* (Guérin, 1966; Gliozzi and Malatesta, 1980). But the tooth presents a right angle of the metaconid, unlike in *N. goral*, the metaconid is less developed (Guérin, 1966; Gliozzi and Malatesta, 1980).

In p4, the tooth has a weak bilobation and present two opposite shallow valleys, like in *Naemorhedus goral* (Guérin, 1966; Gliozzi and Malatesta, 1980). In *Capricornis sumatraensis* (Guérin, 1966; Thein, 1974; Gliozzi and Malatesta, 1980) and *Capra* (Halstead and Collins, 2002; Zeder and Pilaar, 2010; Gillis *et al.*, 2011) present more bilobation. However, the tooth exhibits the sharped hypoconid, the weak developed entostylid, and the enclosed lingual valley, unlike in *N. goral*, it presents rounded hypoconid, more developed entostylid, and more marked lingual valley.

In lower molars, teeth show sharped lingual lobes, a weak development of the mesostylid, and a weak caprine fold, like in *Capra* and *Naemorhedus* (Guérin, 1966;

Thein, 1974; Gliozzi and Malatesta, 1980; Halstead and Collins, 2002; Zeder and Pilaar, 2010; Gillis *et al.*, 2011). Teeth are different to *Capricornis* which presents a very marked metastylid (Guérin, 1966; Thein, 1974; Gliozzi and Malatesta, 1980). The tooth presents smooth surface of protoconid which is similar to *Naemorhedus*, unlike in *Capra*, the protoconid surface is concave on the mesial face (Halstead and Collins, 2002; Zeder and Pilaar, 2010; Gillis *et al.*, 2011). Teeth are mostly closed to *Naemorhedus* cf. *goral*, but they are less developed both lingual stylids and lonids and do not often occurrence of metastylid. In m3, the tooth does not have any vertical rib, unlike in *N. goral* which shows a vertical rib at lingual face of the entoconulid (Gliozzi and Malatesta, 1980).

In dental dimensions, teeth are clearly smaller than *Capricornis* data of both Middle to Late Pleistocene and the recent data. *Naemorhedus grieus* in 3 study sites are larger than the recent. However, they are not clearly sperated; the smaller-size of the Middle to Late Pleistocene overlaps to the recent. Unlike in m2 and m3, the recent data of m2 is wider than Middle to Late Pleistocene one; all m3 data completely overlay on the recent one (Figure 4.100-4.105).

In average measurement ratio digrams, *Naemorhedus griseus* is clearly smaller than both *Capricornis sumatraensis* and *C. milneedwardsii*. In measurement of M1 and M2, they are rarely discovered except Tham Lod Rockshelter. In measurements of M3, all 3 study area is corespoding, Tham Lod Rockshelter data is often smallest, and Tham Prakai Phet is often largest. Except measurement 9, Tham Prakai Phet is smallest. In average measurement ratio digrams of m1, m2, and m3, Tham Lod Rockshelter is corespoding to Tham Prakai Phet and Tham Rak Sai (Figure 4.106-4.111).

Naemorhedus* cf. *goral

In upper molars, the base of the tooth is narrow in labial view, like in *Capricornis* and *Naemorhedus* (Guérin, 1966; Gliozzi and Malatesta, 1980), but in *Capra caucasica*, the tooth is narrower (Rivals, 2002). The mesostyle is more marked than other style, like in *C. sumatraensis* and *N. goral* (Guérin, 1966; Gliozzi and Malatesta, 1980). However, *C. sumatraensis* show more marked mesostyle associated with remakable labial cone. In *N. griseus*, the mesostyle is developed as well as other styles. In labial view, the metacone is weaker prominent than *Naemorhedus griseus*. In

M3, the crown bends backwards, like in *Capra* (Rivals, 2002). But it is different to *N. griseus* which presents a straight crown.

The characteristic of p3 are closed to *N. griseus*. However, *N. griseus* have a right angle of metaconid corner and weak develpoped lingual wall which is not similar to Tham Lod Rockshelter but is closed to advance worn tooth of Tham Prakai Phet. The lower p4 of both *N. goral* and *N. griseus* are less bilobated than *Capricornis*. The labial valley of *N.* cf. *goral* is more marked than *N. griseus*.

In lower molar, the tooth is similar to *N.* griseus which show remakable lingual style along tooth in lingual wall. Unlike in *N. griseus*, the lingual styles are less developed. In the third lobe, the tooth shows a vertical rib at the entoconulid, like in *N. goral* (Guérin, 1966; Gliozzi and Malatesta, 1980) but this vertical rib is absent in *N. griseus*.

In scatter diagram of occlusal length vs the occlusal width, teeth are similar to *N. griseus* which also clearly smaller than recent *Capricornis* and overlap to the recent *N. goral* and *N. gripseus* range (Figure 4.101-3, and 4.104).

Although there is few specucimens of *Naemorhedus* cf. *goral* in Tham Lod Rockshelter and Tham Prakai Phet, they are enought for ratio diagram analysis which are clearly smaller than *C. sumatraensis* and *C. milneedwardsii*. *Naemorhedus* cf. *goral* of Tham Lod Rockshelter data is corespoding to that of Tham Prakai Phet. Tham Lod Rockshelter is smaller in M2 and M3 measuremens (Figure 4.107-9, and 4.410).

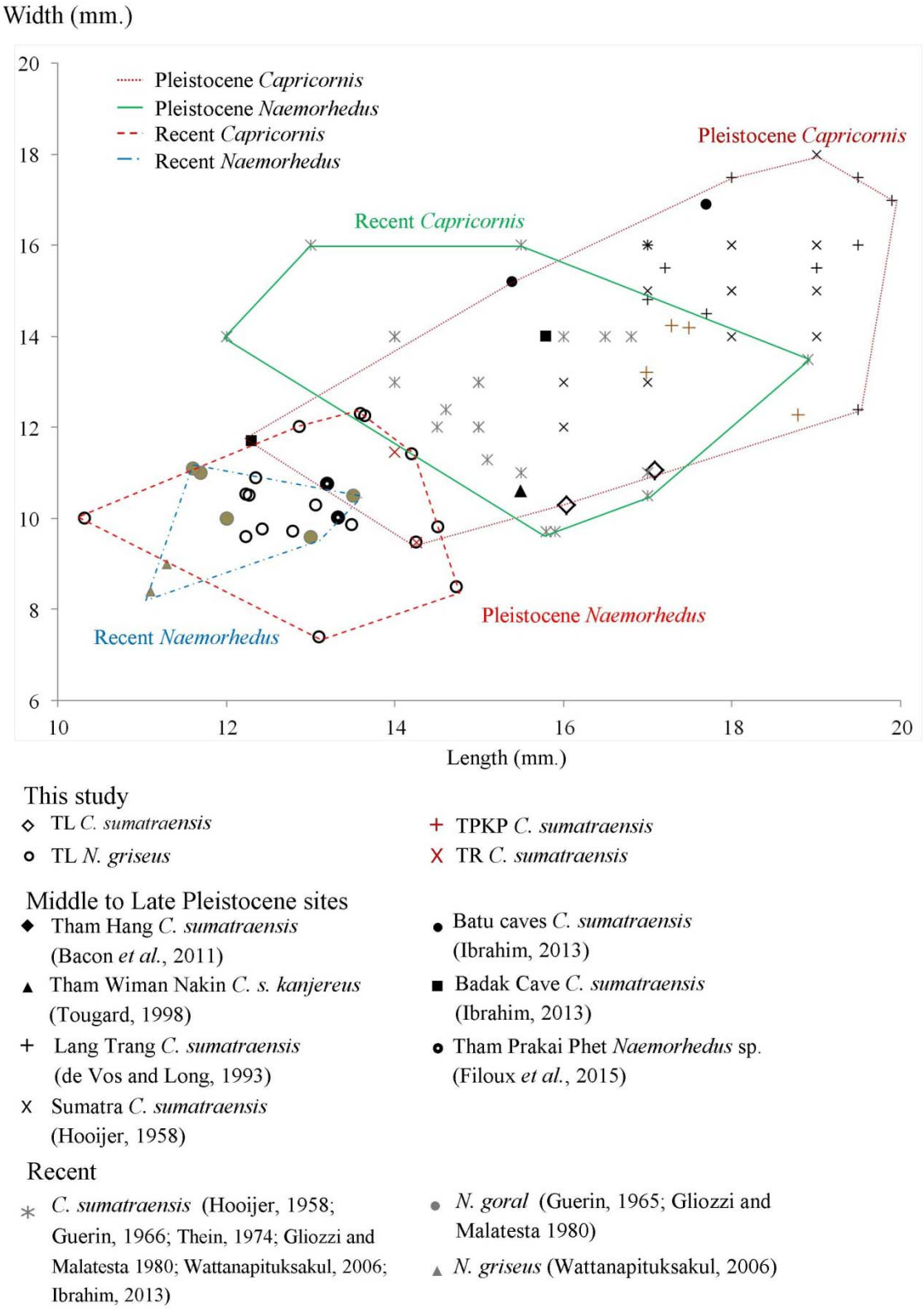


Figure 4.90 A bivariate plot of the occlusal length against the occlusal width of M1 of Middle to Late Middle Pleistocene

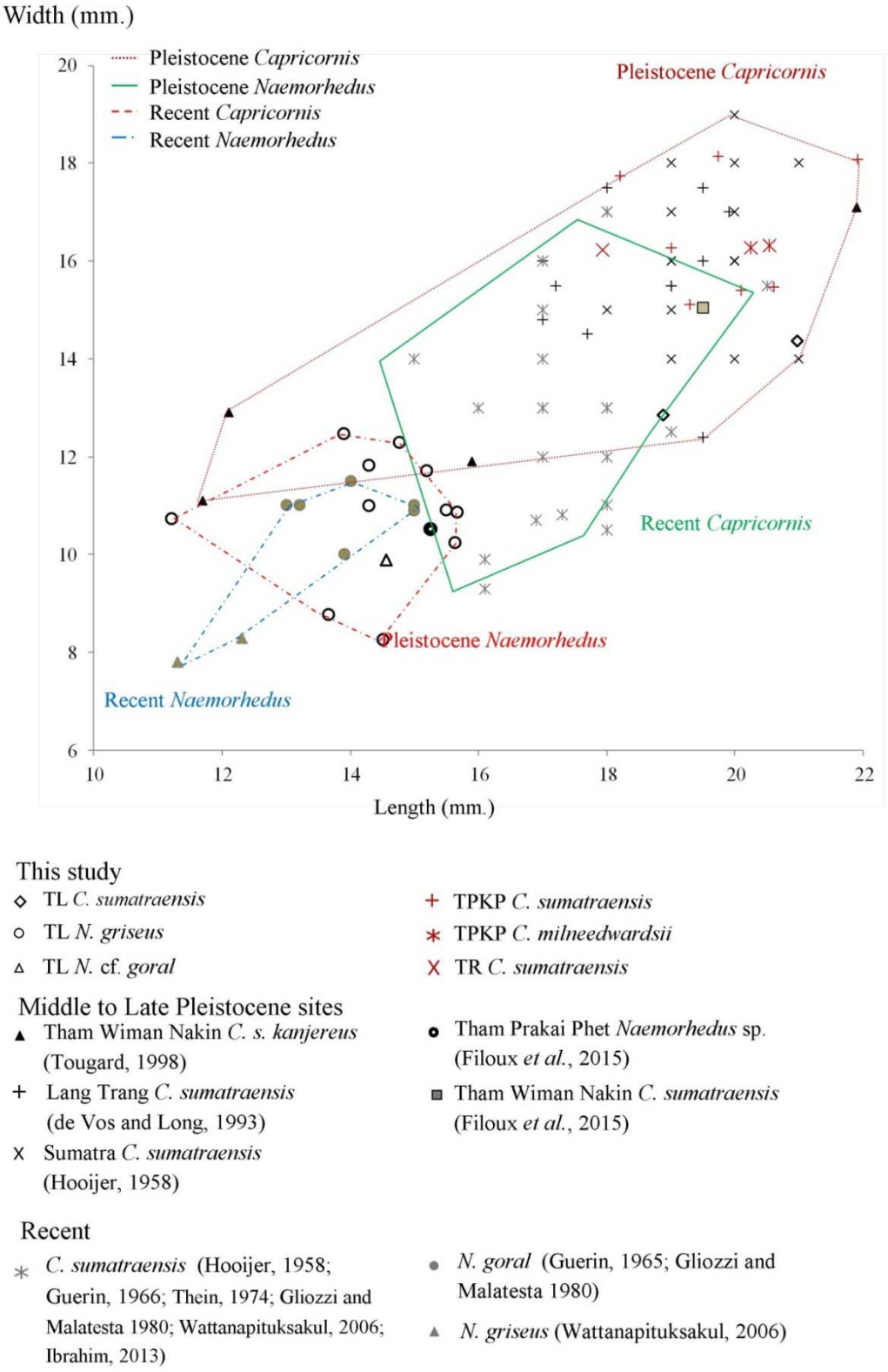


Figure 4.91 A bivariate plot of the occlusal length against the occlusal width of M2 of Middle to Late Middle Pleistocene

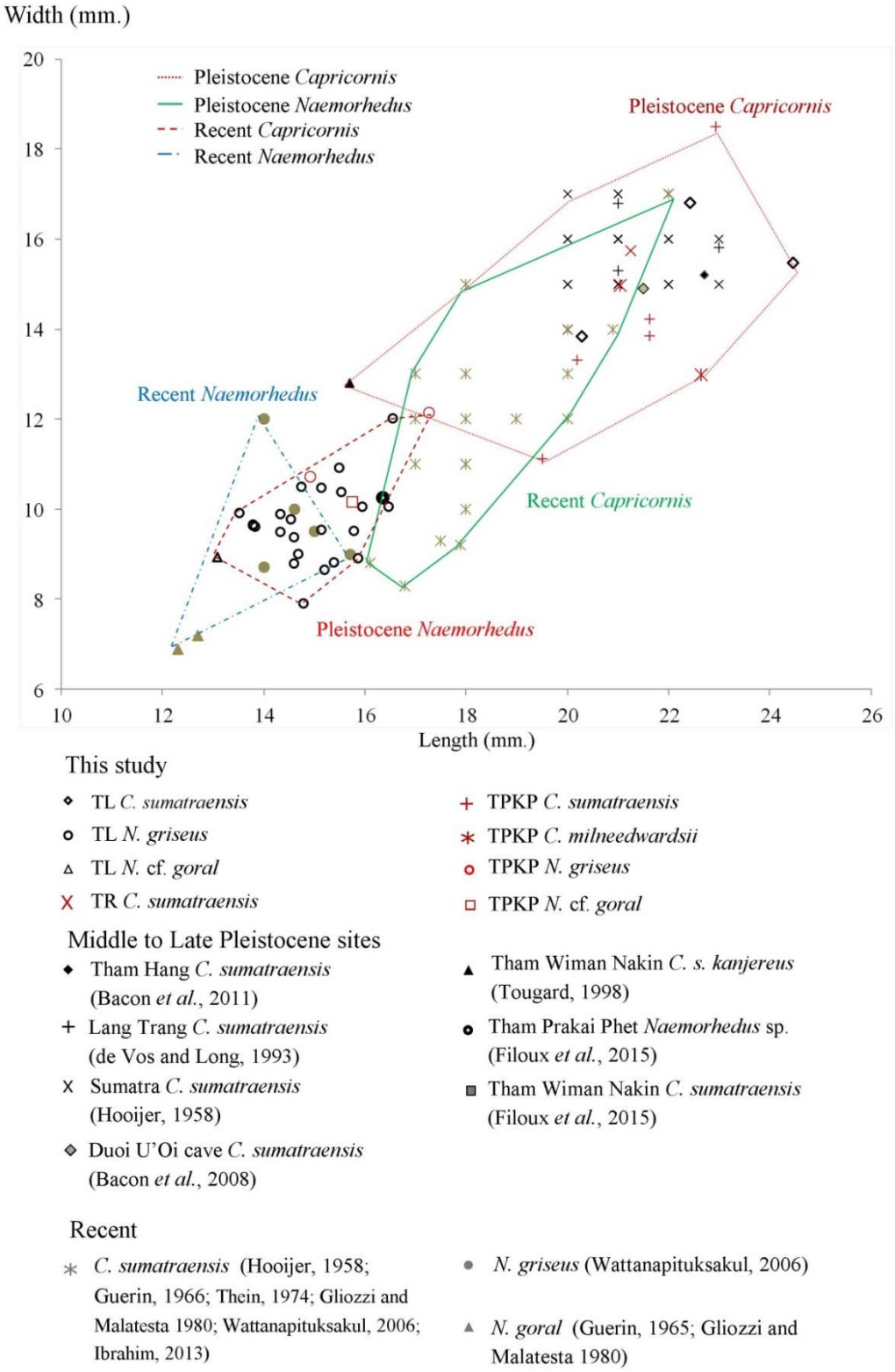


Figure 4.92 A bivariate plot of the occlusal length against the occlusal width of M3 of Middle to Late Middle Pleistocene

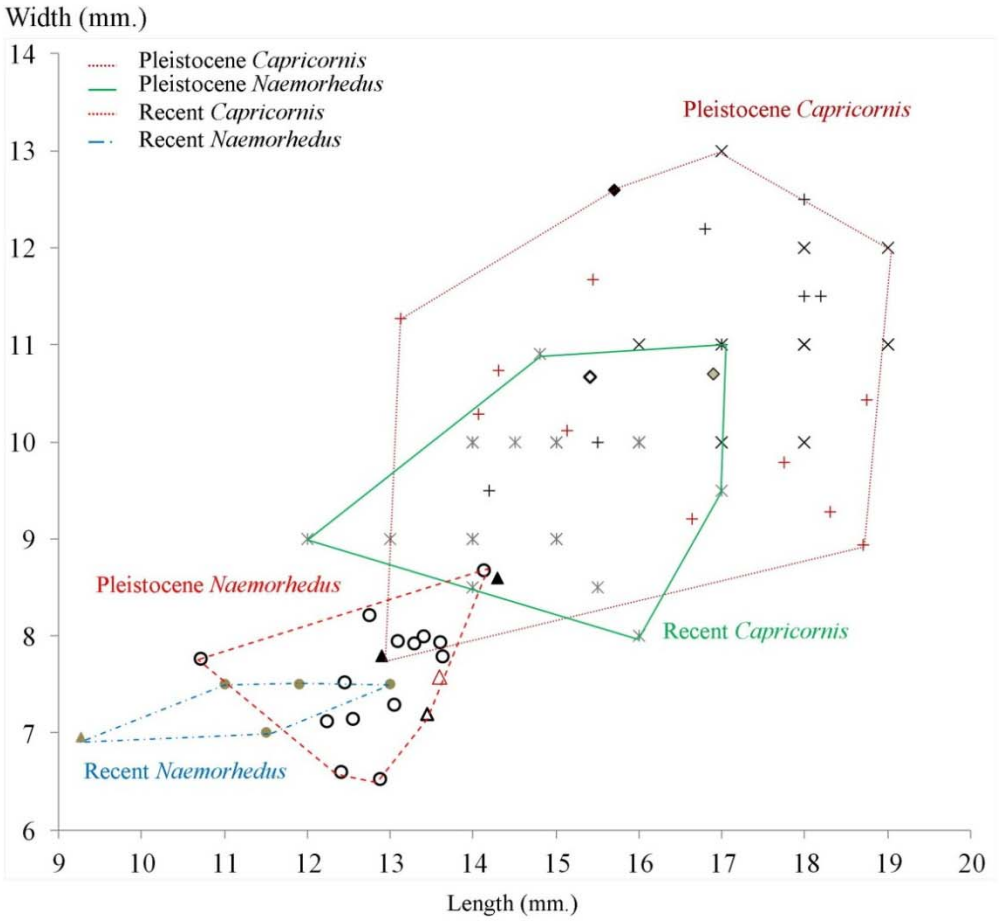
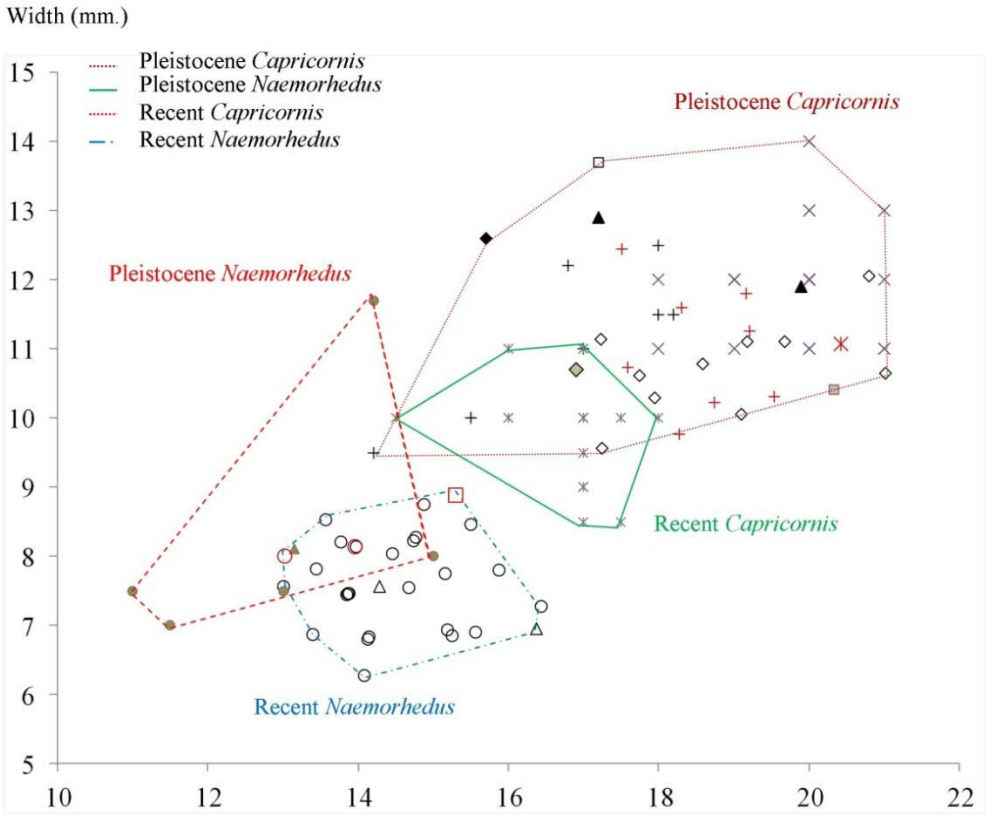


Figure 4.93 A bivariate plot of the occlusal length against the occlusal width of m1 of Middle to Late Middle Pleistocene



This study

- ◇ TL *C. sumatraensis*
- o TL *N. griseus*
- △ TL *N.* cf. *goral*
- X TR *C. sumatraensis*
- \+ TPKP *C. sumatraensis*
- ✳ TPKP *C. milneedwardsii*
- o TPKP *N. griseus*
- △ TPKP *N.* cf. *goral*

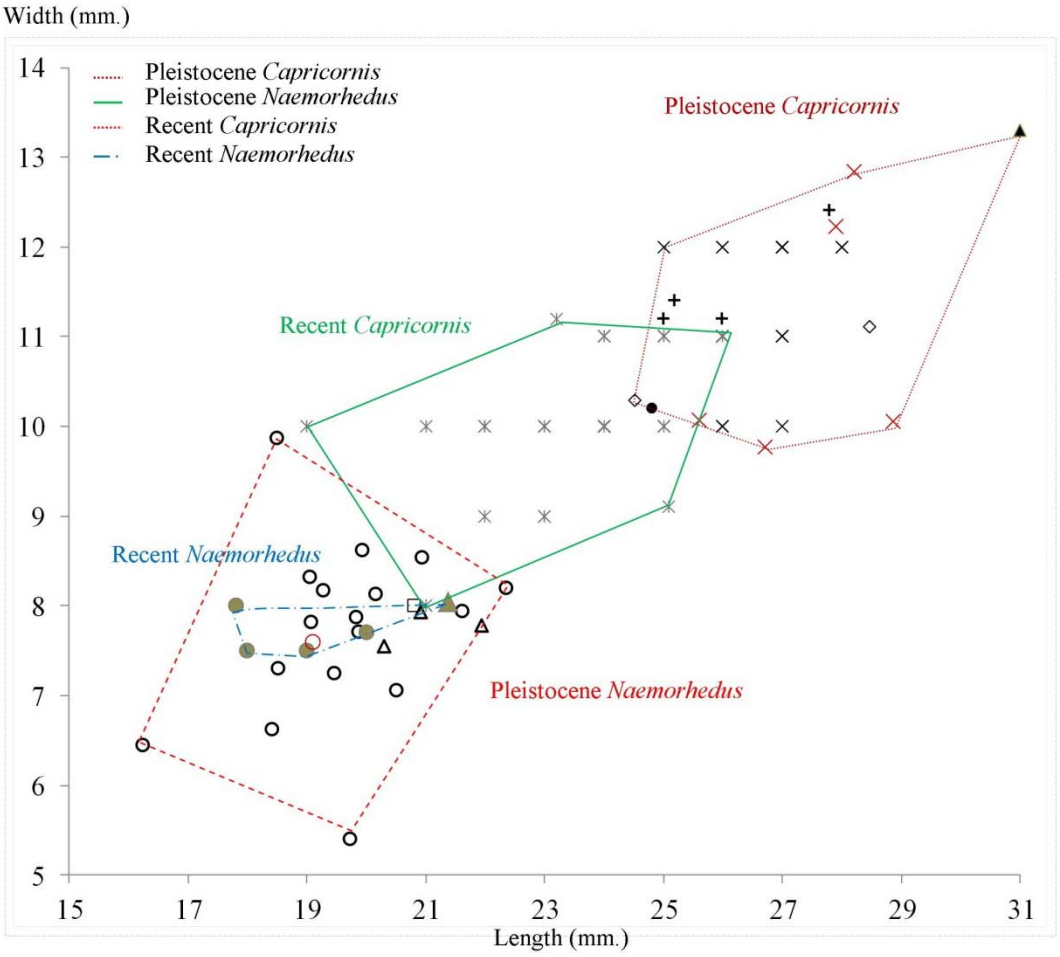
Middle to Late Pleistocene sites

- ◆ Tham Hang *C. sumatraensis* (Bacon *et al.*, 2011)
- \+ Lang Trang *C. sumatraensis* (de Vos and Long, 1993)
- X Sumatra *C. sumatraensis* (Hooijer, 1958)
- ◈ Duoi U'Oi cave *C. sumatraensis* (Bacon *et al.*, 2008)
- ▲ Tham Wiman Nakin *C. s. kanjereus* (Tougard, 1998)
- □ TPKP *C. s. kanjereus* (Tougard, 1998)
- o Tham Prakai Phet *Naemorhedus* sp. (Filoux *et al.*, 2015)
- ■ Tham Wiman Nakin *C. sumatraensis* (Filoux *et al.*, 2015)

Recent

- ✳ *C. sumatraensis* (Hooijer, 1958; Guerin, 1966; Thein, 1974; Gliozzi and Malatesta 1980; Wattanapituksakul, 2006; Ibrahim, 2013)
- ● *N. griseus* (Wattanapituksakul, 2006)
- ▲ *N. goral* (Guerin, 1965; Gliozzi and

Figure 4.94 A bivariate plot of the occlusal length against the occlusal width of m2 of Middle to Late Middle Pleistocene



This study

◇ TL *C. sumatraensis*

o TL *N. griseus*

△ TL *N.* cf. *goral*

\+ TPKP *C. sumatraensis*

o TPKP *N. griseus*

Middle to Late Pleistocene sites

\+ Lang Trang *C. sumatraensis* (de Vos and Long, 1993)

x Sumatra *C. sumatraensis* (Hooijer, 1958)

● Batu caves *C. sumatraensis* (Ibrahim, 2013)

▲ Tham Wiman Nakin *C. s. kanjereus* (Tougard, 1998)

□ TPKP *C. s. kanjereus* (Tougard, 1998)

Recent

✳ *C. sumatraensis* (Hooijer, 1958; Guerin, 1966; Thein, 1974; Gliozzi and Malatesta 1980; Wattanapituksakul, 2006; Ibrahim, 2013)

● *N. griseus* (Wattanapituksakul, 2006)

▲ *N. goral* (Guerin, 1965; Gliozzi and

Figure 4.95 A bivariate plot of the occlusal length against the occlusal width of m3 of Middle to Late Middle Pleistocene

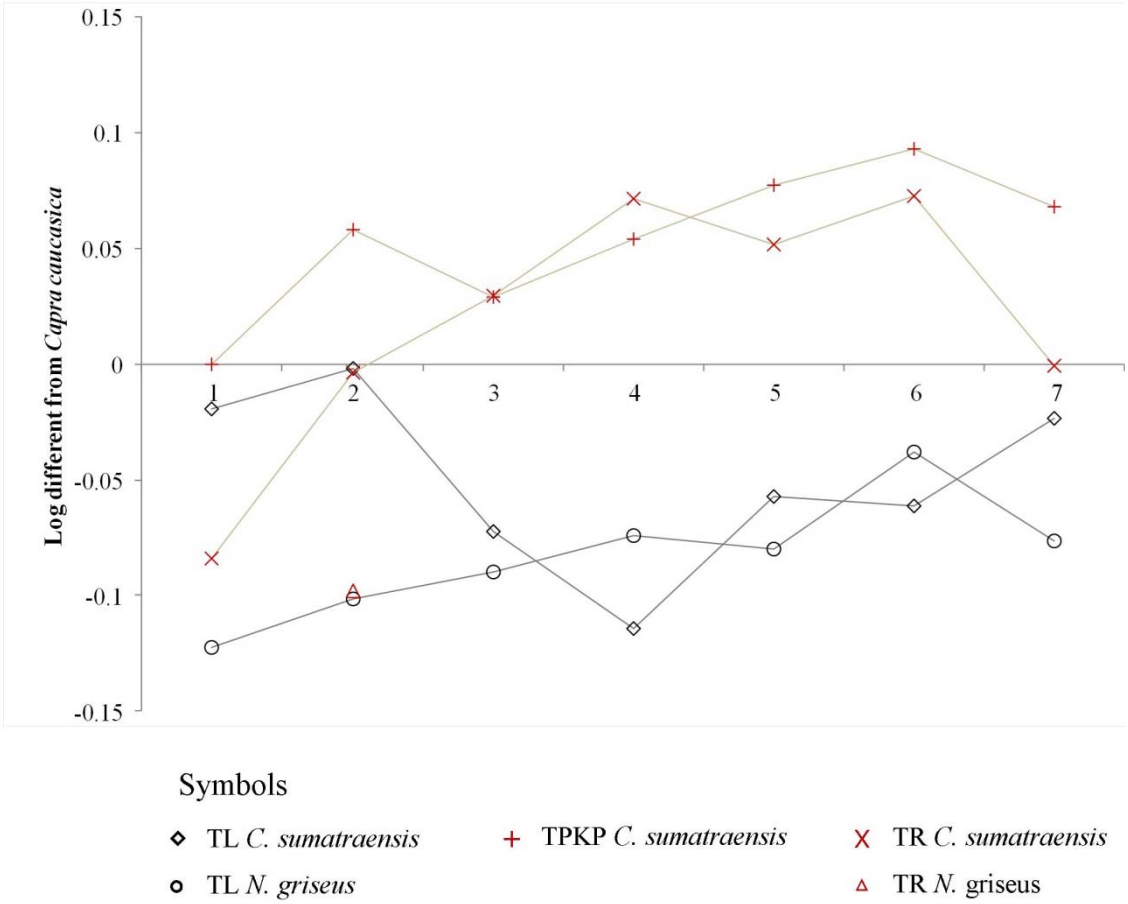


Figure 4.96 Ratio diagram of dental average M1 dimension of Middle to Late Middle Pleistocene Caprinae

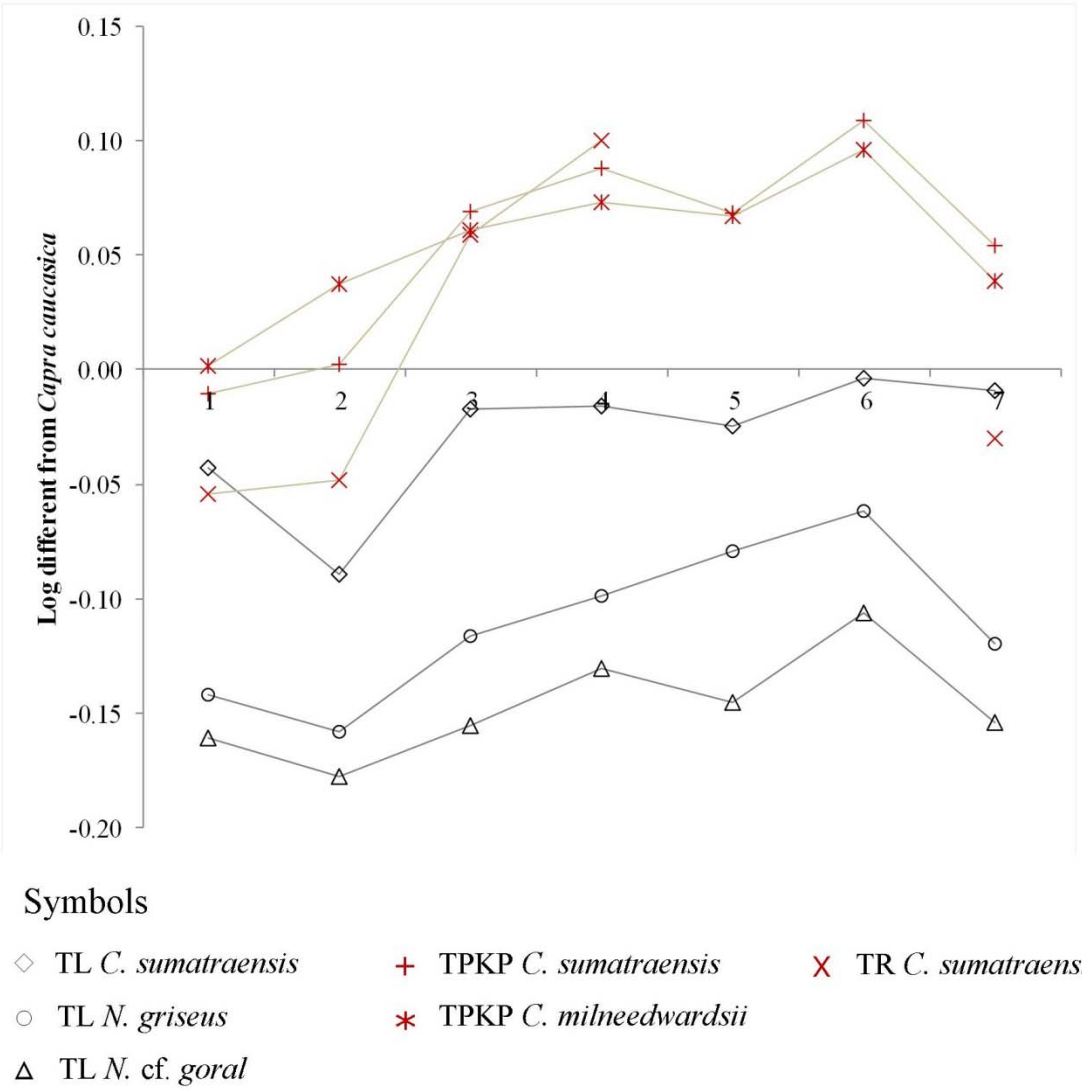
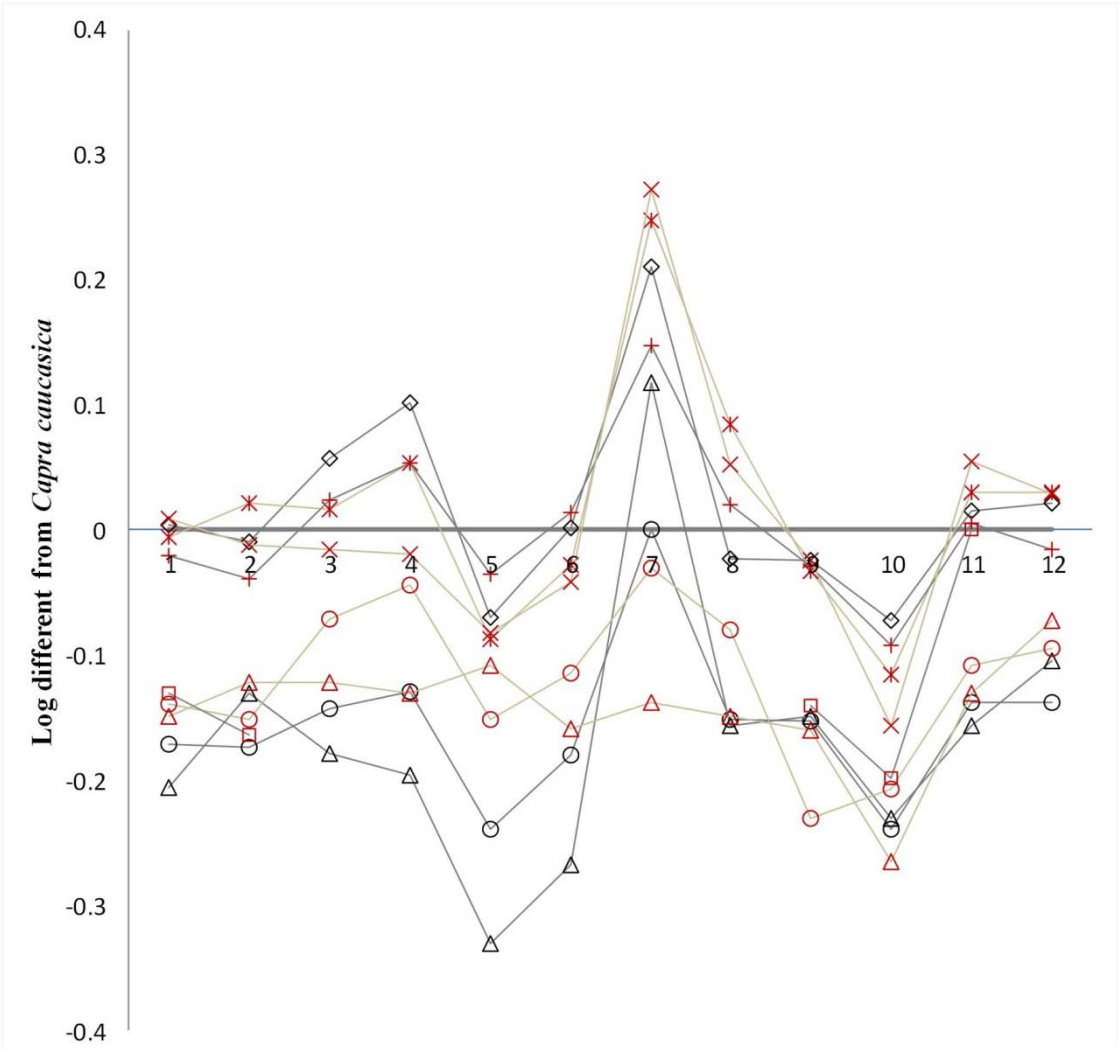


Figure 4.97 Ratio diagram of dental average M2 dimension of Middle to Late Middle Pleistocene Caprinae



Symbols

◇ TL *C. sumatraensis*
○ TL *N. griseus*
△ TL *N.* cf. *goral*
\+ TPKP *C. sumatraensis*
○ TPKP *N. griseus*
△ TPKP *N.* cf. *goral*
✳ TPKP *C. milneedwardsii*
X TR *C. sumatraensis*
□ TR *N. griseus*

Figure 4.98 Ratio diagram of dental average M3 dimension of Middle to Late Middle Pleistocene Caprinae

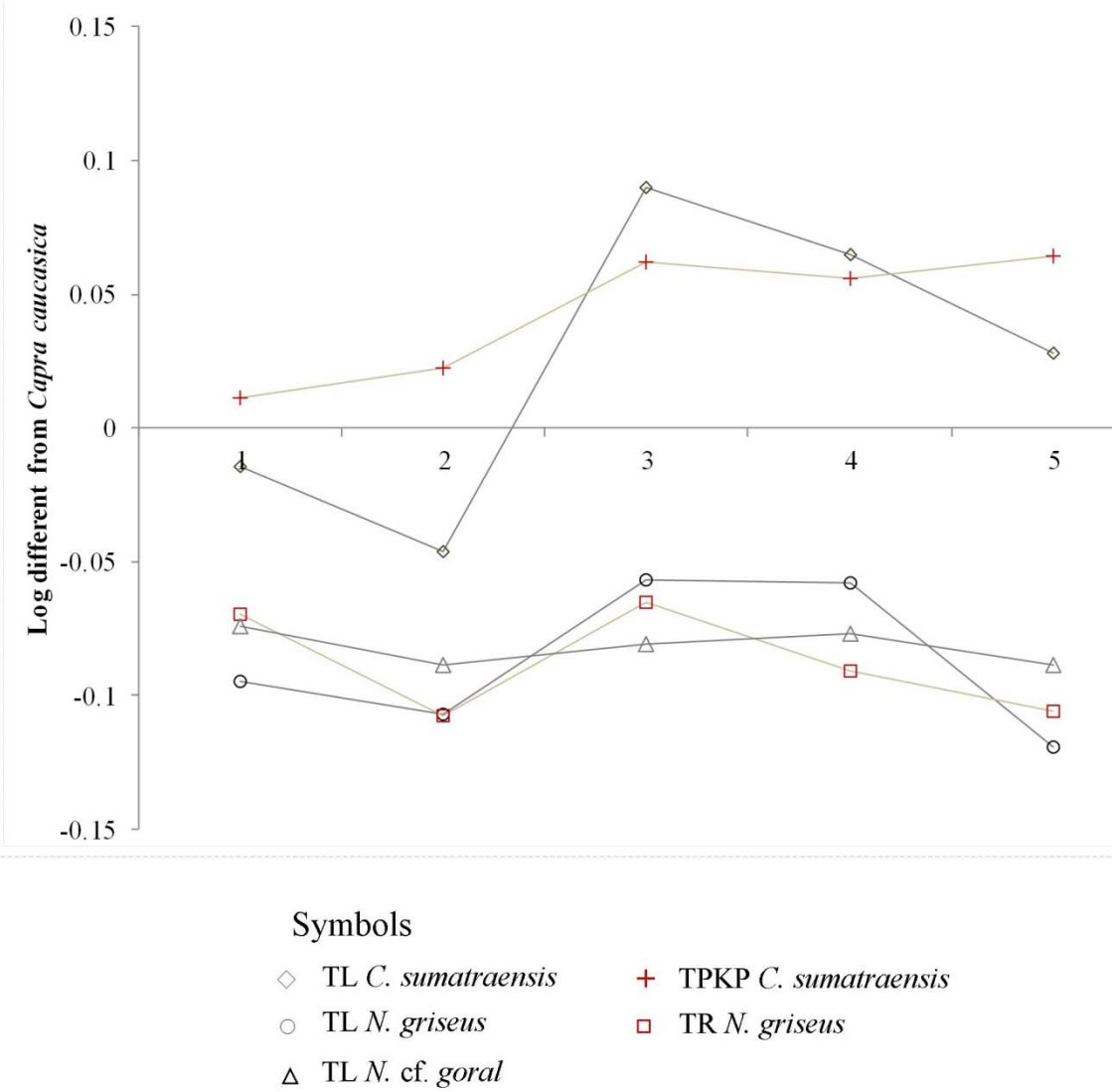


Figure 4.99 Ratio diagram of dental average m1 dimension of Middle to Late Middle Pleistocene Caprinae

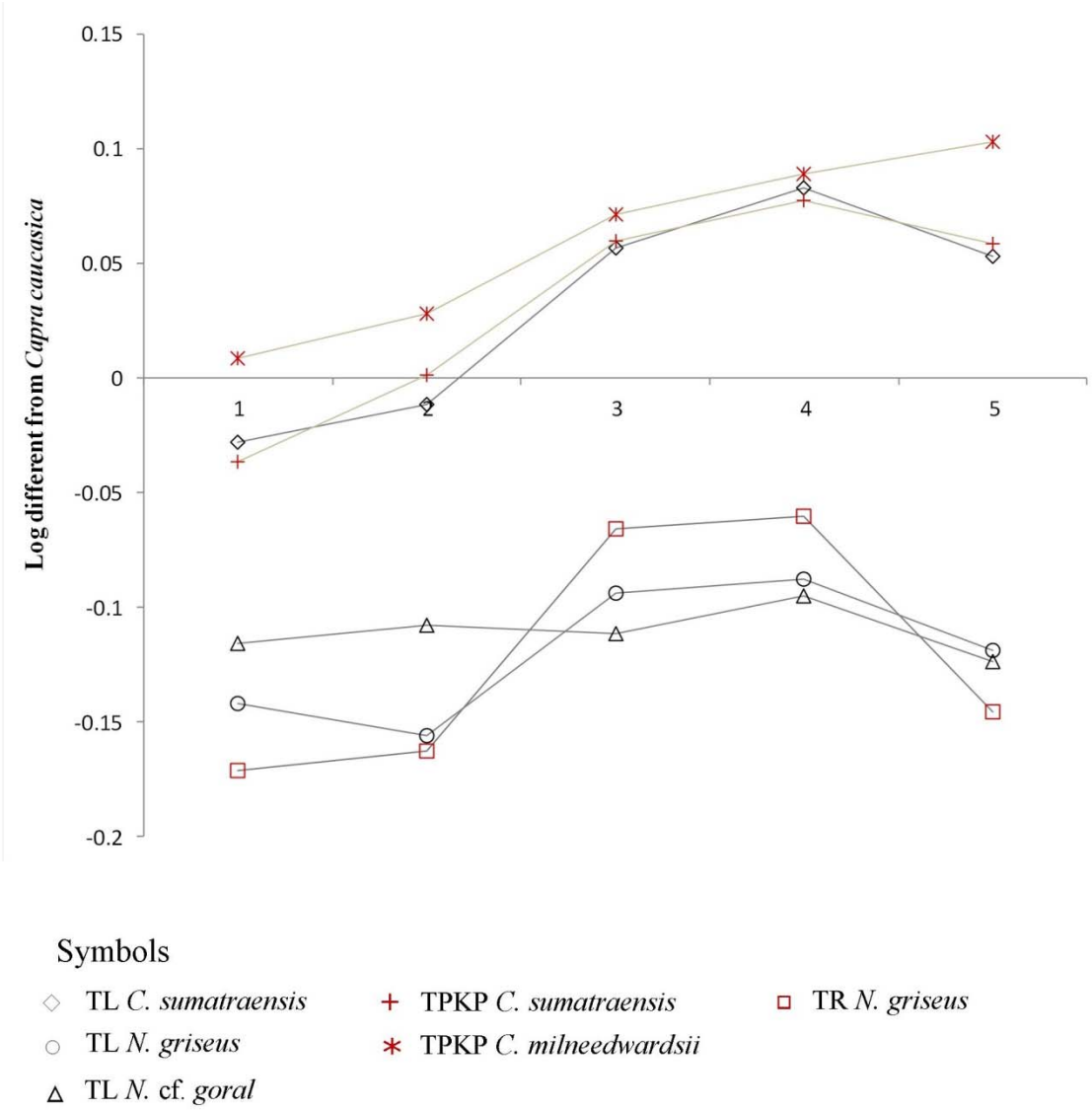


Figure 4.100 Ratio diagram of dental average m2 dimension of Middle to Late Middle Pleistocene Caprinae

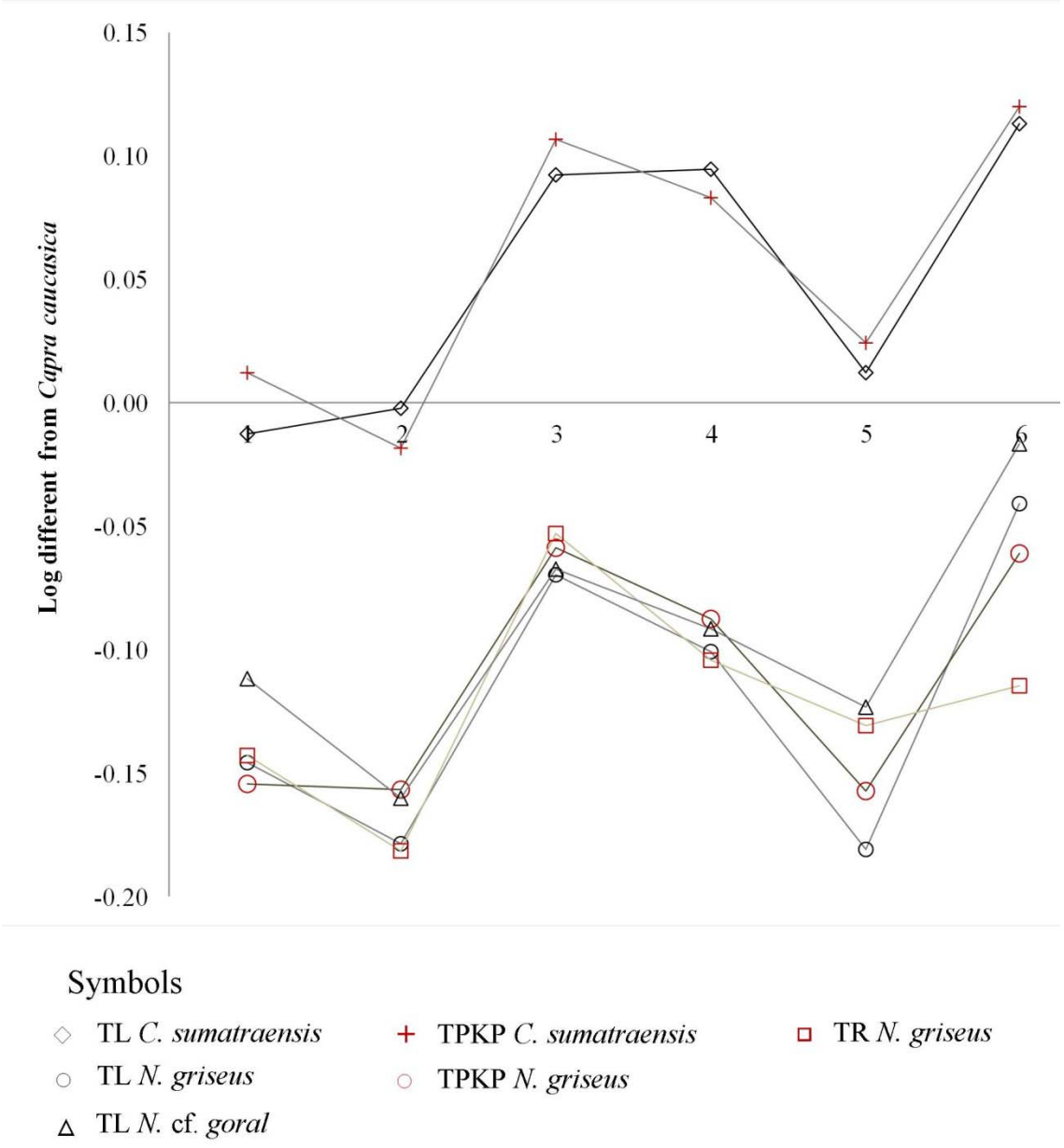


Figure 4.101 Ratio diagram of dental average m3 dimension of Middle to Late Middle Pleistocene Caprinae

CHAPTER 5

PALAEODIET AND MORTALITY PROFILE

This chapter is to present analysis of the palaeodiet and mortality profile of bovids in the Middle to Late Pleistocene using evidence uncovered from Tham Lod Rockshelter, Tham Wiman Nakin, and Tham Rak Sai. Shedding light on their basic life history; such as diet, habitat and even predator – prey relationships.

5.1 Palaeodiet

5.1.1 Mesowear analysis

1) Bovinae

Fossil Bovinae and Caprinae from Tham Lod Rockshelter and Tham Prakai Phet were the focus of the study. The occlusal relief of the complete collection has been researched following the original mesowear technique by Fortelius ans Solounias (2000). The study sample is composed of a total of 40 upper teeth (P4, M1, M2 and M3). Twenty three teeth were selected from Tham Lod Rockshelter, (17 *Bos gaurus*, 3 *Bos javanicus*, and 3 *Bubalus arnee*) and seventeen teeth for Tham Prakai Phet (11 *Bos gaurus*, 5 *Bos javanicus*, and 1*Bubalus arnee*) (Table 5.1 and Figure 5.1).

B.gaurus teeth from Tham Lod Rockshelter and Tham Prakai Phet are respectively characterised by high (94.1% and 100%) and rounded cusps (94.1 and 91%) with a Mihlbachler score of 2.4 and 2.2.

B. javanicus teeth from Tham Lod Rockshelter and Tham Prakai Phet are respectively characterised by high (66.7% and 80%) and rounded cusps (66.7% and 80%) with a Mihlbachler score of 3 and 2.8.

Bubalus arnee teeth from Tham Lod Rockshelter and Tham Prakai Phet are respectively characterised by low (67% and 100%) and rounded cusps (33.3% and 100%) with a Mihlbachler score of 4 and 4.

2) Caprinae

The Caprinae samples were selected for mesowear analysis using a total of 52 well preserved teeth (P4, M1, M2 and M3). Twenty-nine teeth from Tham Lod Rockshelter comprise of *Capricornis sumatraensis*, (24 of *Naemorhedus griseus*, and 4

of *N.* cf. *goral*) and 23 teeth from Tham Prakai Phet (14 of *Capricornis sumatraensis*, six of *C. milneedwardsii*, 2 of *Naemorhedus griseus*, and 1 of *N.* cf. *goral*) (Table 4.92).

C. sumatraensis teeth from Tham Lod Rockshelter and Tham Prakai Phet are respectively characterised by high (100% and 78.6%) and rounded cusps (100% and 35.7%) with a Mihlbachler score of 2 and 2.1.

Capricornis milneedwardsii teeth from Tham Prakai Phet are characterized by high (100%) and rounded cusps (83.3%) with a Mihlbachler score of 2.

Naemorhedus griseus teeth from Tham Lod Rockshelter and Tham Prakai Phet are respectively characterized by a high relief (75% and 0%) and rounded cusps (41.7% and 50%) with a Mihlbachler score of 2.3 and 1.5.

N. cf. *goral* teeth from Tham Lod Rockshelter and Tham Prakai Phet are respectively characterised by a high relief (100% and 0%) and sharp cusps (75% and 100%) with a Mihlbachler score of 1.5 and 1.0.

Table 5.1 Mesowear analysis data (mean absolute counts and percentage) and Mihlbachler score in P4, M1, M2, M3 of Bovidae

Species	HI	Site	N	L	H	S	R	B	% L	% H	% S	% R	% B	Mean M-score
Bos gaurus	4.26	TL	17	1	16	0	16	1	6	94	0	94	6	2.4
B. gaurus	4.64	TPKP	11	0	11	1	10	0	0	100	9	91	0	2.2
B. javanicus	4.56[1]	TL	3	1	2	0	2	1	33	67	0	67	33	3.0
B. javanicus	4.56	TPKP	5	1	4	0	4	1	20	80	0	80	20	2.8
Bubalus arnee	5.47	TL	3	2	1	0	1	2	67	33	0	33	67	4.0
B. arnae	5.47[1]	TPKP	1	1	0	0	1	0	100	0	0	100	0	4.0
Capricornis sumatraensis	3.39[2]	TL	1	0	1	0	1	0	0	100	0	100	0	2.0
C. sumatraensis	3.39[2]	TPKP	14	3	11	6	5	3	21	79	43	36	21	2.1
C. milneedwardsii	3.51	TPKP	6	0	6	1	5	0	0	100	17	83	0	2.0
N. griseus	5.81	TL	24	6	18	8	10	6	25	75	33	42	25	2.3
N. griseus	5.81[1]	TPKP	2	2	0	1	1	0	100	0	50	50	0	1.5
N. cf. *goral*	5.04	TL	4	0	4	3	1	0	0	100	75	25	0	1.5
N. cf. *goral*	5.04[1]	TPKP	1	1	0	1	0	0	100	0	100	0	0	1.0

Remark 1: TL = Tham Lod Rockshelter, TPKP = Tham Prakai Phet, N = number of samples, HI = Hypsodonty Index, L = Low cusp, H = High cusp, S = Sharp relief, R = Round relief, B = Blunt relief, %L = Low cusp percentage, %H = High cusp percentages, %S = Sharp relief percentages, %R = Round relief percentages, %B = Blunt relief percentages, Mean M-score = Mean of Mihlbachler score.

Hypsodonty index defined as crown height divided by crown width of the unworn m3 (Janis, 1988). In some species, no specimens can be analyst for Hypsodonty index which use those of other Pleistocene site (1) or extent ungulate (2) reference from Mendoza and Palmqvist (2007).

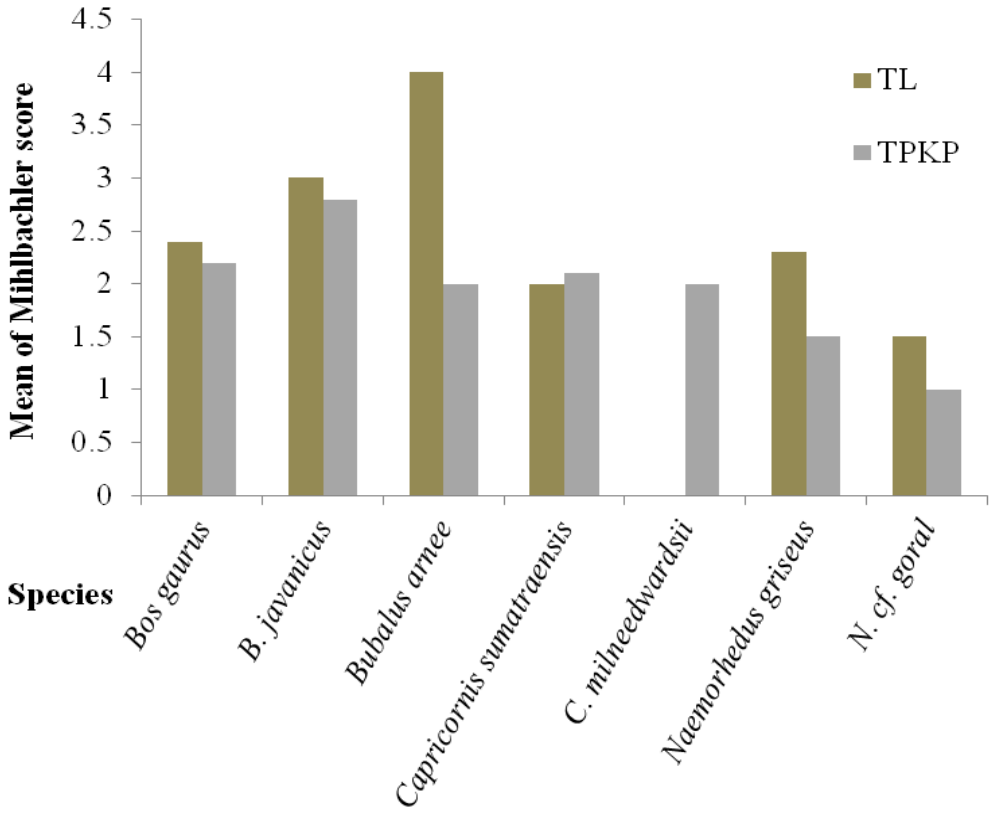


Figure 5.1 Mean of Mihlbachler score histogram of Pleistocene Bovidae: TL = Tham Lod Rockshelter, TPKP = Tham Prakai Phet

3) Analysis

. Some data had to be removed from the studies anlysis due to the few sample available (*Capricornis sumatraensis* in Tham Lod Rockshelter, *Bubalus arnee, Naemorhedus. griseus* and *N.* cf. *goral* in Tham Prakai Phet, only one specimen) and thus, cannot be considered, Figure 5.2.

The bivariate plot shows the average mesowear score (Mihlbachler *et al.*, 2011) against the hypsodonty index, the results of the analyses of extent ungulate (Fortelius and Solounias, 2002) and Late Pleistocene Bovinae are compared to the three class of recent herbivorous feeders: grazers, mixed feeder, and leaf browser (Janis, 1988).

In the Bovinae Subfamily, the genus *Bos* is clearly separated from *Bubalus*. *Bos gaurus* is overlapped between grazer and mixed feeder, while all *B. javanicus* are fall withingrazers. In a recent dietary study, *B. gaurus* and *B. javanicus* were found to

be wider feeders depending on the environment (Prayurasiddhi, 1998; Bidayabha, 2001; Prasopsin *et al.*, 2013). They eat fresh grasses but also fresh leaves, fruit, twigs, and bark of various woody species, as well as coarse dry grasses, and bamboo (Duckworth *et al.*, 2008; Timmins *et al.*, 2008). Reportedly feeding of *B. gaurus* is mostly browse in dense forest than *B. javanicus* which prefers feeding in open habitats (Lekagul and McNeely, 1977). *B. arnee* falls clearly into the category of grazer. In a recent dietary morphology study, *B. arnee* was found to be mostly a grazer but will also eats herbs, fruit, and bark as well as leaves (Hedges *et al.*, 2008). It is often considered to be a true grazer (Lekagul and McNeely, 1977).

In the Subfamily Caprinae, *Capricornis* is dropped below all other genus. *Capricornis sumatraensis* and *C. milneedwardsii* are catagorized as mixed feeders which are considered grazers. In a recent study, it was found that they were mostly browsers of leaves (favored) and shoots (Lekagul and McNeely, 1977; Santiapillai and Widodo, 1989; Duckworth *et al.*, 2008). *Naemorhedus griseus* and *N.* cf. *goral* are within the mixed feeder category which has a wider range than other fauna. Reportedly feeding, ona wide range of foods such as grasses, leaves, twigs and nuts (Duckworth *et al.*, 2008b; Duckworth *et al.*, 2008c).

A comparison between Bovinae at Tham Lod rock shelter against Tham Prakai Phet, found that all Bovinae in both two sites mostly corresponded in the grazer category with the eception of *B. gaurus*. *B. gaurus* in Tham Prakai Phet were more mixed a feeder which indicates that *B. gaurus* was more adapted to dense forest than the population in Tham Lod Rockshelter.

A comparison between Caprinae at at Tham Lod Rockshelter against the population at at Tham Prakai Phet found that all Caprinae in both two sites are within the mixed feeder category. But the dietary morphology of Caprinae in Tham Prakai Phet especially *N. griseus* and *N.* cf. *goral* are more close to that of a mixed feeder than at Tham Prakai Phet which corresponds to *B. gaurus*

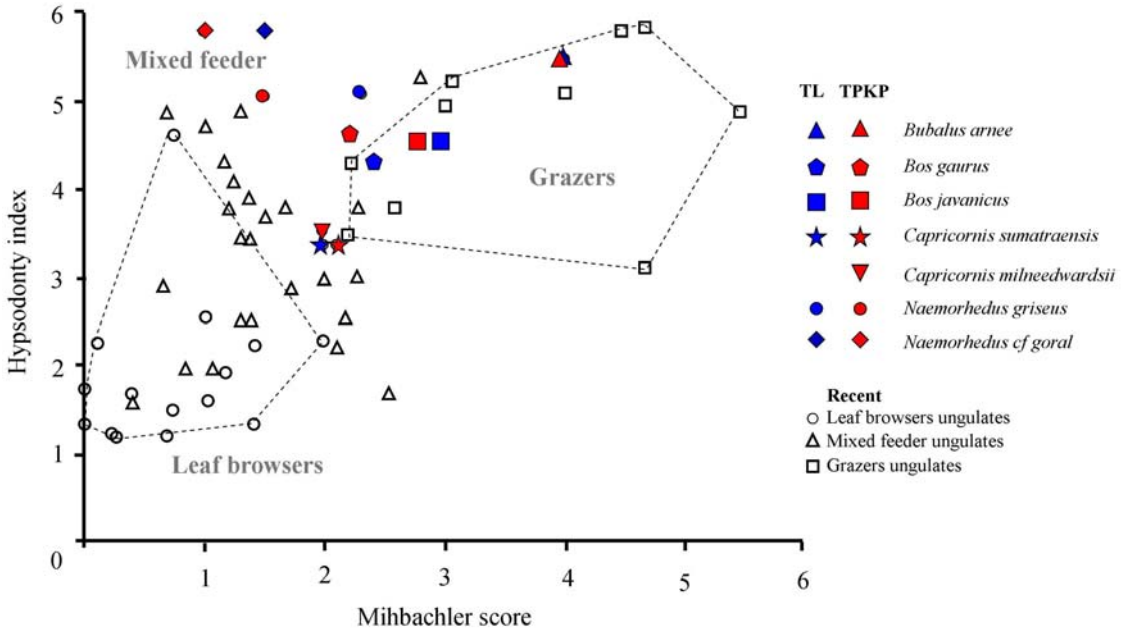


Figure 5.2 An bivariate plot of the average mesowear score against the hypsodonty score for grazers, mixed feeders and leaf browsers between extent ungulates (Fortelius and Solounias, 2002) and Late Pleistocene Bovinae from Tham Lod Rockshelter (TL) and Tham Prakai Phet (TPKP)

5.1.2 Microwear analysis

According to the microwear methodology of Solounias and Semprebon (2002), a collection of 30 dental specimens with a good preservation of the occlusal reliefs can be analyzed to observe the microwear facets. This is due to the Preservation of the specimens and the presentation of different species in the assemblages. However, it should be noted that the samples analyzed for each species is uneven and that number of analyzed teeth is very low (Table 4.92).

Bovinae

The Bovinae samples are composed of 13 teeth with a good occlusal surface preservation. The sample is divided between four teeth from Tham Lod Rockshelter (two samples of *B. gaurus*, two samples of *B javanicus*) and nine teeth from Tham Prakai Phet (four samples of *B. gaurus*, four samples of *B. javanicus*, one sample of *Bubalus arnee*), Table 5.1.

Bos gaurus teeth show many average scratches (12.5 scratches) and some average pits (6.5 pits) with 34.3% of pits found in Tham Lod Rockshelter specimens which is significantly smaller than the number of average scratches of Tham Prakai Phet (20.3 scratches) with some average pits (4.8 pits) and an average pits percentage (15.2%). No large pit and wide scratch profiles are observed on their microwear facets (Figure 4.89).

In *Bos javanicus*, there is also no presence of a large pit and wide scratches. The samples of Tham Lod Rockshelter is characterised by many average scratches (42.0 scratches) and some average pits (8.5 pits) with an average pits percentage (16.9%). In Tham Prakai Phet, teeth have lower average scratches (18.0 scratches) and lower average pits (5.8 pits) than that of Tham Lod Rockshelter but they have a larger percentage of pits (28.6%), Figure 5.3.

In *Bubalus arnee*, only in Tham Prakai Phet can the microwear signature be observedwhich is characterised by many average pits (8 pits) and some average scratches (28 scratches) with some large pits (7 pits). The pit percentage is 25.0% (Figure 5.4).

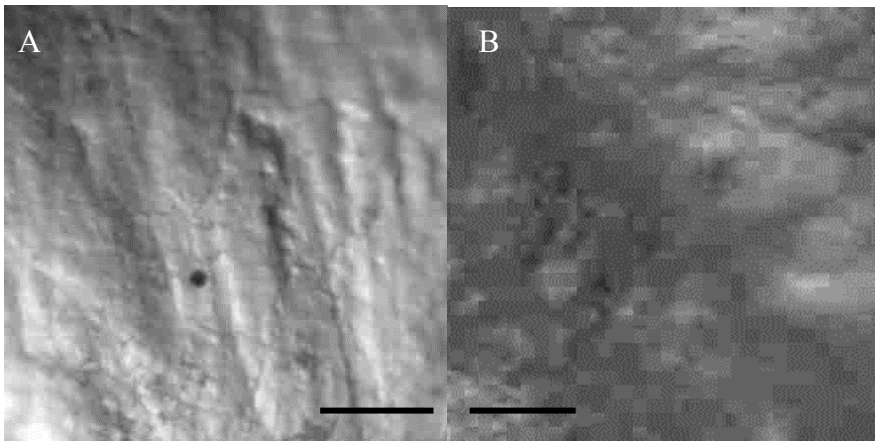


Figure 5.3 Numerical photograph (40X) of molar shearing facet of Late Pleistocene *Bos gaurus*, A) Tham Lod Rockshelter specimen (TLA2329 in Area 2) B) Tham Prakai Phet specimen (TPKP52) (Scale bar = 10 μm.)

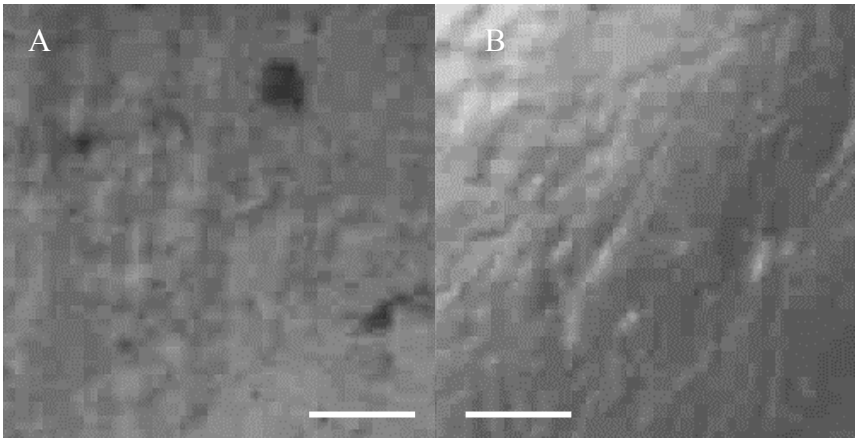


Figure 5.4 Numerical photograph (40X) of molar shearing facet of Late Pleistocene *Bos javanicus*, A) Tham Lod Rockshelter specimen (TL121 in Area 2) B) Tham Prakai Phet specimen (TPKPNE97) (Scale bar = 10 μm.)

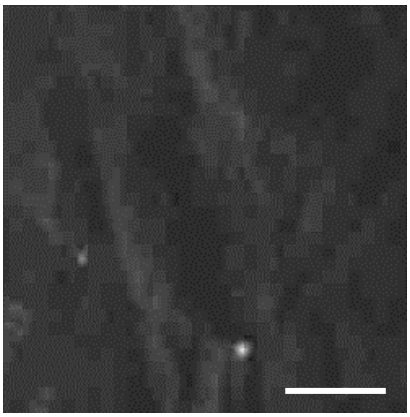


Figure 5.5 Numerical photograph (40X) of molar shearing facet of Late Pleistocene *Bubalus arnee* from Tham Prakai Phet specimen (TPKPNE283) (Scale bar = 10 μm.)

Caprinae

The sample analysed is composed of 17 teeth which presents a well preserved occlusal surface. Specimens from Tham Lod Rockshelter compose of eight teeth (1 sample of *Capricornis sumatraensis*, 6of *Naemorhedus griseus*, and 1*of N.* cf. *goral*) and specimens of Tham Prakai Phet are composed of nine teeth (6 of *Capricornis sumatraensis*, 2 of *C. milneedwardsii*, and 1 of *N.* cf. *goral*), Table 5.2.

The microwear pattern of *C. sumatraensis*, found that themajority present an average number of pits (10 pits) and many average scratches (30 scratches) with a few

average large pits (3 pits) in Tham Lod Rockshelter. It is associated with some pits percentages (17%). In Tham Prakai Phet, samples are characterised by many average scratches (24 scratches) and some small average pits (10.17 pits) with a few average large pits (0.3 pits). The percentage of pits is 27.6% (Figure 5.6).

Only *C. milneedwardsii*, in Tham Prakai Phet presented well preserved specimens that were suitable for this study. The samples present many average scratches (26.5 scratches) and small average pits (11.54 pits) with a few average large pits (1.5 pits). It is associated with a pit percentage of 31% (Figure 5.7).

Naemorhedus griseus is found only in Tham Lod Rockshelter which is characterized by many average scratches (23.5 scratches) and some average pits (9.5 pits). The percentage of pits found in *Naemorhedus griseus* is 31.6% (Figure 5.8).

The microwear pattern of *Naemorhedus* cf. *goral* can be analyzed from both Tham Lod Rockshelter and Tham Prakai Phet. In Tham Lod Rockshelter, samples show some average scratches (9 scratches) and a few average pits (2 pits) with a18.2 percentage of pits. In Tham Prakai Phet, the tooth also has some average scratches (13 scratches) and some average pit (6 pits) associated with 31.6 % of pit percentage (Figure 5.9).

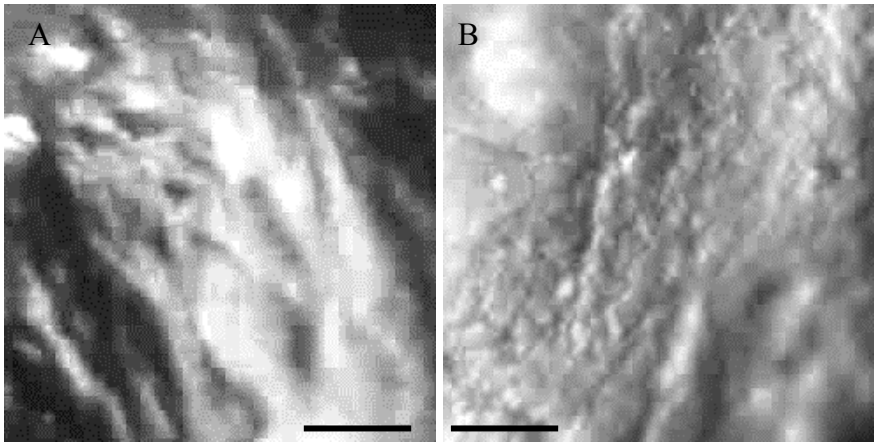


Figure 5.6 Numerical photograph (40X) showing molar shearing facet of a Late Pleistocene *Capricornis sumatraensis*, A) Tham Lod Rockshelter specimen (TL1015a in Area 1); B) Tham Prakai Phet specimen (TPKP SW19) (Scale bar = 10 μm.)

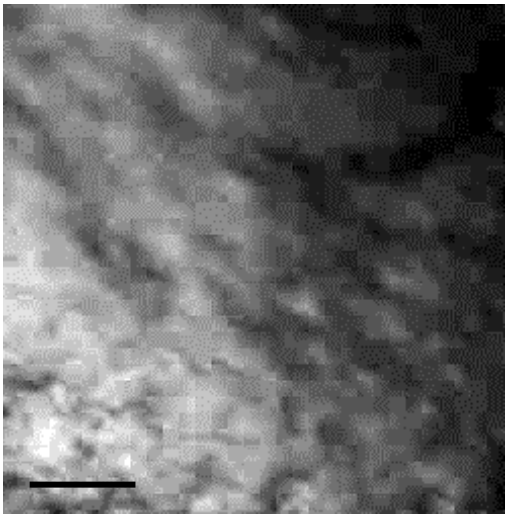


Figure 5.7 Numerical photograph (40X) showing molar shearing facet of a Late Pleistocene *Capricornis milneedwardsii* from Tham Prakai Phet specimen (TPKP NW115) (Scale bar = 10 μm.)

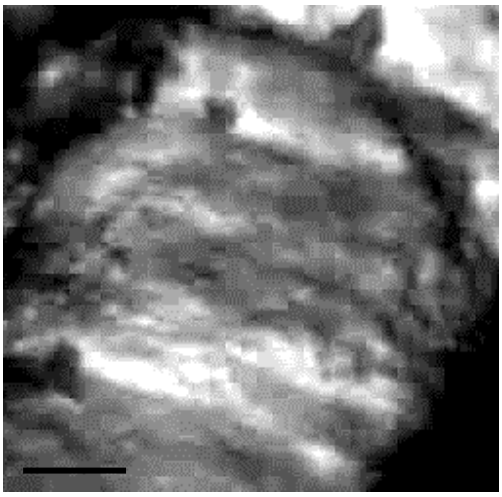


Figure 5.8 Numerical photograph (40X) showing molar shearing facet of a Late Pleistocene *Naemorhedus griseus* from Tham Lod Rockshelter specimen (TL A1742 in Area1) (Scale bar = 10 μm.)

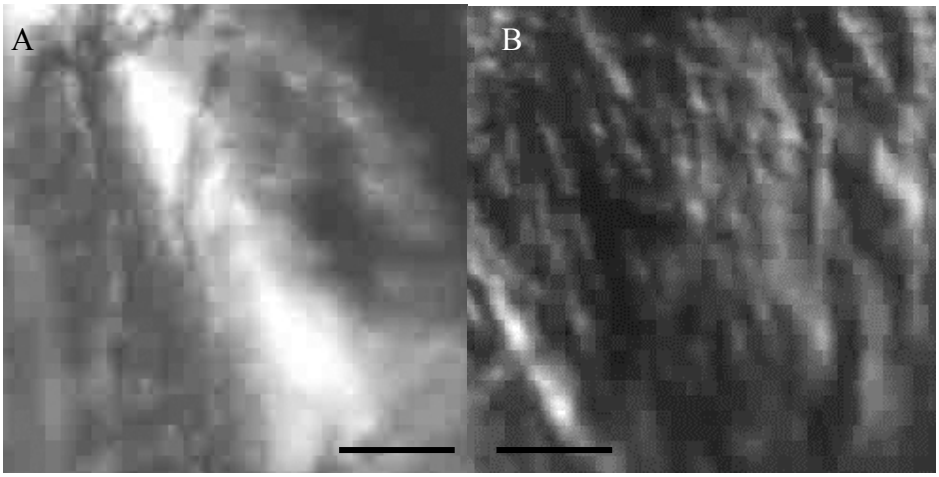


Figure 5.9 Numerical photograph showing the molar shearing facet of a Late Pleistocene *Naemorhedus* cf . *goral*: A) Tham Lod Rockshelter (TL A142 in Area2); B) Tham Prakai Phet (TPKP59) (Scale bar = 10 μm.)

Table 5.2 Microwear analysis data of fossils within the Bovidae Subfamily on M2 and m2 (means absolute count and pit percentages) for Tham Lod Rockshelter (TL) and Tham Pra Kai Phet (TPKP), N = number of the teeth, Nlp = Average number of large pits, Np = Average number of pits, Nws = Average number of wide scratches, Ns = Average number of fine scratches, %P = Pit percentage.

Species	**Site**	**N**	**Nlp**	**Np**	**Nws**	**Ns**	**%P**
Bos gaurus	TL	2	0	6.50	0	12.50	34.3
B. gaurus	TPKP	4	0	4.75	0	20.25	15.2
B. javanicus	TL	2	0	8.50	0	42.00	16.9
B. javanicus	TPKP	4	0	5.75	0	18.00	24.2
Bubalus arnee	TPKP	1	1	8	12	32	16.98
Capricornis sumatraensis	TL	1	3	10	0	30	30.23
C. sumatraensis	TPKP	6	0.3	10.17	0	24.00	30.37
C. milneedwardsii	TPKP	2	1.5	11.54	0	26.50	32.97
Naemorhedus griseus	TL	6	0	9.50	0	23.5	28.78
N. cf. *goral*	TL	1	0	2	0	9	18.2
N. cf. *goral*	TPKP	1	0	6	0	13	31.6

The microwear result is summarized in the bivariate plot demonstrating the average number of pits against the average number of scratches in extant ungulates (Solounias and Semprebon, 2002). As well as fossil samples of Late Pleistocene Bovids which correspond to the three categories of recent ungulates confirmed by Janis (1988): grazer, mixed feeder, and leaf browser. The microwear result pattern shows no overlap between grazer and leaf browser. However, the mixed feeder microwear result pattern is plotted between the plots of both the grazer and leaf browser categories, as well as showing significant overlap with these two categories (Solounias and Semprebon (2002), Figure 5.10.

Overall Late Pleistocene Bovinae specimens are classified with a low range of average number of pits (< 15) and overlap with grazers and mixed feeders, whilst rarely falling in the browser category. In correspondence to pit percentage (Table 4.92), the specimens found in the low range (0 to 17%) are confined as grazers and those in the middle range (21 to 70%) are confined as mixed feeders, following the classifications used by Solounias and Semprebon (2002).

In the Bovinae microwear results, the species *B. javanicus* and *Bubalus arnee* fall in the gap between browser and grazer, associated with a low range percentage. In accordance to a recent study (Lekagul and McNeely 1977; Hedges *et al.*, 2008; Timmins *et al.*, 2008), the two species are mixed feeders which mostly graze. *Bos gaurus* is also considered within the mixed feeder range due to a low range pit percentage. However, *B. gaurus* in Tham Lod Rockshelter is significantly outside the browser category. The *B. gaurus* microwear result is similar to a recent bovid study, this species is more of a browser than *B. javanicus* and *Bubalus arnee* (Lekagul and McNeely 1977; Duckworth *et al.*, 2008)

The Caprinae Subfamily microwear result found, *Capricornis* and *Naemorhedus* overlap significantly in both the grazer and mixed feeder category with a middle range pit percentage in almost all species. In accordance to recent diet reports, they are grazers as well as mixed feeders (Duckworth *et al.*, 2008b; Duckworth *et al.*, 2008c), except for *Naemorhedus* cf. *goral*. All *Naemorhedus* cf. *goral* microwear results are outside the extant browser feeder category with the appropriate middle range

of pit percentage. Late Pleistocene *Naemorhedus* cf. *goral* had a diet of more browse than the extant species and other species within Caprinae.

When comparing the Bovinae specimens at Tham Lod Rockshelter with the Bovinea specimens at Tham Prakai Phet, *B. gaurus* at Tham Lod Rockshelter were not clear predominant feeders but were found outside the browser category based on the bivariate plot. While *B. javanicus* was more of a grazer, based on the low range pit percentage. In Tham Prakai Phet, all bovids are mixed feeders with low range of pit percentages in *B. gaurus* and *B. arnee*. To summarize, in the Tham Prakai Phet site, bovid diets classified them more as grazers than bovids at Tham Lod Rockshelter at least for a short time before they died.

In a comparison between Caprinae at Tham Lod Rockshelter against Caprinae at Tham Prakai Phet, all microwear data of Tham Prakai Phet place Caprinae within the grazer range in the bivariate plot, associated with a mixed feeder range pit percentage. While those of Tham Lod Rockshelter are not clear predominant feeders; *Capricornis sumatraensis* is clearly a mixed feeder, whilst *Naemorhedus griseus* is considered to be mostly a grazer; *Naemorhedus* cf. *goral* is outside the browser category.

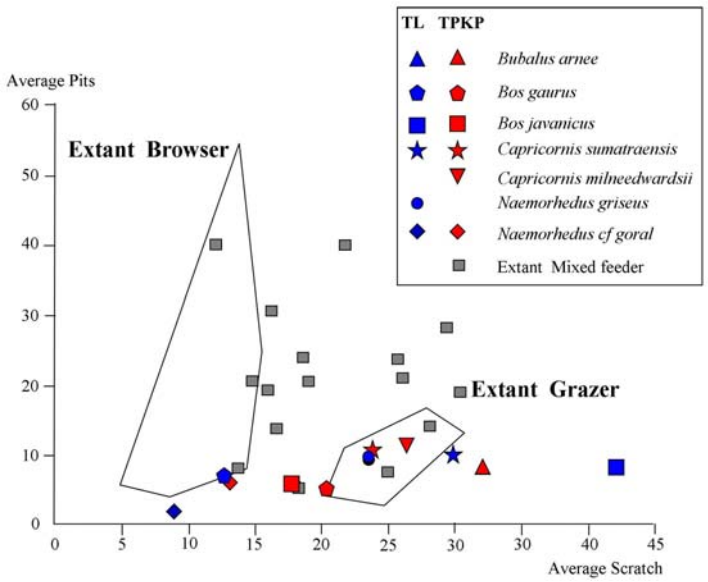


Figure 5.10 Bivariate plot of the average number of pits versus average number of scratches in extant ungulates (Solounias and Semprebon (2002) and fossil samples of Late Pleistocene Bovids from Tham Lod Rockshelter (TL) and Tham Prakai Phet (TPKP)

5.2 Mortality

The individual age at death of bovids can be estimated using dental eruption sequences and wear of isolated teeth (Rivals, 2002). This study used this same principle at the 3 following assemblages: Tham Lod Rockshelter, Tham Prakai Phet, and Tham Rak Sai.

1) Tham Lod Rockshelter

The estimated population size of individuals within the Subfamilies of Bovidae and Caprinae is 134 individuals.

The MNI analysis for Tham Lod Rockshelter (Table 4.93-4.94) is provided for using 3 units which are coordinated with a Layer in Area 1 and 2 following Khaokhiew (2004), and Shoocongdej *et al.* (2007):

The *B. gaurus* population is composed of 134 MNI divided between 29 individuals (6 Juvenile, 19 Adults in their prime and 4 Older individuals). The population of *B. javanicus* is composed of 17 individuals (4 Juveniles, 11 Adults in their prime, 2 MNI Old adults). The population of *B.* cf. *sauveli* is composed of 6 individuals (1 Prime adult and 4 Older individuals). The study has also identified a total population of 9 *Bubalus arnee* (2 Juveniles, 6 Adults in their prime and 1 Older individual)

The population of animals within the Subfamily Caprinae has been calculated with a complete sequence of 73 individuals. The population of *Capricornis sumatraensis* are represented by at least 17 individuals (4 Juveniles, 10 Adults in their prime and 3 Older indivduals), *Naemorhedus griseus* by 40 individuals (11 Juveniles, 25 Adults in their prime and 4 Older individuals) and finally *N. goral* by 16 individuals (4 Juveniles, 11 Adults in their prime, 1 Older individual).

Table 5.3 MNI of Late Pleistocene Bovinae from Tham Lod Rockshelter in each age class: J (Juvenile or ≤3. Years old), P (Adult in its prime or 3.5-12 years old), and O (Older individual or 12-20 years old) (Discamps and Costamagno, 2015)

Unit	*Bos gaurus*			*Bos javanicus*			*Bos sauveli*?			*Bubalus arnee*			Total
	J	P	O	J	P	O	J	P	O	J	P	O	
A	3	6	1	3	5	1	1	2	0	0	1	0	23
B	2	7	2	1	3	1	0	2	1	1	2	0	22
C	1	6	1	0	3	0	0	0	0	1	3	1	16
Total	6	19	4	4	11	2	1	4	1	2	6	1	61
	29			17			6			9			

Table 5.4 MNI of Late Pleistocene Caprinae in Tham Lod Rockshelter in each age class: J (Juvenile or ≤3.5 years old), P (Adult in its prime or 3.5-14.5 years old), and O (Older individuals or 14.5-19.5 years old)

Unit	*Capricornis sumatraensis*			*Naemorhedus griseus*			*N.* cf. *goral*			Total
	J	P	O	J	P	O	J	P	O	
A	1	3	1	2	6	1	0	2	1	16
B	3	6	1	6	13	2	1	3	0	35
C	0	1	1	3	6	1	3	6	0	22
Total	4	10	3	11	25	4	4	11	1	73
	17			40			16			

The Bovidae from Tham Lod Rockshelter (Figure 4.97) are mostly represented by Adults in their prime, it's the most dominant class followed by the Juvenile class and then the Older individual class.

The analysis of the mortality profile using ternary diagrams was achieved for *Bos gaurus*, *B. javanicus*, *Capricornis sumatraensis*, *Naemorhedus griseus* and *N.* cf. *goral* by ternary diagrams. However, for the species *B. sauveli* and *Bubalus arnee*, the NMI was too small than was suggested suitable by Stiner (1998) and Steele (2005).

The former zoning (Stiner, 1990) and further improved zoning (Discamp and Costamagno, 2015) of ternary diagrams is used in this study following the life span of

Bison and African Buffalo as a representation of the Bovinae Subfamily (Juvenile = 0-3 years old, Adults in their prime = 3-12 years old and Older individuals =12-20 years old) suggested by Discamps and Costamagno (2015). This method is also used as a representation for the Subfamily Caprinae by following the life span of Japanese serow (*Capricornis crispus*) (Juvenile = 0-3.5 years old, Adults in their prime = 3.5-14.5 years old, Older individuals =14.5-19.5 years old) following the work of Miura and Yasui (1985) and Kita *et al.* (1987) with a 95% confidence interval around the observed age class percentages.

B. gaurus and *B. javanicus* profiles fall on the boundary between L-shaped and Prime dominance (P zone) in the former zoning ternary diagram (Figure 4.98A). In accordance, they also overlap the boundary between JPO zone and Juvenile-Prime-Old (the corrected proportion ratio: Juvenile>Prime adult>Old adult) and P zone in the improving zoning ternary diagram (Figure 4.98B).

So, two ternary diagrams inform that the mortality reconstructions of Bovinae are linked to human activities. The Bovinae population overlapped the limit between non-selective hunting presented by an L-shaped profile (Stiner, 1990, Discamps and Costamagno, 2015) and selective hunting strategies of ancient humans, as demonstarted by the Prime adult dominance (Stiner, 1990, Discamps and Costamagno, 2015)

Whilist almost all species within Caprinae are found exhibiting an L-shaped profile in the former zoning ternary diagram and JPO zone in the improving zoning ternary diagram, *Naemorhedus* cf. *goral* is found in the Prime dominance zone in the former zoning diagram (Figure 5.11). These Caprinae profiles indicate the use of non-selective hunting by ancient humans.

The genus *Naemorhedus* (*N griseus* and *N* cf. *goral*), are the largest group found within each unit. Their weight is significantly lighter than other species at 22-32 Kg, who will often feed in open areas in groups of 4-12 individuals in high and steep mountainous habitat (Lekagul and McNeely, 1977; Duckworth and MacKinnon, 2008; Duckworth *et al.*, 2008). Thus, *Naemorhedus* provide lower rewards than other species; however, it is possible that hunter-gatherers would be able to collect more than one individual at one time. Moreover, *Naemorhedus* habitat present a better condition for hunting than other fauna due to open area habitat, low interspecific competition

(inaccessibility of almost all other carnivores) as stated in a recent study (Lekagul and McNeely, 1977).

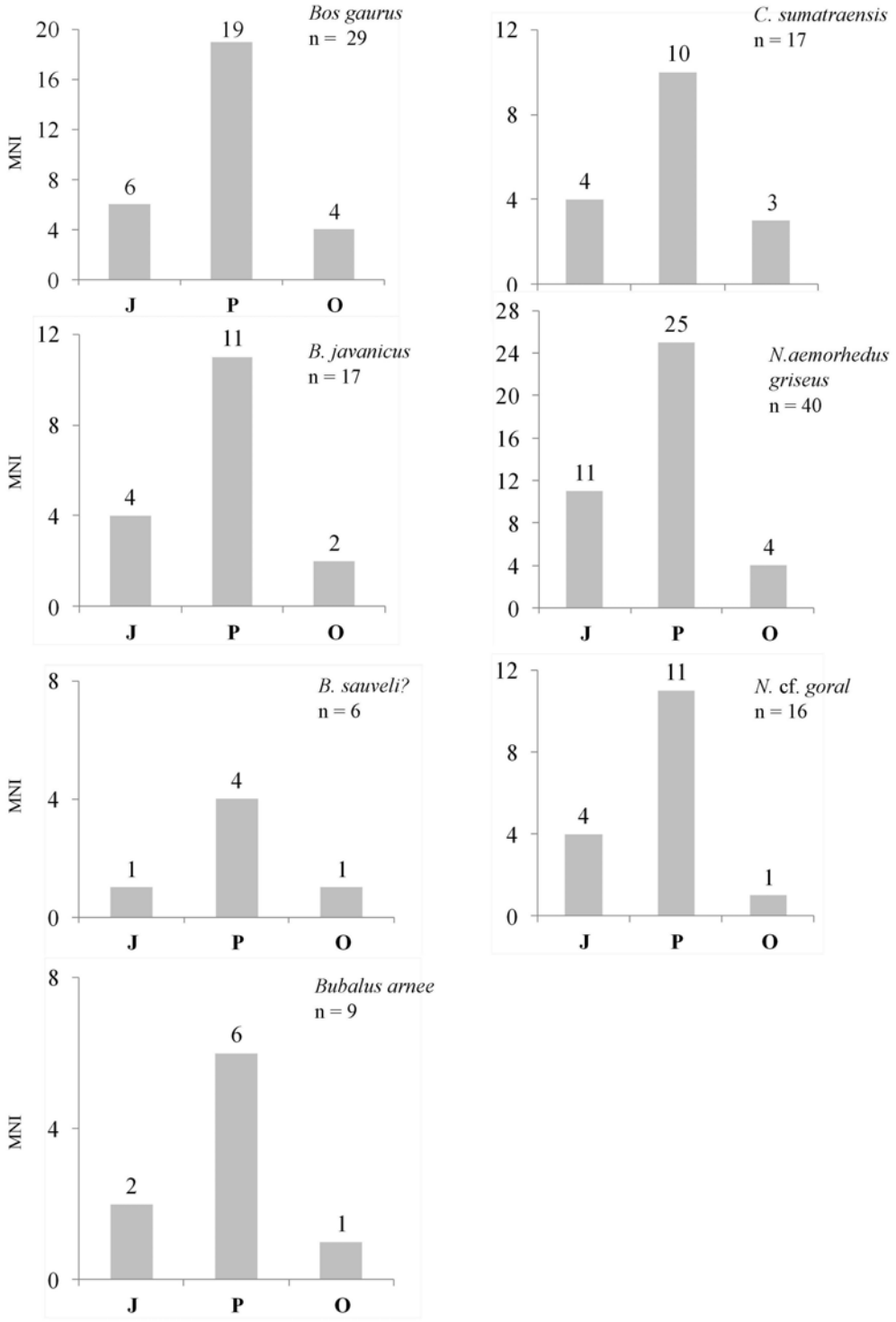


Figure 5.11 Histograms of Bovidae mortality profile for Tham Lod Rockshelte.

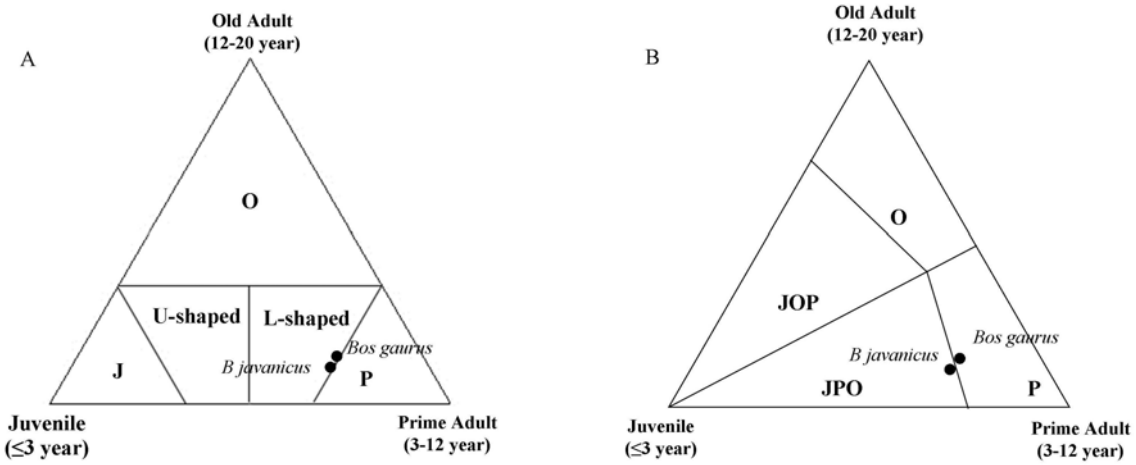


Figure 5.12 The ternary diagrams of Bovinae mortality profiles at Tham Lod Rockshelter with a 95% confidence interval around the observed age class percentages: A) the former zoning pattern (Stiner (1990) and B) the improving zoning pattern (Discamp and Costamagno, 2015)

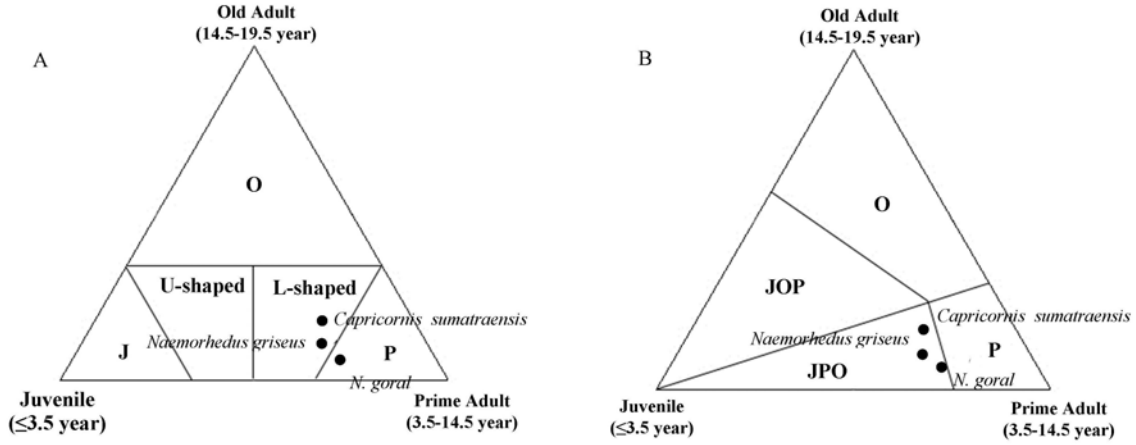


Figure 5.13 The ternary diagrams of Caprinae mortality profiles at Tham Lod Rockshelter with 95% confidence interval around the observed age class percentages: A) the former zoning pattern (Stiner (1990) and B) the improving zoning pattern (Discamp and Costamagno, 2015)

2) Tham Prakai Phet

The Bovidae population size estimated at Tham Prakai Phet is 54 individuals. The population is divided between 15 individuals of *B. gaurus* (2 Juveniles, 9 Adults in their prime and 4 old adults), 13 individuals of *B. javanicus* (2 Juveniles, 8 Prime adults and 3 Older individuals) and 4 individuals of *B. sauveli*? (0 Juveniles, 2 Prime adults and 2 Older individuals), 3 individuals of *Bubalus arnee* (1 Juvenile, 1 adult in its prime and 1 Older individual), 10 individuals of *Capricornis sumatraensis* (1 Juvenile, 6 Adults in their prime and 3 Older individuals), 4 individuals of *C. milneedwardii* (3 Adults in their prime and 1 Older individual), 3 *Naemorhedus griseus* (0 Juveniles, 2 Prime adults and 1 Older individual) and finally 2 *N. goral* (0 Juveniles, 2 Adults in their prime and 0 Older individuals), (Table 5.5-5.6).

Table 5.5 MNI of Late Pleistocene Bovinae at Tham Prakai Phet in each age class: J (Juvenile), P (Adults in their prime), and O (Older individuals)

Species/ Age	***Bos gaurus***			***B. javanicus***			***B. sauveli?***		***Bubalus arnee***			**Total**
	J	**P**	**O**	**J**	**P**	**O**	**P**	**O**	**J**	**P**	**O**	
Total	**2**	**9**	**4**	**2**	**8**	**3**	**2**	**2**	**1**	**1**	**1**	**35**
	15			**13**			**4**		**3**			

Table 5.6 MNI of Late Pleistocene Caprinae at Tham Prakai Phet in each age class: J (Juvenile or ≤3.5 years old), P (Adults in their prime or 3.5-14.5 years old), and O (Older individuals or 14.5-19.5 years old)

Species/Age	***Capricornis sumatraensis***			***C. milneedwardsii***		***Naemorhedus griseus***		***N.* cf. *goral***	**Total**
	J	**PA**	**OA**	**PA**	**OA**	**PA**	**OA**	**PA**	
Total	**1**	**6**	**3**	**3**	**1**	**2**	**1**	**2**	**19**
	10			**4**		**3**		**2**	

Based on our studies findings, the Adults in their prime group is more represented than the other age groups in all species found at Tham Prakai Phet with the exception of *Bos sauveli*? and *Bubalus arnee*. These two species are represented by the same number of individuals for each age class. The number of Prime individuals is not strongly larger than the other groups, but the Older individuals group is often larger than the Juvenile one, unlike in Tham Lod Rockshelter, where the Prime group is clearly largest and the Older individual group is represented by less individuals than the Juvenile group (Figure 4.100).

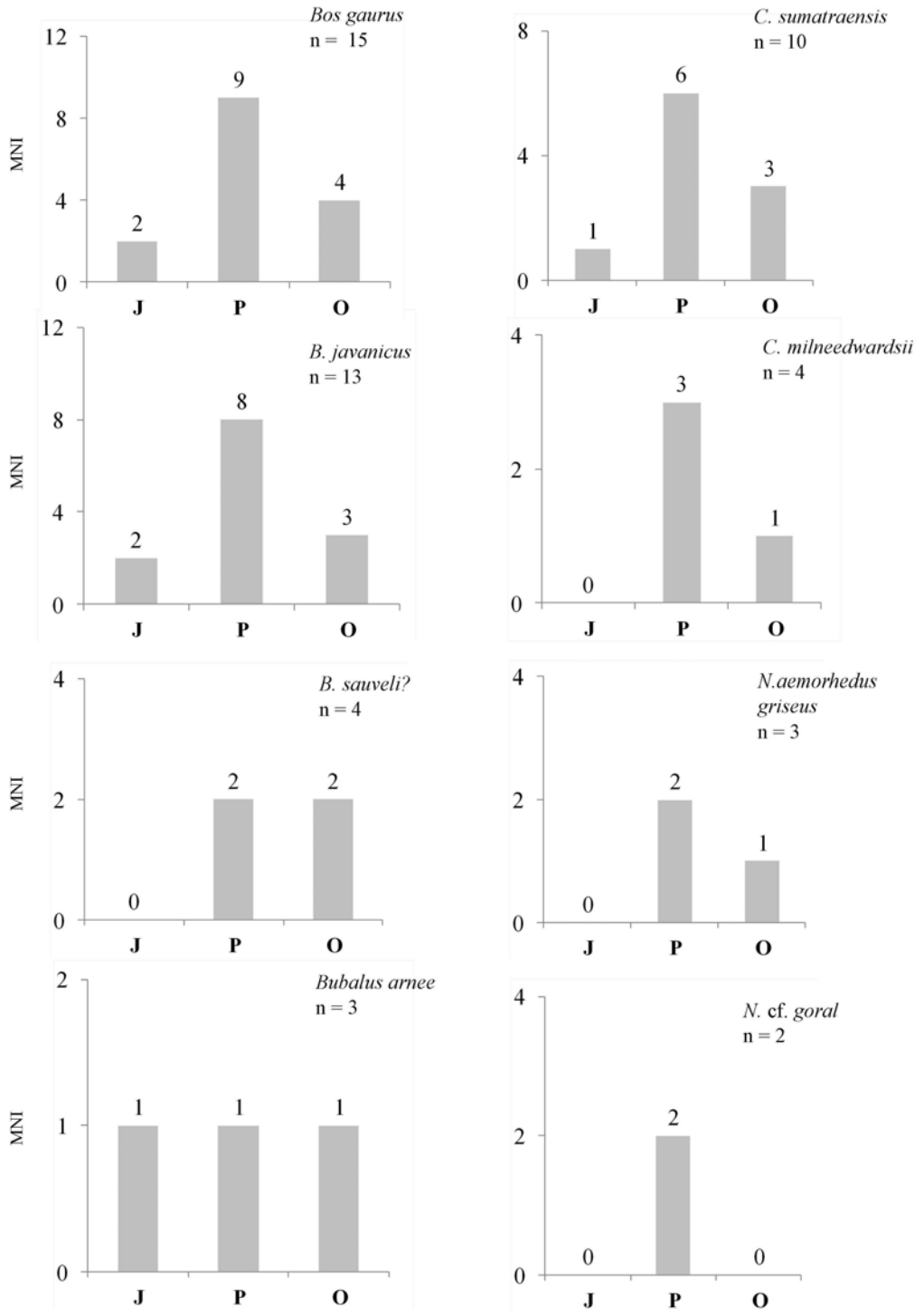


Figure 5.14 The histogram analysis of Bovidae mortality profile diagrams of Tham Prakai Phet

At the Tham Prakai Phet site, only the species *Bos gaurus* and *B. javanicus* can be analyzed in the ternary diagram (MNI ≥12) suggested by Stiner (1998) and Steele (2005). The population of two species can be classified in the L-shaped zone which is much closed to the P-zone than in the former zoning pattern. They can thus be clearly present in P-Zone (Figure 101).

The interpretation of the Prime profile, can be considered as evidence for specific hunting strategies of ancient hunter gatherers (Stiner, 1990; Discamps and Costomagno, 2015; Price *et al.*, 2016) which could be associated with selective ambush techniques (Stiner, 1990; Discamps and Costomagno, 2015). However, the first taphonomic conclusions about the origin of accumulation found at Tham Prakai Phet are linked to a biological agent such as rodents and/or carnivores (Filoux *et al.*, 2014, 2015). No evidence of human activities are present on the bones nor are there lithic tools or artifacts associated with the mammal remains, thus far. So, the Prime adult profile in this study does not correspond with hunter gatherer accumulation. There are many cases of natural accumulations of animal remains not relating to human activities (e.g. Wolverton, 2001; 2006; Khale and Gaudzinski, 2005). The Prime adult profile is present in broader context than is typical of human accumulation. The limiting factors of age group depend on the conditions of intraspecific competition (Wolverton, 2006) or physiological capabilities and ethology during catastrophic events (Khale and Gaudzinski, 2005).

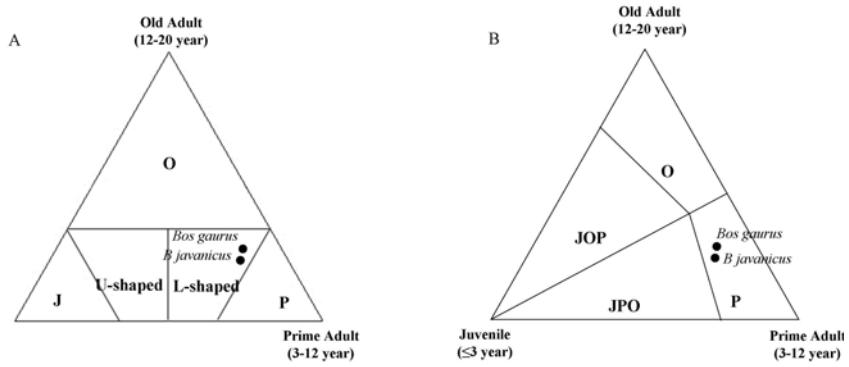


Figure 5.15 The ternary of Bovinae mortality profile diagrams at Tham Prakai Phet with a 95% confidence interval around the observed age class percentages: A) the former zoning pattern (Stiner (1990) and B) the improving zoning pattern (Discamp and Costamagno, 2015)

3) Tham Rak Sai

The Caprinae population AT Tham Rak Sai is composed of five individuals from 3 different species: 1 Older individual *Capricornis sumatraensis*, 1 adult in its prime *C. milneedwardii* and 3 individuals of *Naemorhedus griseus* (1 Juvenile, 1 Adult in its prime, 1 older individual) (Table 5.16).

Table 5.7 MNI of Holocene Caprinae at Tham Rak Sai in each age class: J (Juvenile or ≤3.5 years old), P (Prime adult or 3.5-14.5 years old), and O (Old adult or 14.5-19.5 years old)

Species/ Age	***Capricornis sumatraensis***	***Capricornis milneedwardsii***	***Naemorhedus griseus***			**Total**
	OA	**PA**	**J**	**PA**	**OA**	
Total	1	1	1	1	1	**5**

The sample is too small to define the accumulator agents responsible for the presence of members of Caprinae in the Cave. This is because the number of samples are lower than the minimum number needed for ternary analysis. However, it could be linked to human activity based on lithic tools and artifacts found in the cave that were associated with the mammal remains.

CHAPTER 6

CONCLUSION

6.1 The variation and distribution of Middle to Late Pleistocene Bovids in Southeast Asia

Genus Bos

Three species: *Bos gaurus, B. javanicus, and B.* cf. *sauveli,* from Tham Lod Rockshelter, Tham Prakai Phet correspond to Middle and Late Pleistocene localities such as Tham Prakai Phet (Tougard, 1998), Tham Wiman Nakhin (Tougard, 1998), Kao Pah Nam (Pop *et al.*, 1978), Cave of Monk (Zeitoun *et al.*, 2005, 2010) and Tam Hang (Bacon *et al.*, 2011).

Bos gaurus are present in both large and small sizes which overlaps with the recent and Middle to Late Pleistocene asiatic-specimens and also large-size form (*B. g. grangeri*) from Yenchingkou in South China (Colbert and Hooijer, 1953). However, this study cannot attribute subspecies to large-sized specimens because the previous studies of *B. g. grangeri* (Colbert and Hooijer, 1953) do not focus on isolated teeth. The variation of dental dimensions maybe correlated to sexual dimorphism: males are generally more robust than females in Bovids (Lekagul and McNeely, 1977). Variation of *B. gaurus* dental dimensions possibly corresponds to both large-forms and sexual dimorphism.

The recent distribution of *Bos gaurus* throughout the South mainland, Southeast Asia and Sri Lanka provides a range that overlaps to localities in this study (Lekagul and McNeely, 1977; Duckworth *et al.*, 2008A).

B. javanicus demonstrates an overlap between recent and Late Pleistocene faunas. The existence of sexual dimorphism has not been reported for this species in any recent studies (Lekagul and McNeely, 1977; Timmins *et al.*, 2008A).

B. javanicus has a historical distribution from Southern China throughout the Southeast Asian mainland, the Malaysian Peninsular to Borneo and Java, and possibly the Bali islands. This range overlaps with the localities used in this study (Lekagul and McNeely, 1977; Timmins *et al.*, 2008A).

According to DNA analysis, ***B. sauveli*** is a hybrid form of *B. javanicus* and the local domestic cattle (Hassanin *et al.*, 2006), which is possible due to the presence of both species in the same area (Timmins *et al.*, 2008B). However, it is still considered a valid species due to support of its comparative anatomy and/or behavior (Lekagul and McNeely, 1977, Timmins *et al.*, 2008B). Many paleontological studies still confirm *B. sauveli* as a valid specie such as Tougard (1998), Zeitoun *et al.* (2005, 2010) and Bacon *et al.* (2011). At the same time however, dental morphology of *B. sauveli* using different types of teeth such as M1, M3, m1, m2, m3 does not show a clear distinction (Thein, 1974).

Bos javanicus is historically present in Cambodia, Southern Lao PDR, the Dangrek Mountain range in Northeast Thailand (Thailand- Cambodia bounder) and Western Vietnam (Lekagul and McNeely, 1977; Timmins *et al.*, 2008B). *B. sauveli* has recently been classified on the IUCN Red list of Threatened species as Critically Endangered (possible extinct). All signs or evidence of the species still existing in Thailand have been lost since 1993 (Srikosamatrara and Suteethorn, 1994).

The evidence collected in this study and in previous studies, support the conclusion that the species *Bos sauveli* has never had a wider distribution than what it had during the Late Pleistocene.

Genus *Bubalus*

The dental size of *Bubalus arnee* is closest to that of both recent and Late Pleistocene specimens such as those found at Lang Trang (de Vos and Long, 1993), and Tam Hang (Bacon *et al.*, 2011), but is larger than specimens from Tham Wiman Nakin (Tougard, 1998)

Bubalus arnae achieved a distribution throughout the Indian subcontinent, Southern Sid and Southeast Asia (Hedges et al, 2008). The time of further distribution corresponds to the Late Pleistocene (also this study) allowing for wider distribution throughout Europe, South Asia and Southeast Asia.

Genus *Capricornis*

When considering former paleontological data for this genus, it should be noted that only *C. sumatraensis* or *Naemorhedus sumatraensis* have been used in most previous studies (Tougard *et al.*, 1996; Tougard, 1998; Bacon *et al.*, 2008; 2011)

For ***C. sumatraensis***, many Late Pleistocene specimens including specimens from Tham Prakai Phet, Tham Raksai and some specimens from Tham Lod Rockshelter are larger than the more recent forms. Many sites present evidence for large-form distribution throughout Southeast Asia: Tham Wiman Nakhin (Tougard *et al.*, 1996; Tougard, 1998), Tham Prakai Phet (Filoux *et al.*, 2014, 2015), Cave of Monk (Zeitoun *et al.*, 2005, 2010), Lang Trang (de Vos and Long, 1993), Duoi U'Oi (Bacon *et al.*, 2008), Tam Hang (Bacon *et al.*, 2011), Badak cave and Batu Cave (Ibrahim, 2013; Ibrahim *et. al.*, 3013) and Sumatra Island (Hooijer, 1958). Larger forms are sometimes identified as the subspecies named *C. s. kanjereus* (Tougard *et al.*, 1996; Tougard, 1998; Zeitoun *et al.*, 2010). Only isolated teeth have been preserved and discovered in Southeast Asia, which do not provide enough information for identification at a subspecies level (Hooijer, 1958; de Vos and Long, 1993; Bacon *et al.*, 2008; Bacon *et al.*, 2011), this includes specimens from Tham Lod Rockshelter, Tham Prakai Phet, and Tham Raksai used in this study.

Some previous work considered that there was a decrease in the dental size of Caprinae from the Late Pleistocene into recent times (Wattanapituksakul, 2006). However, the latest data from Tham Lod Rockshelter presents both large-forms and small-forms of *Capricornis sumatraensis* during the Late Pleistocene. Moreover, specimens from caves in the Malay Peninsula represent only small-forms during the same period (Ibrahim *et. al.*, 3013). Consequently, Late Pleistocene *C. sumatraensis* showed both large-forms and small-forms, however after the Late Pleistocene only the small forms managed to survive.

According to current specimen localities, *C. sumatraensis* distribution has been restricted to the lower Southern parts of Thailand and the Kra Isthmus thought Sumatra Island (Wilson and Reeder, 2005; Duckworth *et al.*, 2008a; Duckworth *et al.*, 2008b).

C. milneedwardsii, it present in Tham Prakai Phet and Tham Raksai but was not yet found to be present in paleontological and archaeological sites before this study. Its dental size corresponds with the findings and results of recent studies.

Before 2005, *C. milneedwardsii* was confined as a sub-species of *C. sumatraensis*. Nowadays, *C. milneedwardsii* distribution is considered to range throughout the inland area of Southeast Asia (above the Kra Isthmus in Thailand) (Wilson and Reeder, 2005; Duckworth *et al.*, 2008a; Duckworth *et al.*, 2008b). However, recent studies cannot confirm the fauna turnover or palaeogeographical change of *Capricornis* because of limited *C. milneedwardsii* data in Paleontological sites. Consequently, the revision of Southeast Asian *Capricornis* fossils and sub fossils is needed in order to resolve definitive classification.

Genus *Naemorhedus*

Many Late Pleistocene sites such as Tam Hang (Bacon *et al.*, 2011) and Duoi U'Oi (Bacon *et al.*, 2008) assigned Caprinae specimens as *Naemorhedus*, however this was a synonym name for the species *C. sumatraensis* (Tougard *et al.*, 1996; Tougard, 1998; Bacon *et al.*, 2008, 2011). Preserved specimens of species within the genus *Naemorhedus* are only found in central parts of the Southeast Asian mainland (including this study). The cave of monk shows *N. caudatus* (synonym name of *N. griseus* in the past) and *N. goral* (Zeitoun *et al.*, 2005, 2010) which corresponds to *Naemorhedus* findings at Tham Lod Rockshelter and Tham Prakai Phet.

6.2 Palaeodiet

According to mesowear analysis (long-time feeding before death), the general feeder behavior of all bovids in the Late Pleistocene are that of mixed feeders but there is a tendency for *Bos javanicus* and *Bubalus arnee* to be mostly grazers, which is similar to recent fauna feeding affinities (Lekagul *and* McNeely, 1977; Duckworth *et al.*, 2008a, 2008b, 2008c; Hedges *et al.*, 2008; Timmins *et al.*, 2008; Santiapillai and Widodo, 1989). The studies comparison between sites, shows that some Bovidae species exhibit variation in their feeding behavior. *Bos gaurus*, *Naemorhedus griseus* and *N.* cf. *goral* from Tham Prakai Phet have a higher affinity to mixed feeding than specimens from Tham Lod Rockshelter.

For microwear analysis (short-time feeding before death), the results show that all species at Tham Lod Rockshelter except *B. gaurus* are mostly grazers. While at Tham Prakai Phet, there is a larger variation in feeding: all Bovinae and *Naemorhedus*

griseus are grazes; *Capricornis sumatraensis* is classified as a mixed feeder; and *N.* cf. *goral* is classified as a mixed feeder that will mostly browse.

The mesowear and microwear data, show that the Bovidae diet changes through time, this could be correlated with shifts in climatic conditions. Between 35,000 and 20,000 BP the climatic conditions were wetter and relatively unstable (Marwick and Gagan, 2011). Then the climate became drier from 20,000 to 11,500 BP. This suggests that the intertropical convergence zone shifted southward when the North Atlantic region cooled. This changed the climatic conditions, affecting the vegetation community of the region and thus the feeding behavior of the local Bovidae.

6.3 Mortality

The Mortality profile indicated that the fauna found at the Tham Lod Rockshelter were hunted by hunter-gatherer human settlements which is correlated to non-selected hunting which possibly used ambush hunting techniques. In Tham Prakai Phet, the age structure population reveal a Prime adult dominance, corresponding to possible carnivore hunting activity and/or rodent collection which excludes human accumulation.

REFFERENCE

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APPENDIXES

APPENDIX I

Table of biology of recent bovid in Thailand and in this research

Table 1 Biology of recent bovid in Thailand and in this research.

Toxonomy	Distribution	Habitat	Diet	Herd size	Daily circle	Predators	Life spane
Bos gaurus	Areas in India, Buhtan, Nepal, Bangladesh, Myanmar, Thailand, Indochina, and Malaysia Peninsular (Lekagul and McNeely, 1977; Corbet and Hill, 1992; Duckworth *et al.*, 2008a)	Evergreen, Semi-evergreen, and deciduous forest (Duckworth et al., 2008a), mainly in dense forest (Lekagul and McNeely, 1977; Bidayabha , 2001)	Consideredly most browser (Lekagul and McNeely, 1977; Prayurasiddhi, 1988; Bidayabha, 2001; Prasopsin et al., 2013), reportedly seasonal feeding adaptation depended on each environment (Prayurasiddhi, 1988; Bidayabha, 2001; Prasopsin et al., 2013).	1. Typically 6-20 individuals, or > 20 individuals of maternal herd 2. Solitary or small herd of male adult (Lekagul and McNeely, 1977; Duckworth et al., 2008a)	Naurally diurnal and recently nocturnal influence by human activity (Duckworth et al., 2008a)	Tiger (*Panthera tigris*) and Leopard (Panthera pardus) (Andheria et al. 2007)	8-10 years (Duckworth et al., 2008a)
Bos javanicus	Yunan, South China, Myanmar, Indochina, Thailand, Malaysia Peninsular, Java and Borneo Island, and probably Bali Island (Lekagul and McNeely, 1977; Corbet and Hill, 1992; Timmins *et al.*,	Deciduous, evergreen forest, grassy glades with patches of bamboo forest (Timmins et al., 2008)	Most grazer but perphas considering to a mixed feeder (Lekakul and McNeely, 1977; Prayurasiddhi, 1988; Timmins et al., 2008).	1. 2-10 individuals or up to more than 20 individuals of maternal herd (majority female) 2. Male adult solitaly (Prayurasiddhi, 1988).	Diurnal and nocturnal (Prayurasiddhi, 1988)	Tiger (*Panthera tigris*), Dhole (*Cuon alpinus*) (Prayurasiddhi, 1988)	20-25 year Lekagul and McNeely, 1977)
Bos sauveli	1. Historically present in Cambodia, southern Laos PDR, adjacent parts of Thailand, and western Viet Nam (Lekagul and McNeely, 1977; Corbet and Hill, 1992; Srikosamatara and Suteethorn, 1994; Timmins et al., 2008b)	Open forest (Corbet and Hill, 1992; Timmins et al., 2008b)	Most grazer but perphas considering to a browser (Lekagul and McNeely, 1977; Corbet and Hill, 1992; Timmins *et al.*, 2008b).	1. Small group or up to 20 individuals of maternal herd 2. Solitary or small herd of male adult (Lekagul and McNeely, 1977; Timmins *et al.*, 2008b)	-	-	-

Table 1 Biology of recent bovid in Thailand and in this research (continuous).

Toxonomy	Distribution	Habitat	Diet	Herd size	Daily circle	Predators	Life spane
Bubulus arnee	Historical ranged cross South and Southeast Asia (Lekagul and McNeely, 1977; Hedges, 2008)	Low lying alluvial grassland dominated by deciduous forest and with a marked dry season (Lekagul and McNeely, 1977; Hedges, 2008)	Almost grazer but perphas considering to a mixed feeder (Lekagul and McNeely, 1977; Hedges, 2008)	1. 10-20 individuals or ≤100 individuals of maternal herds 2. Solitary or herd (≤10 individuals) of male adult (Hedges, 2008)	Diurnal and nocturnal (Hedges, 2008)	Tiger(Panthera tigris) (Chairath, 2001), Flooding also cause of losing juvenile (Chairath, 2001)	25 years (Hedges, 2008)
Capricornis sumatraensis	Southern Thailand (below Kra Isthumun), Peninsular Malaysia to Sumatra Island (Duckworth *et al.*, 2008b)	Steep limstone mountain (Lekagul and McNeely, 1977; Duckworth et al., 2008b)	Most browser (Kruaehong and Ngamphangsai, 1983)	1. Mostly solitaly (Duckworth et al., 2008b) 2. Reportedly small herd (≤ 7 individuals) (Nowak, 1991)	Feeding on early moring and late evening (Duckworth et al., 2008b)	-	> 10 years (Lekagul and Mcneely 1977)
Capricornis milneedwardsii	Cambodia, China, Lao People's Democratic Republic, Myanmar, Thailand (Upper Kra Isthmus), Viet Nam (Duckworth *et al.*, 2008c)	1. Steep limstone mountain and cliff,Occuing on small offshore islands (Duckworth et al., 2008C) 2. Ventical movement during day (Hengsuwan, 2004)	Mostly Browser (Duckworth et al., 2008C)rowser (Duckworth et al., 2008C)	Mostly solitaly (Duckworth et al., 2008C)	Mostly nocturnal (Duckworth et al., 2008C)	-	

Table 1 Biology of recent bovid in Thailand and in this research (continuous).

Toxonomy	Distribution	Habitat	Diet	Herd size	Daily circle	Predators	Life spane
Naemorhedus griseus	China, India, Myanmar, Thailand (Northwest), Viet Nam (Duckworth *et al.*, 2008d)	1. subtropical, mixed forests, and evergreen-deciduous forests near steep limstone mountain and cliff (Duckworth *et al.*, 2008d) 2. Horizontal movement during day (Hengsuwan, 2004)	Mixed feeder (Duckworth et al., 2008d)	1. Mostly small herd (4-12 individuals) (Lekagul and McNeely, 1977;Duckworth et al., 2008d) 2. Old male solitary (Duckworth et al., 2008d)	Feeding on moring and near evening (Duckworth *et al.*, 2008d)	Inaccessible to predartor (Lekagul and McNeely, 1977)	>15 years (Duckworth et al., 2008d)
Naemorhedus goral	Across the Himalayas including Bhutan, China (southern Tibet), northern India (including Sikkim), Nepal, and northern Pakistan (Duckworth and MacKinnon, 2008)	Evergreen forests near steep limstone mountain and cliff (Duckworth and MacKinnon, 2008)	Mixed feeder (Duckworth and MacKinnon, 2008)	1. Mostly small herd (4-12 individuals) (Lekagul and McNeely, 1977;Duckworth *et al.*, 2008d) 2. Old male solitary (Duckworth and MacKinnon, 2008)	Early moring and late evening (Duckworth and MacKinnon, 2008)	-	>15 years (Duckworth and MacKinnon, 2008)

APPENDIX II

Table of Middle to Late Pleistocene Bovinae data.

Table 1 Upper DP2 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	5
1	TPKPNW171	*Bubalus arnee*	TPKP	R	22.06	-	12.84	13.57

Table 2 Upper DP4 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TPKP27	*Bos gaurus*	TPKP	L	26.3	24.63	18.82	16.69	21.66
2	TPKPNE116	*Bos javanicus*	TPKP	R	25.29	26.76	16.08	15.3	21.05
3	TPKPSW72	*Bos javanicus*	TPKP	L	26.38	22.24	18.69	26.38	-
4	TPKPNW185	*Bos javanicus*	TPKP	R	-	-	-	-	-

Table 3 Upper DP3 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TPKPNW44	*Bos gaurus*	TPKP	L	-	-	13.19	16.77	18.37
2	TPKPSW15	*Bos gaurus*	TPKP		-	-	-	-	-
3	TPKPSE133	*Bos javanicus*	TPKP	L	23.88	23.97	15.65	-	17.98
4	TPKPSE77	*Bos javanicus*	TPKP	L	21.59	18.95	11.38	-	17.23

Table 3 Upper P2 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	5
1	TLA1413	*Bos gaurus*	TL/A1	R	19.55	16.77	15.08	14.90
2	TLA1507	*Bos gaurus*	TL/A1	R	14.18	15.76	14.45	14.61
3	TLA499	*Bos gaurus*	TL/A1	R	17.44	19.72	15.57	-
4	TLA2488	*Bos gaurus*	TL/A1	R	18.49	-	13.41	-
5	TLA3605	*Bos gaurus*	TL/A1	L	18.89	18.63	14.00	12.95
6	TPKPSE183	*Bos gaurus*	TPKP	R	19.37	18.5	13.83	14.81
7	TPKP40	*Bos javanicus*	TPKP	L	-	-	-	-
8	TPKP47	*Bos javanicus*	TPKP	L	20.46	18.77	14.76	14.86
9	TPKPSE67	*Bos javanicus*	TPKP	L	20.46	-	-	-
10	TPKPNW23	*Bos javanicus*	TPKP	R	20.8	18.05	14.05	15.65
11	TPKPSE92	*Bos javanicus*	TPKP	R	21.48	18.54	14.29	14.98
12	TPKPSW39	*Bubalus arnee*	TPKP	L	20.25	19.15	16.93	18.25

Table 4 Upper P3 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	5
1	TLA1110	*Bos gaurus*	TL/A2	R	19.62	17.52	16.07	17.83
2	TLA2489	*Bos gaurus*	TL/A1	R	19.44	17.52	14.92	15.79
3	TLA3606a	*Bos gaurus*	TL/A1	L	20.35	15.49	19.54	19.26
4	TLA3699	*Bos gaurus*	TL/A1	R	-	-	15.10	-
5	TLA4301	*Bos gaurus*	TL/A1	L	21.19	-	12.58	-
6	TPKP32	*Bos gaurus*	TPKP	L	17.58	15.85	18.58	19.68
7	TLA1078	*Bos javanicus*	TL/A2	R	20.74	18.17	13.92	16.37
8	TLA4300	*Bos javanicus*	TL/A1	R	22.67	21.84	19.26	17.93
9	TLA613	*Bos javanicus*	TL/A2	R	20.53	18.84	14.09	16.27
10	TPKPNW43	*Bos javanicus*	TPKP	R	19.24	18.72	16.44	17.95
11	TPKPSE224	*Bos javanicus*	TPKP	L	20.84	19.28	20.07	19.57
12	TLA1538	*Bubalus arnee*	TL/A1	R	19.14	16.34	18.84	18.85
13	TPKPSW59	*Bubalus arnee*	TPKP	L	21.71	17.58	21.35	20.09

Table 5 Upper P4 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	5
1	TLA2263	*Bos gaurus*	TL/A2	L	20.18	17.58	19.45	22.18
2	TLA2373	*Bos gaurus*	TL/A2	R	19.18	20.05	16.89	20.11
3	TLA3606b	*Bos gaurus*	TL/A1	L	19.28	17.06	19.10	21.20
4	TLA3708	*Bos gaurus*	TL/A1	R	-	-	-	-
5	TLA462	*Bos gaurus*	TL/A2	L	17.00	15.77	-	-
6	TLA540a	*Bos gaurus*	TL/A1	L	18.78	15.72	18.72	15.73
7	TLA92	*Bos gaurus*	TL/A2	R	15.74	-	16.60	-
8	TPKPNW81	*Bos gaurus*	TPKP	R	19.81	16.1	-	-
9	TPKPSE4	*Bos gaurus*	TPKP	R	17.91	16.48	22.14	21.84
10	TPKPSE125	*Bos gaurus*	TPKP	R	18.64	17.12	21.15	22.5
11	TPKPSE225	*Bos javanicus*	TPKP	R	19.66	18.73	-	-
12	TLA611	*Bos javanicus*	TL/A2	R	-	-	-	-
13	TLA614	*Bos javanicus*	TL/A2	R	17.99	15.95	14.17	-
14	TLA770	*Bos javanicus*	TL/A1	L	19.21	17.58	19.25	-
15	TPKPSE156	*Bos javanicus*	TPKP	L	16.79	13.44	-	-
16	TPKPSE214	*Bos javanicus*	TPKP	L	19.53	17.29	-	-
17	TPKPSE85	*Bos javanicus*	TPKP	L	18.4	16.64	18.42	20.85

Table 6 Upper P4 of Middle to Late Pleistocene Bovinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	5
18	TPKPSW190	*Bos javanicus*	TPKP	R	**19.27**	**16.73**	**18.39**	**21.53**
19	TLA1023	*Bubalus arnee*	TL/A2	L	**20.80**	**19.34**	**20.13**	-
20	TPKPSE198	*Bubalus arnee*	TPKP	R	**18.21**	**17.15**	**21.58**	**22.09**
21	TPKPSE47	*Bubalus arnee*	TPKP	L	**23.7**	**18.95**	**23.33**	**23.54**

Table 7 Upper M1 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	5	7	Et
1	TLA1166	*Bos gaurus*	TL/A1	R	25.54	21.29	19.93	18.93	-	5.08
2	TLA135	*Bos gaurus*	TL/A2	L	28.58	26.41	-	18.42	28.89	5.54
3	TLA1436	*Bos* gaurus	TL/A1	L	28.49	23.57	14.59	14.50	-	6.12
4	TLA1944	*Bos gaurus*	TL/A1	R	28.15	23.43	17.82	17.27	25.27	6.46
5	TLA2137	*Bos gaurus*	TL/A2	L	25.96	23.65	18.69	17.83	25.19	6.10
6	TLA3035	*Bos gaurus*	TL/A1	R	29.46	25.16	18.45	17.50	23.84	-
7	TLA3607	*Bos gaurus*	TL/A1	L	26.38	25.32	20.46	18.96	25.45	-
8	TLA4344	*Bos gaurus*	TL/A1	L	22.67	-	19.26	17.93	-	-
9	TLA502	*Bos gaurus*	TL/A2	L	32.83	27.78	-	20.92	27.33	-
10	TLA540b	*Bos gaurus*	TL/A1	L	25.63	22.71	20.35	20.28	24.25	-
12	TPKP28	*Bos gaurus*	TPKP	L	27.06	-	16.83	16.79	-	5.19
13	TPKPSE120	*Bos gaurus*	TPKP	R	26.04	22.38	17.68	18.65	23.92	-
14	TPKPSE57	*Bos gaurus*	TPKP	L	-	-	18.97	-	-	-
15	TPKPSE58	*Bos gaurus*	TPKP	L	27.89	25.85	18.39	17.14	24.65	6.21
16	TPKPSW90	*Bos gaurus*	TPKP	R	28.51	26.7	16.61	15.74	24.52	-
17	TPKPSW127	*Bos gaurus*	TPKP	R	23.43	22.19	20.52	22.26	25.35	2.81
18	TPKPNW164	*Bos gaurus*	TPKP	R	7.67	23.59	21.19	20.67	23.98	6.03
19	TPKP35	*Bos javanicus*	TPKP	R	-	-	-	-	-	-
20	TPKPSE186	*Bos javanicus*	TPKP	L	28.52	24.73	16.16	15.83	-	5.57
21	TPKPSE21	*Bos javanicus*	TPKP	R	26.61	22.51	17.01	15.33	-	5.36
22	TPKPSE49	*Bos javanicus*	TPKP	R	29.21	22.78	16.15	15.55	-	6.62
23	TLA1800	*Bubalus arnee*	TL/A2	R	31.26	31.17	23.93	23.64	28.52	4.81
24	TLA2274	*Bubalus arnee*	TL/A2	L	27.37	26.34	22.57	23.76	27.52	4.57

Table 8 Upper M2 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	5	7	Et
1	TLA1054	*Bos gaurus*	TL/A2	L	26.50	28.00	22.56	-	29.78	9.88
2	TLA1565	*Bos gaurus*	TL/A2	L	26.18	22.00	17.50	16.06	24.76	-
3	TLA1667	*Bos gaurus*	TL/A2	L	-	-	-	-	-	-
4	TLA1906	*Bos gaurus*	TL/A1	R	31.31	24.69	16.54	16.00	26.15	-
5	TLA1909	*Bos gaurus*	TL/A2	R	25.08	22.67	19.36	17.24	23.98	7.66
6	TLA33	*Bos gaurus*	TL/A2	L	28.49	25.34	17.16	18.33	26.3	-
7	TLA3608	*Bos gaurus*	TL/A1	L	28.74	27.38	21.11	19.76	27.83	-
8	TLA501	*Bos gaurus*	TL/A2	L	34.12	30.34	20.86	20.98	-	-
9	TLA807	*Bos gaurus*	TL/A2	R	29.51	26.72	18.29	15.22	27.35	-
10	TLA849	*Bos gaurus*	TL/A2	R	30.73	26.98	20.58	19.69	25.8	-
11	TLA931	*Bos gaurus*	TL/A2	L	27.59	23.86	19.79	17.60	28.74	8.28
12	TPKPNE196	*Bos gaurus*	TPKP	R	29.81	-	-	19.44	-	8.49
13	TPKPNE227	*Bos gaurus*	TPKP	L	28.29	27.61	26.08	26.56	29.78	5.36
14	TPKP31	*Bos gaurus*	TPKP	L	28.36	25.95	17.82	17.12	24.76	7.63
15	TPKPNW116	*Bos gaurus*	TPKP	R	25.5	24.92	23.45	22.54	26.15	4.51
16	TPKPNW164	*Bos gaurus*	TPKP	R	27.67	23.59	21.19	20.67	23.98	6.03
17	TPKPSE2	*Bos gaurus*	TPKP	R	27.22	26.23	22.88	22.42	27.83	5.41
18	TPKPSE243	*Bos gaurus*	TPKP	L	30.82	25.36	19.43	18.38	-	6.92
19	TPKPSE5	*Bos gaurus*	TPKP	R	29.26	25.68	24.77	26.00	27.35	5.72
20	TPKPSW104	*Bos gaurus*	TPKP	L	27.15	27.6	22.86	23.06	28.74	5.42
21	TPKPSW181	*Bos gaurus*	TPKP	L	30.57	27.6	22.81	22.77	28.56	5.16
22	TPKPSW44	*Bos gaurus*	TPKP	R	32.02	26.95	19.51	18.58	26.81	8.14
23	TPKPSE244	Bos gaurus	TPKP	L	34.07	29.42	20.79	19.45	31.09	7.33
24	TPKPNW62	Bos gaurus	TPKP	L	30.78	-	17.60	16.44	22.83	-
25	TPKPNW28	Bos gaurus	TPKP	R	24.41	23.30	23.30	25.21	27.27	5.06
26	TPKPNW7	Bos javanicus	TPKP	R	30.45	-	18.67	16.00	-	6.44
27	TLA2329	*Bos javanicus*	TL/A2	R	25.31	25.07	19.33	16.46	28.56	5.15
28	TLA41	*Bos javanicus*	TL/A2	R	25.16	23.02	20.42	20.34	26.81	6.91
29	TLA808	*Bos javanicus*	TL/A2	L	28.53	23.28	18.22	17.21	-	6.01
30	TPKPNE137	*Bos javanicus*	TPKP	L	32.26	28.62	18.16	19.57	25.18	6.3
31	TPKPNW134	*Bos javanicus*	TPKP	L	32.54	27.79	19.22	18.2	24.8	5.33
32	TPKPSE228	*Bos javanicus*	TPKP	R	-	-	21.16	20.29	-	8.83
33	TPKPNW39	*Bos javanicus*	TPKP	L	29.81	25.91	21.86	21.16	26.3	5.40
34	TPKPSE78	*Bos javanicus*	TPKP	L	-	-	20.59	-	25.8	3.70
35	TPKPSW70	*Bos javanicus*	TPKP	L	27.50	27.21	24.97	-		-
36	TPKPSE53	*Bos cf. sauveli*	TPKP	R	29.06	27.7	24.88	26.05	28.09	-

Table 8 Upper M2 of Middle to Late Pleistocene Bovinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	5	7	Et
37	TPKPSE53	*Bos* cf. *sauveli*	TPKP	R	29.06	27.7	24.88	26.05	28.09	-
38	TLA1802	*Bubalus arnee*	TL/A2	R	32.26	34.54	24.25	19.25	22.59	5.69
39	TLA2272	*Bubalus arnee*	TL/A2	L	32.82	32.05	22.23	26.07	28.09	-
40	TLA3696	*Bubalus arnee*	TL/A1	L	30.22	-	15.89	15.77	-	5.37

Table 9 Upper M3 of Middle to Late Pleistocene Bovinae measurement.

No	Col Num	species	Site/Area	Lateral	1	2	3	5	6	8	9	10	EnL
1	NE102	*Bos gaurus*	TPKP	L	36.52	35.57	23.33	26.45	21.06	23.46	12.43	15.86	6.02
2	NW9	*Bos gaurus*	TPKP	L	30.39	31.3	20.34	27.68	19.02	22.82	10.91	11.12	8.86
3	SE116	*Bos gaurus*	TPKP	L	33.34	33.75	-	-	19.9	25.09	11.75	9.26	8.08
4	SE46	*Bos gaurus*	TPKP	L	31.48	32.82	16.48	27.42	16.65	25.06	12.08	9.71	8.34
5	SE50	*Bos gaurus*	TPKP	L	31.46	-	-	-	17.26	23.41	10.01	11.69	8.11
6	A13	*Bos gaurus*	TL/A2	R	-	29.00	23.33	24.58	22.43	24.24	9.62	9.00	8.64
7	A133	*Bos gaurus*	TL/A2	L	28.13	-	16.75	-	15.42	-	10.19	9.66	-
8	A1587	*Bos gaurus*	TL/A2	L	30.38	30.05	21.79	24.31	20.32	22.84	10.71	10.98	8.69
9	A1801	*Bos gaurus*	TL/A2	L	30.56	-	20.89	22.66	18.21	-	11.35	10.38	4.65
10	A1911	*Bos gaurus*	TL/A2	L	31.00	30.29	19.71	24.07	18.27	23.25	11.17	11.11	5.20
11	A202	*Bos gaurus*	TL/A2	R	30.50	29.95	22.02	24.83	20.25	22.17	11.15	10.12	5.25
12	A2052	*Bos gaurus*	TL/A2	R	32.82	30.40	24.98	21.79	-	24.10	9.49	11.76	-
13	A335	*Bos gaurus*	TL/A2	R	30.25e	30.41	20.44	25.83	17.78	21.89	12.18	10.23	5.65
14	A3603+ A3604	*Bos gaurus*	TL/A1	L	34.26	36.31	21.62	18.54	8.05	-	12.75	10.64	-
15	A775	*Bos gaurus*	TL/A2	R	31.01	31.51	21.31	25.65	18.53	22.90	9.77	10.41	8.74
16	A83	*Bos gaurus*	TL/A2	L	30.36e	28.11	15.24e	-	20.23	21.85	9.49	10.38	7.73
17	NE159	*Bos javanicus*	TPKP	R	-	27.16	17.8	27.17	18.02	25.52	10.04	10.42	4.09
18	no 25	*Bos javanicus*	TPKP	L	-	-	19.22	26.71	-	-	9.58	-	7.17
19	no 26	*Bos javanicus*	TPKP	R	-	-	21.74	26.88	-	26.49	9.82	10.33	6..26
20	SE33	*Bos javanicus*	TPKP	R	31.31	31.73	21.19	24.64	19.63	24.14	11.81	11.69	8.52
21	NE11	*Bos javanicus*	TPKP	L	28.8	28.46	17.78	25.26	15.69	23.47	-	-	-
22	A120	*Bos javanicus*	TL/A2	R	27.42	-	16.43	-	-	-	9.58	10.25	-
23	A1567	*Bos javanicus*	TL/A2	L	25.41	28.34	16.59	22.99	15.69	-	9.46	9.93	5.87
24	A2105	*Bos javanicus*	TL/A2	R	31.87	31.53	21.20	25.02	22.19	23.64	10.39	10.91	7.30
25	A2330	*Bos javanicus*	TL/A2	R	26.87	29.71	-	23.57	16.99	22.46	8.50	8.51	5.94
26	A433	*Bos javanicus*	TL/A2	L	27.98	28.36	20.45	24.30	17.38	21.12	11.35	8.80	-
27	A434	*Bos javanicus*	TL/A2	R	28.32	24.21	17.58	16.10	14.76	-	-	-	6.58
28	A1607	*Bos* cf. *sauveli*	TL/A1	R	34.84	34.14	24.09	21.58	21.87	25.91	13.29	10.40	7.24
29	A2270	*Bubalus arnee*	TL/A2	L	-	-	-	-	19.78	23.15	12.14	12.64	6.48
30	A2271	*Bubalus arnee*	TL/A2	L	-	-	-	-	-	-	-	-	-
31	A6742	*Bubalus arnee*	TL/A1	R	-	37.59	23.21	-	-	-	10.78	-	-
32	A6744	*Bubalus arnee*	TL/A1	R	31.86	-	-	-	19.46	-	10.82	11.47	-

Table 10 Lower dp3 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TPKPNE312	*Bos gaurus*	TPKP	R	23.54	21.75	9.55	9.91	7.25
2	TPKPNW127	*Bos gaurus*	TPKP	L	23.01	20.54	11.18	10.99	7.20
3	TPKPNW6	*Bos javanicus*	TPKP	L	20.18	19.87	10.56	10.55	4.19
4	TPKPSE105	*Bos javanicus*	TPKP	L	18.93	19.34	9.61	9.75	4.33
5	TPKPSW177	*Bos javanicus*	TPKP	L	23.07	21.76	10.32	11.02	5.97

Table 10 Lower dp4 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6
1	TPKP SE101	*Bos gaurus*	TPKP	R	40.03	32.08	12.58	13.25	13.8	16.02
2	TPKP SE255	*Bos gaurus*	TPKP	R	-	-	13.14	14.60	-	-
2	TPKP SW162	*Bos javanicus*	TPKP	L	40.89	31.86	11.01	12.42	12.06	16.97
3	TPKP SW20	*Bos* cf. *sauveli*	TPKP	R	34.93	29.03	11.44	11.57	12.37	17.71

Table 11 Lower p2 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4
1	TLA1605a	*Bos gaurus*	TL/A1	L	13.65	16.48	9.15	10.53
2	TLA180	*Bos gaurus*	TL/A2	L	12.97	13.14	7.46	9.69
3	TLA6212	*Bos gaurus*	TL/A1	L	16.67	14.88	9.07	10.37
4	TPKPNE3	*Bos gaurus*	TPKP	R	14.20	13.50	8.15	9.92
5	TPKPSW80.1	*Bos gaurus*	TPKP	R	13.10	14.19	8.04	9.50
6	TLA1269	*Bos javanicus*	TL/A1	L	9.89	11.07	-	8.69
7	TLA928a	*Bos javanicus*	TL/A1	R	10.28	11.81	6.10	8.54
8	TPKPNW162	*Bos javanicus*	TPKP	R	13.57	13.62	11.09	10.11
9	TPKPNW24	*Bos javanicus*	TPKP	L	12.68	14.00	7.86	9.43

Table 11 Lower p3 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TLA1357	*Bos gaurus*	TL/A1	R	22.44	21.63	12.37	11.31	4.08
2	TLA1605b	*Bos gaurus*	TL/A1	L	21.96	-	12.83	13.01	-
3	TLA4105	*Bos gaurus*	TL/A1	L	20.94	18.64	12.72	12.45	-
4	TLA7055	*Bos gaurus*	TL/A1	R	21.19	18.80	12.58	12.73	-
5	TLA716a	*Bos gaurus*	TL/A2	R	22.04	-	12.42	-	4.21

Table 11 Lower p3 of Middle to Late Pleistocene Bovinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
6	TLA91	*Bos gaurus*	TL/A2	R	22.13	-	12.24	-	-
7	TPKPNE290	*Bos gaurus*	TPKP	R	22.9	21.86	13.41	14.16	6.30
8	TPKPNW198	*Bos gaurus*	TPKP	R	21.36	19.21	11.55	12.13	4.39
9	TPKPSE151	*Bos gaurus*	TPKP	L	23.67	21.74	14.25	14.01	6.70
10	TPKPSE195	*Bos gaurus*	TPKP	L	20.36	19.99	12.19	11.98	1.94
11	TPKPSE239	*Bos gaurus*	TPKP	L	21.76	19.85	12.18	12.36	5.23
12	TPKPSW119	*Bos gaurus*	TPKP	R	23.46	22.06	12.59	13.66	6.12
13	TPKPSW68.1	*Bos gaurus*	TPKP	R	-	-	-	-	-
14	TPKPSW80.2	*Bos gaurus*	TPKP	R	21.11	18.42	12.44	12.52	6.337
15	TPKPSW91	*Bos gaurus*	TPKP	L	-	-	-	-	-
16	TPKPNW29	*Bos gaurus*	TPKP	R	19.11	18.51	12.17	11.96	2.80
17	TPKPSE25	*Bos gaurus*	TPKP	R	21.45	20.4	11.00	11.48	5.05
18	TLA1418	*Bos javanicus*	TL/A1	L	-	-	-	-	-
19	TLA3704	*Bos javanicus*	TL/A1	L	-	-	-	-	-
20	TLA627	*Bos javanicus*	TL/A2	L	20.89	20.29	10.29	11.78	5.58
21	TLA7703	*Bos javanicus*	TL/A1	L	24.56	-	12.54	-	-
22	TLA928b	*Bos javanicus*	TL/A1	R	19.73	18.98	8.99	10.16	-
23	TPKPNE231	*Bos javanicus*	TPKP	L	-	-	-	-	-
24	TPKPNE252	*Bos javanicus*	TPKP	R	22.45	19.66	12.01	12.42	5.98
25	TPKP57	*Bos javanicus*	TPKP	L	21.8	19.68	12.22	11.83	-
26	TPKPNW138	*Bos javanicus*	TPKP	L	21.33	20.56	12.74	12.47	5.36
27	TPKPSE184	*Bos javanicus*	TPKP	L	-	-	-	-	-
28	TPKPSW163	*Bos javanicus*	TPKP	L	-	-	-	-	-
29	TPKPSW37	*Bos javanicus*	TPKP	R	21.45	12.15	-	-	-
30	TPKPSW78	*Bos javanicus*	TPKP	L	20.04	-	10.25	-	-
31	TPKPNW190	*Bos javanicus*	TPKP	L	-	-	-	-	-
32	TPKPSW103	*Bos javanicus*	TPKP	L	21.91	19.50	11.02	13.60	5.10
33	TPKPNE114	*Bos javanicus*	TPKP	L	-	-	-	-	-
34	TLA1303	*Bos* cf. *sauveli*	TL/A2	L	-	-	-	-	-
35	TPKPSE41.2	*Bos* cf. *sauveli*	TPKP	L					
36	TPKPNW87	*Bos* cf. *sauveli*	TPKP	L	-	-	-	-	-
37	TLA5236	*Bubalus arnee*	TL/A1	L	23.22	-	12.00	-	-

Table 12 Lower p4 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TLA3152	*Bos gaurus*	TL/A1	L	21.31	21.15	13.21	14.24	3.26
2	TLA3432	*Bos gaurus*	TL/A1	R	21.12	18.72	12.38	13.55	3.47
3	TLA3695	*Bos gaurus*	TL/A1	L	-	-	13.65	-	-
4	TLA491	*Bos gaurus*	TL/A1	L	21.80	21.10	11.06	13.54	-
5	TLA716b	*Bos* gaurus	TL/A2	R	22.97	-	13.06	-	3.90
6	TLA7358	*Bos gaurus*	TL/A1	R	25.97	-	11.43	11.18	-
6	TLA912	*Bos gaurus*	TL/A1	L	23.17	22.44	11.32	12.80	-
7	TPKPNE39	*Bos gaurus*	TPKP	R	24.17	21.59	15.6	14.01	4.02
8	TPKPSE80	*Bos gaurus*	TPKP	L	23.58	23.79	14.33	15.02	1.78
9	TPKPSW103	*Bos gaurus*	TPKP	L	21.91	19.5	11.02	13.6	5.1
10	TPKPSW193	*Bos gaurus*	TPKP	R	21.78	21.25	14.76	13.64	-
11	TPKPSW11	*Bos gaurus*	TPKP	L	23.91	23.51	14.2	13.59	3.33
12	TPKPSE199	*Bos gaurus*	TPKP	L	-	-	-	-	-
13	TPKPNW87	*Bos gaurus*	TPKP	L	-	-	-	-	-
14	TPKPSW136	*Bos gaurus*	TPKP	L	21.66	20.41	12.72	12.77	1.6
15	TPKPNW110	*Bos gaurus*	TPKP	L	25.22	24.58	13.77	13.39	4.28
16	TPKPNE121	*Bos gaurus*	TPKP	R	25.77	24.6	13.31	14.07	4.3
17	TPKPSE199	*Bos gaurus*	TPKP	L	-	-	-	-	-
18	TLA2344	*Bos javanicus*	TL/A2	L	23.80	24.93	10.95	12.78	4.33
19	TLA571	*Bos javanicus*	TL/A2	L	20.73	20.61	12.44	11.68	2.14
20	TLA628	*Bos javanicus*	TL/A2	L	23.92	23.29	11.20	12.13e	6.66
21	TLA928c	*Bos javanicus*	TL/A1	R	22.07	22.67	10.72	11.00	-
22	TPKPNE262	*Bos javanicus*	TPKP	L	25.27	21.79	15.22	13.67	6.78
23	TPKPNW148	*Bos javanicus*	TPKP	R	-	-	-	-	-
24	TPKPNW85	*Bos javanicus*	TPKP	L	-	-	-	-	-
25	TPKPSW150	*Bos javanicus*	TPKP	R	-	-	-	-	-
26	TPKP101	*Bos javanicus*	TPKP	R	-	-	-	-	-
27	TPKPSW6	*Bos javanicus*	TPKP	R	-	-	-	-	-
28	TLA1282	*Bos cf. sauveli*	TL/A2	L	25.21	25.86	13.70	14.02	-
29	TPKPSW136	*Bos cf. sauveli*	TPKP	L	21.66	20.41	12.72	12.77	1.6
30	TPKP207	*Bos cf. sauveli*	TPKP	L	22.38	21.39	12	11.66	3.92
31	TPKPNW215	*Bubalus arnee*	TPKP	R	22.91	23.41	15.17	16.44	2.45

Table 13 Lower m1 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TLA1506	*Bos gaurus*	TL/A1	L	25.91	23.73	13.29	13.61	14.41
2	TLA1677	*Bos gaurus*	TL/A1	R	27.64	25.06	14.34	13.38	18.84
3	TLA1720a	*Bos gaurus*	TL/A1	L	-	-	-	-	-
4	TLA1791	*Bos gaurus*	TL/A1	L	24.75	22.52	14.54	14.79	16.56
5	TLA286	*Bos gaurus*	TL/A1	R	-	-	13.07	-	-
6	TLA7153	*Bos gaurus*	TL/A1	R	25.51	23.65	15.31	15.57	16.91
7	TLA716c	*Bos gaurus*	TL/A2	R	28.31	-	15.04	15.97	-
8	TLA720	*Bos gaurus*	TL/A2	R	26.54	25.86	19.00	18.22	19.37
9	TLA7863a	*Bos gaurus*	TL/A1	R	27.39	-	13.01	13.46	-
10	TLA1854	*Bos gaurus*	TL/A2	R	21.72	22.96	17.63	18.06	18.08
11	TLA441	*Bos gaurus*	TL/A2	R	21.06	18.29	16.74	16.81	20.90
12	TPKPNE271	*Bos gaurus*	TPKP	R	26.11	25.92	19.48	19.27	20.35
13	TPKPNE168	*Bos gaurus*	TPKP	L	26.86	21.60	13.31	-	16.16
14	TPKPNE303	*Bos gaurus*	TPKP	R	-	-	-	-	-
15	TPKPNE50	*Bos gaurus*	TPKP	R	26.04	23.30	16.60	-	-
16	TPKP11	*Bos gaurus*	TPKP	L	27.14	-	14.73	14.77	-
17	TPKP33	*Bos gaurus*	TPKP	R	23.95	22.24	14.44	15.01	15.77
18	TPKPNW166	*Bos gaurus*	TPKP	R	23.24	23.99	13.31	13.11	15.44
19	TPKPSE118	*Bos gaurus*	TPKP	L	24.94	22.84	14.58	14.62	15.01
20	TPKPSE182	*Bos gaurus*	TPKP	L	23.38	23.66	14.61	15.43	16.64
21	TPKPSE84	*Bos gaurus*	TPKP	L	23.40	2200	16.81	15.42	18.66
22	TPKPSW82	*Bos gaurus*	TPKP	L	25.94	-	17.44	-	-
38	TPKPSE100	*Bos gaurus*	TPKP	R	25.0	23.2	14.6	14.3	17.4
39	TPKPNW84	*Bos gaurus*	TPKP	R	24.8	23.8	17.	17.5	18.6
26	TPKPSW208	*Bos gaurus*	TPKP	R	25.21	26.71	18.52	17.59	19.74
27	TPKPSW21	*Bos gaurus*	TPKP	L	25.59	16.87	17.09	16.92	17.72
28	TLA1099	*Bos javanicus*	TL/A2	R	26.96	-	13.16	-	-
29	TLA2351	*Bos javanicus*	TL/A2	L	25.46	21.36	11.71	11.42	14.60
30	TLA329	*Bos javanicus*	TL/A2	R	25.62	22.75	14.07	13.71	14..84
31	TLA500	*Bos javanicus*	TL/A1	R	25.74	23.37	12.26	11.9	15.5
32	TLA570	*Bos javanicus*	TL/A2	L	24.97	23.91	12.81	12.69	15.27
33	TLA626	*Bos javanicus*	TL/A2	L	25.91	21.25	14.01	13.93	15.41
34	TLA782	*Bos javanicus*	TL/A2	L	23.10	20.83	14.51	15.39	14.89

Table 13 Lower m1 of Middle to Late Pleistocene Bovinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
35	TLA915	*Bos javanicus*	TL/A1	R	23.34	22.43	14.48	14.15	14.43
26	TPKPSW132	*Bos javanicus*	TPKP	R	25.3	22.89	14.62	15.51	18.07
37	TPKP30	*Bos javanicus*	TPKP	R	27.07	25.46	15.09	14.68	16.03
38	TPKPNW169	*Bos javanicus*	TPKP	L	25.20	23.84	15.02	15.42	16.41
39	TPKP124	*Bos javanicus*	TPKP	L	32.30	30.30	12.08	12.11	17.44
40	TPKPNW177	*Bos javanicus*	TPKP	L	-	-	-	-	-
41	TPKPNW96	*Bos javanicus*	TPKP	R	25.07	23.32	-	-	-
42	TPKPSE112	*Bos javanicus*	TPKP	L	28.48	27.30	14.55	14.95	17.8
43	TPKPSE207	*Bos javanicus*	TPKP	R	25.88	23.53	15.38	15.81	17.26
44	TPKPSE35	*Bos javanicus*	TPKP	R	27.32	-	-	-	-
45	TPKPSE88	*Bos javanicus*	TPKP	R	25.64	25.03	15.96	15.61	16.41
46	TPKPSW102	*Bos javanicus*	TPKP	L	24.41	23.51	14.47	14.31	17.07
47	TPKPSW96	*Bos javanicus*	TPKP	L	25.64	24.71	14.78	15.38	17.6
48	TLA2273	*Bubalus arnee*	TL/A2	L	30.31	25.79	15.67	-	-

Table 14 Lower m2 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TLA1076	*Bos gaurus*	TL/A2	L	27.10	26.43	18.99	18.73	20.23
2	TLA119	*Bos gaurus*	TL/A2	L	30.58	25.21	13.03	12.25	18.59
3	TLA1207	*Bos gaurus*	TL/A1	L	24.69	22.68	13.62	13.79	16.73
4	TLA122	*Bos gaurus*	TL/A2	L	26.56	25.26	16.70	14.76	16.76
5	TLA1226	*Bos gaurus*	TL/A1	R	26.27	21.08	12.87	12.61	16.69
6	TLA1284	*Bos gaurus*	TL/A2	L	26.28	22.56	12.73	12.93	18.25
7	TLA1439	*Bos gaurus*	TL/A2	R	28.92	27.55	17.84	16.97	20.68
8	TLA1487	*Bos gaurus*	TL/A2	R	28.52	26.50	14.84	14.35	18.89
9	TLA1606	*Bos gaurus*	TL/A1	R	-	23.79	14.16	14.45	20.45
10	TLA1720b	*Bos gaurus*	TL/A1	L	26.21	-	12.69	12.49	-
11	TLA2106	*Bos gaurus*	TL/A2	R	28.10	26.35	13.32	14.11	18.63
12	TLA2138	*Bos gaurus*	TL/A2	R	28.01	23.62	14.09	13.52	20.19
13	TLA2202	*Bos gaurus*	TL/A2	R	31.61	26.58	11.87	12.91	18.53
14	TLA3697	*Bos gaurus*	TL/A1	L	31.18	-	14.51	14.77	17.61
15	TLA4204	*Bos gaurus*	TL/A1	L	29.28	25.39	12.96	12.47	17.59
16	TLA4210	*Bos gaurus*	TL/A1	L	27.32	26.88	16.13	15.51	18.81

Table 14 Lower m2 of Middle to Late Pleistocene Bovinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
17	TLA716d	*Bos gaurus*	TL/A2	R	31.78	-	15.69	16.72	-
18	TLA7863b	*Bos gaurus*	TL/A1	R	32.16	-	14.81	13.97	-
19	TLA81	*Bos gaurus*	TL/A2	L	25.46	25.54	13.84	13.47	18.42
20	TLA927	*Bos gaurus*	TL/A1	R	33.05	-	14.97	-	15.01
21	TLA934	*Bos gaurus*	TL/A1	R	26.59	24.13	14.25	14.99	15.83
23	TPKP12	*Bos gaurus*	TPKP	L	27.9	25.43	14.16	14.29	17.1
24	TPKPNW212	*Bos gaurus*	TPKP	R	32.19	25.11	10.72	10.03	17.86
25	TPKPNW214	*Bos gaurus*	TPKP	L	32.01	32.99	-	-	-
26	TPKPNW48	*Bos gaurus*	TPKP	L	31.35	29.49	17.79	18.17	20.68
27	TPKPSE13	*Bos gaurus*	TPKP	R	28.95	26.18	14.26	13.93	19.03
28	TPKPSE18	*Bos gaurus*	TPKP	L	27.21	25.21	15.26	14.94	16.8
29	TPKPSW201	*Bos gaurus*	TPKP	R	25.37	25.04	18.45	18.07	18.77
30	TPKPSW74	*Bos gaurus*	TPKP	L	28.74	25.25	15.68	15.43	18.56
31	TPKP 52	*Bos gaurus*	TPKP	R	29.58	27.82	18.2e	18.45	22.5
32	TPKPSE41.1	*Bos gaurus*	TPKP	R	37.63	32.25	16.36	16.69	19.04
33	TPKPSE34	*Bos gaurus*	TPKP	L	33.29	-	-	12.34	-
34	TPKPSE213	*Bos gaurus*	TPKP	L	33.89	-	11.77	13.01	-
35	TLA1087	*Bos javanicus*	TL/A2	L	27.03	23.29	13.17	12.72	16.09
36	TLA1288	*Bos javanicus*	TL/A1	L	33.59	29.37	15.02	14.98	16.97
37	TLA495	*Bos javanicus*	TL/A1	R	26.42e	-	14.48	-	-
38	TLA7455	*Bos javanicus*	TL/A1	R	20.01e	-	-	-	13.70
39	TLA920	*Bos javanicus*	TL/A1	L	26.11	23.83	12.98	12.46	15.71
40	TPKPNE309	*Bos javanicus*	TPKP	L	31.86	27.27e	10.55	10.7	15.63e
41	TPKPNE31	*Bos javanicus*	TPKP	R	28.59	28.5	19.2	19.36	20.37
42	TPKPNE97	*Bos javanicus*	TPKP	L	26.99	27.9	17.44	17.61	20.27
43	TPKP24	*Bos javanicus*	TPKP	R	30.51	28.49	15.66	14.95	19.71
44	TPKP71	*Bos javanicus*	TPKP	R	-	-	-	-	-
45	TPKPNW128	*Bos javanicus*	TPKP	L	28.56	26.69	17.02	17.47	19.06
46	TPKPNW82	*Bos javanicus*	TPKP	R	28.19	27.49	15.96	15.77	17.69
47	TPKPSE55	*Bos javanicus*	TPKP	L	30.72	29.09	15.52	16.01	18.27
48	TPKPSE96	*Bos javanicus*	TPKP	R	27.18	26.8	17.58	19.21	19.69
49	TPKPSW17	*Bos javanicus*	TPKP	L	31.37	-	11.02	10.72	13.72
50	TPKPSW214	*Bos javanicus*	TPKP	R	28.06	26.8	19.56	18.8	19.75

Table 14 Lower m2 of Middle to Late Pleistocene Bovinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
51	TLA121	*Bos javanicus*	TL/A2	L	-	-	-	-	-
52	TLA1148a	*Bubalus arnee*	TL/A2	R	30.61	18.70	19.56	19.46	19.20
53	TLA2269	*Bubalus arnee*	TL/A2	L	33.15	-	-	16.74	-
54	TPKPNE283	*Bubalus arnee*	TPKP	L	33.26	27.12	18.15	19.15	19.31
55	TPKPNW152	*Bubalus arnee*	TPKP	L	31.37	30.81	20.22	19.73	21.31
56	TPKPNW62	*Bubalus arnee*	TPKP	L	30.78	-	17.6	-	20.52
57	TPKPSE95	*Bubalus arnee*	TPKP	R	-	-	-	18.05	-
58	TPKPNE310	*Bubalus arnee*	TPKP	L	-	-	13.60	-	-

Table 15 Lower m3 of Middle to Late Pleistocene Bovinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6
1	TPKPNE274	*Bos gaurus*	TPKP	R	43.35	45.71	17.00	16.65	8.07	19.72
2	TPKP20	*Bos gaurus*	TPKP	R	40.28	41.25	13.30	13.31	6.34	-
3	TPKPNW135	*Bos gaurus*	TPKP	L	40.61	40.21	12.79	13.27	6.72	17.37
4	TPKPSE121	*Bos gaurus*	TPKP	L	38.41	38.55	14.88	13.43	5.97	16.93
5	TPKPSE134	*Bos gaurus*	TPKP	R	43.85	42.03	19.12		9.83	19.81
6	TPKPSE17	*Bos gaurus*	TPKP	R	36.33	35.13	16.23	15.83	9.39	16.42
7	TPKPSE201.1	*Bos gaurus*	TPKP	L	44.42	46.29	18.18	16.26	8.81	19.3
8	TPKPSE71	*Bos gaurus*	TPKP	L	44.05	45.61	16.9	15.92	7.93	20.39
9	TPKPSW53	*Bos gaurus*	TPKP	R	-	-	-	14.73	10.12	16.88
10	TPKPSW73	*Bos gaurus*	TPKP	R	43.71	45.61	18.4	17.02	10.13	18.91
11	TLA1799	*Bos gaurus*	TL/A2	R	39.46	42.20	15.13	14.61	6.82	19.93
12	TLA1327	*Bos gaurus*	TL/A2	L	40.01	-	17.51	-	-	-
13	TLA134	*Bos gaurus*	TL/A2	L	45.58	44.90	15.29	15.45	7.64	17.71
14	TLA1374	*Bos gaurus*	TL/A2	R	37.15	36.16	12.93	13.87	7.46	14.19
15	TLA1434	*Bos gaurus*	TL/A1	L	35.36	-	12.32	12.79	5.23	-
16	TLA1440	*Bos gaurus*	TL/A2	L	-	-	-	14.66	7.39	-
17	TLA1489+1490	*Bos gaurus*	TL/A2	R	34.01	35.20	15.77	13.50	6.33	19.41
18	TLA1939	*Bos gaurus*	TL/A1	R	33.72	36.70	-	12.58	-	16.45
19	TLA2103	*Bos gaurus*	TL/A2	R	30.59	-	17.90	17.83	-	-
20	TLA2139	*Bos gaurus*	TL/A2	R	38.22	40.81	16.60	15.98	8.44	-
21	TLA3154	*Bos gaurus*	TL/A1	L	36.24	41.57	14.20	14.63	-	19.62
22	TLA36	*Bos gaurus*	TL/A2	L	37.89	39.56	14.92	14.33	6.22	-

Table 15 Lower m3 of Middle to Late Pleistocene Bovinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6
23	TLA78+A77	*Bos gaurus*	TL/A2	L	34.62	35.27	14.02	14.58	6.09	20.10
24	TLA80	*Bos gaurus*	TL/A2	L	-	-	-	16.42	9.14	-
25	TLA282	*Bos gaurus*	TL/A1	L	37.63	38.07	15.44	14.59	-	16.38
26	TLA136	*Bos gaurus*	TL/A2	R	31.25	-	16.60	13.29	-	16.65
27	TLA2328	*Bos javanicus*	TL/A2	R	34.73	-	12.00	11.96	5.74	14.88
28	TLA2372	*Bos javanicus*	TL/A2	R	37.12	42.45	12.98	12.91	4.75	17.66
29	TLA35	*Bos javanicus*	TL/A2	R	38.23	-	14.69	14.06	6.62	15.92
30	TLA5389	*Bos javanicus*	TL/A1	R	-	-	-	-	-	-
31	TLA6739	*Bos javanicus*	TL/A1	R	-	27.19	-	14.42	5.91	17.64
32	TLA721	*Bos javanicus*	TL/A2	L	-	-	-	13.09	6.13	-
33	TLA921	*Bos javanicus*	TL/A1	L	34.98	39.52	12.70	12.36	7.33	16.03
34	TPKPNE38	*Bos javanicus*	TPKP	R	-	-	13.61	13.39	5.91e	17.62
35	TPKPNE43	*Bos javanicus*	TPKP	L	36.42	35.87	15.06	15.46	7.72	15.2
36	TPKP19	*Bos javanicus*	TPKP	L	38.34	41.68	12.71	11.71	5.09	17.2
37	TPKP22	*Bos javanicus*	TPKP	L	39.36	38.6	14.92	14.86	6.95	16.26
38	TPKP29	*Bos javanicus*	TPKP	L	-	-	-	-	-	-
39	TPKPNW170	*Bos javanicus*	TPKP	L	43.01	45.95	14.81	14.81	6.96	19.6
40	TPKPNW5	*Bos javanicus*	TPKP	L	41.14	40.18	14.53	14.37	7.08	19.19
41	TPKPSE189	*Bos javanicus*	TPKP	L	40.48	40.60	15.11	15.09	7.20	-
42	TPKPSE208	*Bos javanicus*	TPKP	R	38.08	-	13.08	12.66	5.26	16.97
43	TPKPSE215	*Bos javanicus*	TPKP	R	44.89	43.9	15.02	14.87	6.62	19.2
44	TPKPSE240	*Bos javanicus*	TPKP	L	40.35	41.31	15.49	15.19	6.83	19.15
45	TPKPSE48	*Bos javanicus*	TPKP	L	-	-	-	16.96	8.85	17.24e
46	TLA1014	*Bos* cf. *sauveli*	TL/A1	L	38.14	41.94	14.61	13.63	8.54	-
47	TLA1021	*Bos* cf. *sauveli*	TL/A1	L	36.13	-	13.92	13.24	7.55	-
48	TLA1292	*Bos* cf. *sauveli*	TL/A1	L	41.58	40.87	16.23	16.81	9.42	18.73
49	TLA1732	*Bos* cf. *sauveli*	TL/A2	R	34.71	35.05	12.15	12.13	8.51	16.19
51	TLA1109	*Bubalus arnee*	TL/A2	L		-	17.31	17.13		18.64
52	TLA1148b	*Bubalus arnee*	TL/A2	R	-	-	-	-	-	-
53	TLA2050	*Bubalus arnee*	TL/A2	R	-	-	-	-	-	-
54	TLA2262	*Bubalus arnee*	TL/A2	L	-	-	-	16.87	8.90	-
55	TLA2266+A2267+A2265	*Bubalus arnee*	TL/A2	L	47.77	-	17.87	16.60	9.32	-
56	TPKPSE98	*Bubalus arnee*	TPKP	R	45.91	-	15.00	15.9	7.88	-

APPENDIX III

Table of Middle to Late Pleistocene Caprinae data

Table 1 Upper DP2 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/Area	Side	1	2	3	4
1	TLA2133	*Naemorhedus griseus*	TL/A1	L	9.18	-	7.11	-

Table 2 Upper DP4 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6	7
1	TPKPSW54	*Capricornis sumatraensis*	TPKP	L	17.51	14.97	12.18	11.66	11.23	10.29	13.46
2	TPKPSW14	*Naemorhedus griseus*	TPKP	L	14.42	-	-	9.21	13.16	-	-
3	TR13	*Naemorhedus griseus*	TR	R	12.62	10.04	-	-	8.76	7.65	13.58

Table 3 Upper P2 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4
1	TPKPNE119	*Capricornis sumatraensis*	TPKP	R	13.91	12.95	10.19	10.85
2	TPKPNW223	*Capricornis sumatraensis*	TPKP	L	11.82	11.06	9.71	10.14
3	TPKPSW210	*Capricornis sumatraensis*	TPKP	R	12.53	10.88	10.33	10.58
4	TPKPNE6.3	*Capricornis sumatraensis*	TPKP	L	11.80	11.61	10.33	11.65

Table 4 Upper P3 of Middle to Late Pleistocene Caprinae measurements (Cont.).

No	Col. Num.	Species	Site/Area	Side	1	2	3	4	5
1	TPKPSW217	*Capricornis Sumatraensis*	TPKP	L	13.90	12.56	12.60	12.22	14.10
2	TPKPNW151	*Capricornis sumatraensis*	TPKP	R	13.69	12.17	11.84	10.83	11.42
3	TPKPSE211	*Capricornis sumatraensis*	TPKP	L	13.29	12.07	12.77	12.44	12.37
4	TPKPSE175	*Capricornis sumatraensis*	TPKP	L	11.12	10.21	-	-	-
5	TPKP42	*Capricornis sumatraensis*	TPKP	L	10.9	10.16	14.13	13.32	13.61
6	TPKPSW148.1	*Capricornis sumatraensis*	TPKP	L	10.27	9.61	13.12	11.61	13.19
7	TPKPNE135	*Capricornis milneedwardsii*	TPKP	L	14.10	13.07	12.35	-	13.99
8	TLA1994a	*Naemorhedus griseus*	TL/A1	L	8.99	-	9.97	9.12	10.12
9	TPKPSE 222	*Naemorhedus griseus*	TPKP	L	10.05	9.31	9.87	-	8.54
10	TPKPSE93	*Naemorhedus griseus*	TPKP	R	10.44	9.53	9.23	-	8.21

Table 5 Upper P4 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/Area	Side	1	2	3	4	5
1	TPKPSE144	*Capricornis sumatraensis*	TPKP	L	13.72	12.13	11.89	11.09	13.23
2	TPKPSE159	*Capricornis sumatraensis*	TPKP	L	11.28	10.03	14.58	13.49	14.94
3	TPKPSW134	*Capricornis sumatraensis*	TPKP	L	13.02	11.39	12.36	10.72	11.18
4	TPKPNE249	*Capricornis milneedwardsii*	TPKP	R	14.60	13.57	13.28	10.87	15.64
5	TLA531	*Naemorhedus griseus*	TL/A1	R	9.84	7.75	8.28	9.01	8.47
6	TLA3706	*Naemorhedus griseus*	TL/A1	L	9.83	-	8.96	-	8.19
7	TLA6270	*Naemorhedus griseus*	TL/A1	L	9.36	7.48	8.98	7.53	9.80
8	TLA7431	*Naemorhedus griseus*	TL/A1	L	8.60	7.51	9.07	8.33	9.78
9	TLA1994b	*Naemorhedus griseus*	TL/A1	R	9.89	-	11.05	9.54	-
10	TLA1121	*Naemorhedus griseus*	TL/A1	L	-	8.83	-	-	-

Table 6 Upper M1 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6	7
1	TL A3452	*Capricornis sumatraensis*	TL /A1	R	17.09	14.16	11.06	9.20	10.37	9.34	14.92
2	TL A3961	*Capricornis sumatraensis*	TL/A1	L	-	-	-	-	9.12	-	-
3	TL A205	*Capricornis sumatraensis*	TL/A2	L	16.04	13.52	10.29	8.53	9.26	8.04	12.79
4	TPKP NE113	*Capricornis sumatraensis*	TPKP	L	-	-	-	-	-	-	-
5	TPKP NE269	*Capricornis sumatraensis*	TPKP	L	17.28	15.75	14.24	13.23	13.91	13.43	16.15
6	TPKP NE277	*Capricornis sumatraensis*	TPKP	R	17.49	15.12	14.19	14	13.14	12.68	18.22
7	TPKP NW3	*Capricornis sumatraensis*	TPKP	L	16.98	16.15	13.2	13.06	13.06	12.02	17.61
8	TPKP SW48	*Capricornis sumatraensis*	TPKP	R	16.15	16.38	-	-	13.75	13.06	16.43
9	TPKP SW53	*Capricornis sumatraensis*	TPKP	L	18.78	16.11	12.27	12.02	11.39	10.84	17.16
10	TR4	*Capricornis sumatraensis*	TR	L	14.25	11.24	9.47	8.19	7.98	6.87	11.5

Table 6 Upper M1 of Middle to Late Pleistocene Caprinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6	7
11	TR8	*Capricornis sumatraensis*	TR	R	14.00	13.25	11.46	11.95	9.82	8.97	13.09
12	TL A119	*Naemorhedus griseus*	TL/ A2	L	-	-	-	-	6.64	8.50	-
13	TL A1013	*Naemorhedus griseus*	TL/ A1	R	13.49	11.00	9.86	8.71	8.95	7.64	9.25
14	TL A1855	*Naemorhedus griseus*	TL/ A1	L	12.43	9.33	9.76	9.13	9.39	8.57	11.20
15	TL A1996	*Naemorhedus griseus*	TL/ A1	R	13.60	11.66	12.30	12.12	10.31	9.84	13.66
16	TL A2001	*Naemorhedus griseus*	TL/ A1	R	13.11	11.31	7.38	7.58	7.80	-	-
17	TLA3441	*Naemorhedus griseus*	TL/ A1	L	12.24	9.73	10.53	10.29	9.71	9.01	12.93
18	TLA4792	*Naemorhedus griseus*	TL/ A1	R	12.80	10.30	9.72	9.11	8.65	8.72	12.13
19	TL A6144	*Naemorhedus griseus*	TL/ A1	R	12.87	11.63	12.01	11.76	10.62	10.32	13.23
20	TL A7376	*Naemorhedus griseus*	TL/ A1	L	14.21	12.79	11.40	10.64	10.84	9.35	12.81
21	TL A1091	*Naemorhedus griseus*	TL/ A2	L	13.65	12.23	12.25	11.44	10.77	9.66	12.82
22	TL A1097	*Naemorhedus griseus*	TL/ A2	L	14.51	-	9.81	8.77	-	12.78	-
23	TL A12	*Naemorhedus griseus*	TL/ A2	R	10.32	-	10.00	9.92	8.95	-	-
24	TL A120	*Naemorhedus griseus*	TL/ A2	L	-	-	-	-	-	-	-
25	TL A40	*Naemorhedus griseus*	TL/ A2	L	-	-	-	-	-	-	-
26	TL A1958	*Naemorhedus griseus*	TL/ A2	L	12.28	9.58	10.51	10.41	9.35	-	14.40
27	TL A23	*Naemorhedus griseus*	TL/ A2	L	13.06	11.10	10.28	9.64	8.57	9.62	-
28	TL A2370	*Naemorhedus griseus*	TL/ A2	R	12.24	9.71	9.58	9.25	8.74	11.25	-
29	TL A45	*Naemorhedus griseus*	TL/ A2	R	13.49	11.94	-	-	9.21	8.65	-
30	TL A576	*Naemorhedus griseus*	TL/ A2	R	12.68	12.03	-	-	-	-	-
31	TL A673	*Naemorhedus griseus*	TL/ A2	R	12.36	11.04	10.89	10.04	-	-	12.13

Table 6 Upper M1 of Middle to Late Pleistocene Caprinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6	7
32	TL A697	*Naemorhedus griseus*	TL/ A2	L	14.74	10.61	8.49	8.54	8.00	6.74	11.29
33	TL A834	*Naemorhedus griseus*	TL/ A2	L	14.25	11.24	9.47	8.19	7.98	6.87	11.50
34	TR16	*Naemorhedus griseus*	TR	R	14.58	14.31	15.55	15.28	14.77	14.71	16.14

Table 7 Upper M2 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6	7
1	TL A1410	*Capricornis sumatraensis*	TL/ A1	R	-	-	-	-	-	-	-
2	TL A3702	*Capricornis sumatraensis*	TL/ A1	R	15.17	13.01	-	-	11.49	10.63	-
3	TL A4208	*Capricornis sumatraensis*	TL/ A1	R	20.98	17.38	14.35	12.07	11.60	11.20	17.83
4	TL A6750a	*Capricornis sumatraensis*	TL/ A1	L	20.27	-	-	-	-	-	-
5	TL A7847	*Capricornis sumatraensis*	TL/ A1	L	18.89	15.69	12.84	12.02	11.56	9.92	16.18
6	TL A2231a	*Capricornis sumatraensis*	TL/ A1	R	-	-	-	-	-	-	-
7	TL A7361	*Capricornis sumatraensis*	TL/ A1	L	16.68	-	-	-	-	9.72	-
8	TPKP NE104	*Capricornis sumatraensis*	TPKP	L	20.2	19.13	-	-	-	-	-
9	TPKP NE162	*Capricornis sumatraensis*	TPKP	L	20.09	20.35	15.4	13.99	13.02	12.65	22.61
10	TPKP NE6a	*Capricornis sumatraensis*	TPKP	R	21.92	19.28	18.08	17.39	18.66	17.64	21.16
11	TPKP73	*Capricornis sumatraensis*	TPKP	L	19.02	18.07	-	-	10.98	10.57	-
12	TPKP NW196	*Capricornis sumatraensis*	TPKP	R	19.29	18.59	15.12	15.19	15.07	14.35	18.86
13	TPKP NW70	*Capricornis sumatraensis*	TPKP	R	19.00	18.07	16.28	13.54	13.67	12.75	17.66
14	TPKP SW189	*Capricornis sumatraensis*	TPKP	R	19.73	19.26	18.14	16.58	15.23	14.5	22.56
15	TPKP SW19	*Capricornis sumatraensis*	TPKP	R	20.61	19.62	15.46	13.94	13.03	12.1	19.61
16	TPKP SW149	*Capricornis sumatraensis*	TPKP	L	18.2	18.91	17.74	16.41	16.07	14.59	17.9
17	TPKP SE230	*Capricornis sumatraensis*	TPKP	R	20.3	18.7	-	-	13.18	11.94	17.04

Table 7 Upper M2 of Middle to Late Pleistocene Caprinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6	7
18	TR6	*Capricornis sumatraensis*	TR	R	17.93	16.9	16.22	15.74	-	-	16.2
19	TPKP NE305	*Capricornis milneedwardsii*	TPKP	R	20.53	21.37	16.32	14.18	13.68	11.32	18.49
20	TPKP NW115	*Capricornis milneedwardsii*	TPKP	L	20.24	20.89	16.27	15.39	14.09	13.79	19.52
21	TPKP NW118	*Capricornis milneedwardsii*	TPKP	R	20.47	19.52	-	-	15.07	14.06	-
22	TL A1742	*Naemorhedus griseus*	TL/ A1	R	15.64	14.38	10.24	9.27	8.56	8.22	12.70
23	TL A1995	*Naemorhedus griseus*	TL/ A1	R	14.78	14.67	12.27	11.31	10.35	9.54	14.37
24	TL A3616	*Naemorhedus griseus*	TL/ A1	L	14.51	-	8.25	7.44	8.75	8.61	-
25	TL A4543	*Naemorhedus griseus*	TL/ A1	R	14.30	13.00	10.98	10.92	9.41	9.50	14.64
26	TL A6940	*Naemorhedus griseus*	TL/ A1	L	11.21	9.61	10.73	10.04	10.80	10.74	11.03
27	TL A7362	*Naemorhedus griseus*	TL/ A1	R	13.90	13.66	12.46	11.99	11.93	10.39	13.22
28	TL A7377	*Naemorhedus griseus*	TL/ A1	L	15.68	13.65	10.85	9.70	9.55	8.27	13.25
29	TL A7637	*Naemorhedus griseus*	TL/ A1	L	-	-	11.01	9.33	-	-	-
30	TL A7719	*Naemorhedus griseus*	TL/ A1	R	13.66	10.81	8.77	7.89	7.76	7.14	10.76
31	TL A7846	*Naemorhedus griseus*	TL/ A1	R	-	-	-	-	-	-	-
32	TL A13a	*Naemorhedus griseus*	TL/ A2	R	14.64	-	-	-	9.69	8.47	-
33	TLA1932	*Naemorhedus griseus*	TL/ A2	L	15.50	13.82	10.90	10.09	15.67	-	-
34	TL A2017	*Naemorhedus griseus*	TL/ A2	R	-	-	-	-	10.69	-	15.51
35	TL A2083	*Naemorhedus griseus*	TL/ A2	R	15.87	13.38	-	10.44	-	-	-
36	TL A44	*Naemorhedus griseus*	TL/ A2	R	15.12	12.86	-	-	8.64	8.75	-
37	TL A739	*Naemorhedus griseus*	TL/ A1	R	14.3	13.46	11.82	9.97	10.48	9.79	13.13
38	TLA1959 +1956	*Naemorhedus griseus*	TL/ A2	L	15.39	14.28	-	-	10.01	9.14	12.62

Table 7 Upper M2 of Middle to Late Pleistocene Caprinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6	7
39	TL A1643	*Naemorhedus griseus*	TL/A2	L	15.19	12.87	11.70	10.86	10.63	9.37	13.76
40	TL A1933	*Naemorhedus* cf. *goral*	TL/A1	L	14.57	13.09	9.88	9.30	8.60	7.44	13.35
41	TL A7375	*Naemorhedus* cf. *goral*	TL/ A1	L	14.12	10.93	10.34	9.74	7.78	8.10	11.27
42	TL A1174	*Naemorhedus* cf. *goral*	TL/ A2	R	-	-	-	-	10.63	9.83	12.94
43	TL A1745	*Naemorhedus* cf. *goral*	TL/ A2	L	13.50	12.50	10.30	8.70	9.00	7.40	12.30
44	TL A142	*Naemorhedus* cf. *goral*	TL/ A2	R	13.87	13.60	9.09	-	7.76	-	11.06

Table 8 Upper M3 of Middle to Late Pleistocene Caprinae measurement.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6	7	8	9	10	11	12
1	TLA472	*Capricornis sumatraensis*	TL/A1	R	22.44	22.77	16.79	16.27	12.67	11.26	16.34	14.04	7.52	7.86	20.57	20.12
2	TLA6750b	*Capricornis sumatraensis*	TL/A1	L	20.29	21.44	13.83	12.38	11.71	10.54	15.72	12.94	6.42	8.06	19.24	20.62
3	TLA7483	*Capricornis sumatraensis*	TL/A1	L	24.47	23.72	15.47	16.24	14.48	13.80	17.05	-	-	-	-	-
4	TLA2231b	*Capricornis sumatraensis*	TL/A1	R	-	-	-	-	-	-	-	-	-	-	-	-
5	TPKPNW123	*Capricornis sumatraensis*	TPKP	R	21.63	21.06	14.23	13.38	15.57	13.27	12.29	13.79	6.99	8.19	19.47	19.14
6	TPKPNW211	*Capricornis sumatraensis*	TPKP	R	20.20	21.00	13.30	12.17	16.19	11.71	10.81	15.36	6.81	6.69	19.38	19.33
7	TPKPSW106	*Capricornis sumatraensis*	TPKP	R	22.93	21.28	18.50	17.76	15.58	15.11	16.86	15.37	7.08	8.16	19.80	18.97
8	TPKPNE192	*Capricornis sumatraensis*	TPKP	R	19.52	20.45	11.11	11.00	10.84	9.51	15.27	15.66	6.97	7.28	19.14	18.03
9	TPKPNE294	*Capricornis sumatraensis*	TPKP	L	21.63	21.84	13.86	12.65	11.82	11.58	15.42	14.27	6.62	7.75	19.39	18.14
10	TPKPNE278	*Capricornis milneedwardsii*	TPKP	L	22.64	22.52	12.99	11.33	12.58	10.74	18.85	16.03	6.96	6.55	21.79	20.76
11	TPKPSW191	*Capricornis milneedwardsii*	TPKP	R	21.05	24.69	14.96	14.48	12.31	11.15	16.88	20.28	6.82	7.19	20.31	22.65
12	TPKPSW52.2	*Capricornis milneedwardsii*	TPKP	R	22.01	25.60	-	14.33	-	11.43	17.64	15.44	6.71	7.89	19.60	18.90
13	TR5	*Capricornis sumatraensis*	TR	L	21.25	19.63	15.75	16	16.91	13.51	13.29	15.62	7.87	7.18	20.54	20.23
14	TLA1181	*Naemorhedus griseus*	TL/A1	R	13.81	14.86	9.63	9.16	7.40	7.42	10.83	9.22	4.39	4.32	13.48	13.51
15	TLA1367	*Naemorhedus griseus*	TL/A1	L	14.33	16.16	9.87	8.83	8.05	7.18	12.31	9.39	4.93	5.09	14.61	14.56
16	TLA1421	*Naemorhedus griseus*	TL/A1	R	14.61	14.91	8.77	6.95	6.49	6.18	10.51	9.18	5.10	5.03	14.16	14.49
17	TLA1741	*Naemorhedus griseus*	TL/A1	R	15.21	17.79	8.63	8.63	7.05	6.56	12.06	11.32	5.73	5.56	14.36	15.65
18	TLA1753	*Naemorhedus griseus*	TL/A1	R	15.39	15.02	8.81	8.83	8.52	7.20	12.09	9.44	4.18	3.19	13.92	14.25
19	TLA1812	*Naemorhedus griseus*	TL/A2	L	14.34	14.33	9.49	8.45	10.80	7.90	6.32	8.92	5.35	5.44	13.47	13.03
20	TLA2006	*Naemorhedus griseus*	TL/A1	R	14.75	15.88	10.48	9.52	7.40	6.25	-	-	-	-	14.32	15.38
21	TLA2208	*Naemorhedus griseus*	TL/A1	L	13.53	16.06	9.91	9.95	8.29	7.49	8.59	11.84	4.86	5.02	13.37	13.49

Table 8 Upper M3 of Middle to Late Pleistocene Caprinae measurement (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6	7	8	9	10	11	12
22	TLA2209	*Naemorhedus griseus*	TL/A1	L	13.81	16.12	9.65	9.17	9.42	7.95	11.19	8.85	5.63	-	14.10	15.24
23	TLA3661	*Naemorhedus griseus*	TL/A1	R	15.95	14.63	10.05	-	-	-	-	-	4.53	6.12	-	-
24	TLA6267	*Naemorhedus griseus*	TL/A1	R	16.48	14.28	10.05	9.69	8.32	7.59	12.07	-	4.68	7.03	14.43	-
25	TLA6713	*Naemorhedus griseus*	TL/A1	L	14.60	17.55	9.37	8.43	7.98	6.72	12.23	10.23	5.54	5.95	13.15	14.83
26	TLA6939	*Naemorhedus griseus*	TL/A1	L	15.54	14.64	10.36	9.42	10.71	10.18	10.23	11.32	4.54	4.89	13.93	12.47
27	TLA7465	*Naemorhedus griseus*	TL/A1	L	15.79	16.38	9.51	9.06	8.62	7.42	-	-	5.13	5.38	15.06	-
28	TLA7480	*Naemorhedus griseus*	TL/A1	R	14.70	15.40	8.98	8.51	8.00	6.86	11.99	9.42	5.60	4.16	13.51	13.67
29	TLA7708	*Naemorhedus griseus*	TL/A1	R	16.57	14.45	12.00	11.33	9.13	8.99	12.30	9.47	5.85	6.11	15.32	14.78
30	TLA7743	*Naemorhedus griseus*	TL/A1	R	15.51	15.18	10.91	9.91	8.68	8.42	11.06	9.93	4.91	6.38	13.61	12.92
31	TLA13b	*Naemorhedus griseus*	TL/A2	R	14.55	-	9.76	8.57	6.78	7.82	-	-	5.24	6.58	14.34	-
32	TLA2127	*Naemorhedus griseus*	TL/A2	L	14.79	15.62	7.89	7.05	8.72	8.82	10.69	9.11	5.65	5.68	13.80	13.82
33	TLA2359	*Naemorhedus griseus*	TL/A2	L	15.15	17.26	9.53	8.50	12.29	8.46	6.68	12.30	5.82	5.26	13.85	15.01
34	TLA738	*Naemorhedus griseus*	TL/A2	L	15.87	13.94	8.89	8.36	9.80	7.97	6.64	9.44	5.17	5.24	13.94	13.80
35	TLA2376	*Naemorhedus griseus*	TL/A2	R	15.15	15.35	10.47	9.06	9.09	10.04	8.03	11.37	6.02	5.75	14.22	13.25
36	TLA829	*Naemorhedus griseus*	TL/A2	R	13.84	15.62	9.60	6.25	11.69	8.75	5.69	9.71	5.27	5.70	13.10	14.14
37	TPKPSE72	*Naemorhedus griseus*	TPKP	R	17.26	15.82	12.14	12.14	12.20	10.59	9.49	10.43	3.93	6.99	15.88	16.27
38	TPKP45	*Naemorhedus griseus*	TPKP	L	14.92	16.84	10.72	9.27	9.26	7.61	9.30	13.24	4.73	4.66	14.08	14.91
39	TR17	*Naemorhedus griseus*	TR	L	16.45	15.87	-	-	-	-	-	-	5.33	5.95	14.78	-
40	TPKPSW54	*Naemorhedus* cf. *goral*	TPKP	R	15.75	17.49	10.15	8.76	11.85	8.20	7.33	10.09	5.09	5.11	14.22	16.44
41	TLA1921	*Naemorhedus* cf. *goral*	TL/A1	L	13.10	18.14	8.92	7.55	7.10	6.40	13.21	9.91	5.12	5.43	13.62	16.13
42	TLA143	*Naemorhedus* cf. *goral*	TL/A2	R	14.53	16.13	-	-	-	-	-	-	5.34	5.63	13.18	14.36

Table 9 Lower dp4 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6
1	TPKPNE5	*Capricornis milneedwardsii*	TPKP	L	22.26	20.99	6.63	8.92	9.10	10.62
2	TPKPSE16	*Capricornis sumatraensis*	TPKP	R	21.91	19.16	6.76	9.24	9.42	9.74
3	TPKPNE257	*Capricornis sumatraensis*	TPKP	L	19.91	16.75	7.01	8.58	9.54	10.05
4	TR	*Naemorhedus griseus*	TR	L	14.93	12.88	7.07	6.99	5.88	-

Table 10 Lower p2 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TPKP SW66	*Capricornis milneedwardsii*	TPKP	R	11.45	9.80	6.64	6.00	2.78

Table 11 Lower p3 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TPKPSE87	*Capricornis sumatraensis*	TPKP	L	13.66	13.38	8.12	8.15	3.82
2	TPKPNE202	*Capricornis sumatraensis*	TPKP	L	11.91	11.26	8.77	8.18	-
3	TPKPSW203	*Capricornis sumatraensis*	TPKP	R	13.78	13.47	9.11	9.13	2.43
4	TPKPNE123	*Capricornis milneedwardsii*	TPKP	L	14.79	14.51	10.02	9.10	-
5	TPKPSE9	*Naemorhedus* cf. *goral*	TPKP	L	9.50	8.33	-	5.52	3.53
7	TLA2132a	*Naemorhedus* cf. *goral*	TL/A1	R	9.76	9.61	6.27	6.41	3.41
8	TLA7786	*Naemorhedus* cf. *goral*	TL/A1	R	9.35	8.93	6.23	5.54	-
9	TLA1102a	*Naemorhedus griseus*	TL/A1	L	9.66	9.92	6.44	6.50	3.06
10	TLA1615a	*Naemorhedus griseus*	TL/A1	L	-	-	-	-	-
11	TLA2373	*Naemorhedus griseus*	TL/A1	L	9.42	-	6.16	-	3.93
12	TLA6910	*Naemorhedus griseus*	TL/A1	R	9.14	8.25	6.03	5.71	3.70
13	TLA7671a	*Naemorhedus griseus*	TL/A1	L	-	8.30	-	8.24	-
14	TR18	*Naemorhedus griseus*	TR	R	8.41	7.12	5.14	4.73	2.64

Table 12 Lower p4 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TLA530	*Capricornis sumatraensis*	TL/A1	R	15.69	15.80	8.70	8.99	10.27
2	TLA1364	*Capricornis sumatraensis*	TL/A1	R	16.88	14.38	9.70	9.06	9.60
3	TLA2363	*Capricornis sumatraensis*	TL/A2	L	17.77	16.64	8.84	7.86	8.41
4	TPKPNW121	*Capricornis sumatraensis*	TPKP	R	13.57	12.73	9.04	8.61	8.66
5	TPKPNW95	*Capricornis sumatraensis*	TPKP	L	16.46	15.65	9.75	7.16	9.16
6	TPKPNE169	*Capricornis sumatraensis*	TPKP	L	16.32	15.94	9.49	8.94	9.67
7	TPKPNW22	*Capricornis sumatraensis*	TPKP	R	15.35	15.29	9.41	8.17	8.93
8	TPKPSE89	*Capricornis sumatraensis*	TPKP	L	14.98	14.9	10.80	8.95	10.59
9	TPKPSE177	*Capricornis sumatraensis*	TPKP	R	16.92	16.03	9.00	7.82	9.44
10	TPKPNE184	*Capricornis sumatraensis*	TPKP	L	-	-	-	7.43	8.65
11	TPKPNW72	*Capricornis milneedwardsii*	TPKP	L	16.04	15.32	9.5	7.56	9.58
12	TPKPNE154	*Capricornis milneedwardsii*	TPKP	L	16.77	16.85	9.6	8.52	9.21
13	TLA2132b	*Naemorhedus* cf. *goral*	TL/A1	R	11.43	-	6.62	6.26	-
14	TLA1102b	*Naemorhedus griseus*	TL/A1	L	11.48	10.63	6.78	6.96	-
15	TLA1455	*Naemorhedus griseus*	TL/A1	R	11.88	10.06	6.39	5.95	5.55
16	TLA1615b	*Naemorhedus griseus*	TL/A1	L	9.97	-	6.92	5.83	5.60
17	TLA3427	*Naemorhedus griseus*	TL/A1	L	11.48	10.25	6.00	5.94	6.14
18	TLA7359	*Naemorhedus griseus*	TL/A1	R	11.85	9.16	6.65	5.87	6.10
19	TLA7671b	*Naemorhedus griseus*	TL/A1	L	10.33	-	-	-	-

Table 13 Lower m1 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TLA1752	*Capricornis sumatraensis*	TL/A1	L	-	-	-	11.11	-
2	TLA7195	*Capricornis sumatraensis*	TL/A1	R	-	-	-	-	-
3	TLA7663	*Capricornis sumatraensis*	TL/A1	L	15.42	12.63	10.66	9.44	10.25
4	TPKPNE80	*Capricornis sumatraensis*	TPKP	L	14.07	13.90	10.29	10.96	11.45
5	TPKPNE93	*Capricornis sumatraensis*	TPKP	R	18.31	15.12	9.28	9.48	11.08
6	TPKP34	*Capricornis sumatraensis*	TPKP	L	16.64	14.84	9.20	8.75	11.16
7	TPKPSW170	*Capricornis sumatraensis*	TPKP	R	18.75	15.71	10.43	9.86	11.43
8	TPKPSW211	*Capricornis sumatraensis*	TPKP	R	17.75	16.61	9.79	9.70	11.16
9	TPKPSW28	*Capricornis sumatraensis*	TPKP	R	18.71	16.5	8.94	8.46	10.11
10	TPKPSE176	*Capricornis sumatraensis*	TPKP	R	16.76	-	-	-	-
11	TPKPSW214	*Capricornis sumatraensis*	TPKP	L	13.13	13.83	11.27	11.31	11.1
12	TPKPNE297.1	*Capricornis sumatraensis*	TPKP	R	14.31	12.47	10.73	10.00	11.41
13	TPKP36	*Capricornis sumatraensis*	TPKP	R	15.14	14.09	10.11	12.10	11.45
14	TLA791	*Naemorhedus* cf. *goral*	TL/A1	R	13.45	11.46	7.19	7.41	7.84
15	TLA263a	*Naemorhedus griseus*	TL/A1	L	12.42	-	6.59	7.24	-
16	TLA1102c	*Naemorhedus griseus*	TL/A1	L	13.10	12.13	7.94	8.55	3.41
17	TLA1456	*Naemorhedus griseus*	TL/A1	R	13.29	11.02	7.91	7.84	8.02
18	TLA1542	*Naemorhedus griseus*	TL/A1	R	10.72	-	7.76	7.70	-
19	TLA1805	*Naemorhedus griseus*	TL/A1	R	14.13	13.02	8.67	8.41	8.82
20	TLA3453	*Naemorhedus griseus*	TL/A1	R	13.41	12.74	7.99	7.66	-
21	TLA5148	*Naemorhedus griseus*	TL/A1	L	13.64	-	7.78	-	-
22	TLA5164	*Naemorhedus griseus*	TL/A1	R	13.05	10.22	7.28	7.40	7.26
23	TLA5194	*Naemorhedus griseus*	TL/A1	R	12.75	11.04	8.21	8.35	7.95
24	TLA7373	*Naemorhedus griseus*	TL/A1	R	13.61	12.36	7.93	8.34	8.53
25	TLA7670	*Naemorhedus griseus*	TL/A1	L	11.99	9.93	-	7.82	7.21
26	TLA1184	*Naemorhedus griseus*	TL/A2	L	12.45	11.01	7.52	7.50	7.28
27	TLA145	*Naemorhedus griseus*	TL/A2	L	12.56	7.21	7.14	-	-
28	TLA43	*Naemorhedus griseus*	TL/A2	L	12.24	10.58	7.11	7.33	7.30
29	TLA741	*Naemorhedus griseus*	TL/A2	L	12.88	10.52	6.52	6.50	7.29
30	TR9	*Naemorhedus griseus*	TR	R	13.59	10.97	7.57	7.15	7.77
31	TR15	*Naemorhedus griseus*	TR	R	-	-	7.34	7.2	7.29

Table 14 Lower m2 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
1	TLA507a	*Capricornis sumatraensis*	TL/A1	L	17.23	16.91	11.14	11.37	-
2	TLA980	*Capricornis sumatraensis*	TL/A1	L	17.74	-	10.62	10.34	-
3	TLA1015a	*Capricornis sumatraensis*	TL/A1	L	17.25	-	9.57	10.67	-
4	TLA1169	*Capricornis sumatraensis*	TL/A1	R	21.02	17.79	10.65	-	-
5	TLA1431	*Capricornis sumatraensis*	TL/A1	R	20.80	-	12.05	12.88	-
6	TLA2207	*Capricornis sumatraensis*	TL/A1	L	17.95	-	10.29	10.23	-
7	TLA7371	*Capricornis sumatraensis*	TL/A1	L	19.10	16.60	10.05	10.01	12.15
8	TLA7464	*Capricornis sumatraensis*	TL/A1	L	17.98	15.81	-	-	11.54
9	TLA1353	*Capricornis sumatraensis*	TL/A2	L	19.18	16.88	11.10	-	12.09
10	TLA144	*Capricornis sumatraensis*	TL/A2	R	19.67	18.23	11.10	11.45	12.34
11	TLA2085	*Capricornis sumatraensis*	TL/A2	R	18.59	16.91	10.78	10.60	13.45
12	TLA12	*Capricornis sumatraensis*	TL/A2	L	-	-	10.40	-	-
13	TPKPNE188	*Capricornis sumatraensis*	TPKP	L	19.56	18.96	-	11.24	12.96
14	TPKPNE275	*Capricornis sumatraensis*	TPKP	R	19.21	17.31	11.26	10.55	12.58
15	TPKPNE301	*Capricornis sumatraensis*	TPKP	R	-	-	-	13.11	12.63
16	TPKP50	*Capricornis sumatraensis*	TPKP	L	18.27	17.12	9.76	9.80	13.10
17	TPKP53	*Capricornis sumatraensis*	TPKP	R	18.31	17.38	11.59	10.96	11.07
18	TPKPSW173	*Capricornis sumatraensis*	TPKP	L	19.54	19.85	10.31	9.43	16.61
19	TPKPSE221	*Capricornis sumatraensis*	TPKP	L	17.59	17.72	10.74	10.59	11.81
20	TPKPSE81	*Capricornis sumatraensis*	TPKP	L	19.35	17.33	-	11.79	12.41
21	TPKPSE148	*Capricornis sumatraensis*	TPKP	L	19.17	18.21	11.80	11.60	13.06
22	TPKPNW168	*Capricornis sumatraensis*	TPKP	L	17.51	17.14	12.44	12.28	12.54
23	TPKPNE14	*Capricornis sumatraensis*	TPKP	R	18.74	18.13	10.22	10.04	11.52
24	TPKP59	*Capricornis sumatraensis*	TPKP	L	15.29	13.56	8.88	8.06	9.26
25	TPKPNE66	*Capricornis milneedwardsii*	TPKP	L	20.42	18.64	11.08	11.09	13.82
26	TLA258	*Naemorhedus griseus*	TL/A1	L	13.86	11.85	7.47	7.29	7.39
27	TLA263b	*Naemorhedus griseus*	TL/A1	L	14.15	-	6.84	6.85	-
28	TLA1213	*Naemorhedus griseus*	TL/A1	R	14.73	13.96	8.22	8.22	8.76
29	TLA1417	*Naemorhedus griseus*	TL/A1	R	13.56	12.16	8.53	8.25	9.00
30	TLA1654	*Naemorhedus griseus*	TL/A1	L	15.25	10.87	6.86	6.56	8.11
31	TLA1744	*Naemorhedus griseus*	TL/A1	R	14.88	14.49	8.76	8.33	10.67
32	TLA1807	*Naemorhedus griseus*	TL/A1	L	15.56	12.05	6.90	6.54	-
33	TLA1920	*Naemorhedus griseus*	TL/A1	L	14.13	11.90	6.81	7.19	7.99

Table 14 Lower m2 of Middle to Late Pleistocene Caprinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5
34	TLA3054	*Naemorhedus griseus*	TL/A1	L	15.87	13.66	7.80	7.56	8.96
35	TLA4544	*Naemorhedus griseus*	TL/A1	R	13.40	-	6.87	-	-
36	TLA4791	*Naemorhedus griseus*	TL/A1	R	13.45	12.41	7.82	7.44	8.44
37	TLA5154	*Naemorhedus griseus*	TL/A1	L	13.77	11.50	8.21	7.86	7.72
38	TLA5411	*Naemorhedus griseus*	TL/A1	L	15.19	13.67	6.94	6.27	8.24
39	TLA6783	*Naemorhedus griseus*	TL/A1	R	15.15	13.00	7.75	7.36	8.20
40	TLA7360	*Naemorhedus griseus*	TL/A1	L	14.45	13.29	8.04	8.07	8.91
41	TLA1175	*Naemorhedus griseus*	TL/A2	L	13.88	11.43	7.46	7.28	8.07
42	TLA1178	*Naemorhedus griseus*	TL/A2	R	16.43	-	7.27	6.78	-
43	TLA1185	*Naemorhedus griseus*	TL/A2	L	13.85	11.43	7.45	7.17	7.92
44	TLA1948	*Naemorhedus griseus*	TL/A2	L	-	12.40	7.83	-	7.80
45	TLA2084	*Naemorhedus griseus*	TL/A2	L	14.77	13.56	8.28	7.63	8.10
46	TLA2175	*Naemorhedus griseus*	TL/A2	L	13.01	10.73	7.57	7.50	7.52
47	TLA2176	*Naemorhedus griseus*	TL/A2	L	13.97	12.70	8.14	8.41	8.91
48	TLA577	*Naemorhedus griseus*	TL/A2	R	14.08	11.48	6.28	6.13	7.16
49	TLA140	*Naemorhedus griseus*	TL/A2	R	14.67	7.96	7.55	7.67	7.99
50	TLA521	*Naemorhedus* cf. *goral*	TL/A1	R	14.28	14.03	7.57	7.26	8.25
51	TLA7154	*Naemorhedus* cf. *goral*	TL/A1	L	16.38	13.23	6.96	7.25	8.15
52	TR10	*Naemorhedus griseus*	TR	R	13.02	10.53	8.01	7.66	7.62
53	TR262	*Naemorhedus griseus*	TR	R	13.95	13.50	8.14	8.05	7.96

Table 15 Lower m3 of Middle to Late Pleistocene Caprinae measurements.

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6
1	TLA507b	*Capricornis sumatraensis*	TL/A1	L	28.47	28.92	11.11	11.59	-	12.22
2	TLA1015b	*Capricornis sumatraensis*	TL/A1	L	24.52	-	10.29	10.17	6.15	-
3	TLA3813	*Capricornis sumatraensis*	TL/A1	L	-	-	12.13	11.70	-	-
4	TLA1983	*Capricornis sumatraensis*	TL/A1	R						
5	TPKPNE73	*Capricornis sumatraensis*	TPKP	R	-	-	-	-	5.55	-
6	TPKP49	*Capricornis sumatraensis*	TPKP	L	28.86	26.82	10.05	9.09	5.30	11.78
7	TPKPNW10	*Capricornis sumatraensis*	TPKP	L	27.9	27.81	12.23	11.61	6.87	13.53

Table 15 Lower m3 of Middle to Late Pleistocene Caprinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6
8	TPKPNW181	*Capricornis sumatraensis*	TPKP	R	25.61	27.21	10.07	9.92	5.16	11.12
9	TPKPNW56	*Capricornis sumatraensis*	TPKP	R	29.60	27.76	14.01	13.07	7.99	13.92
10	TPKPSW1	*Capricornis sumatraensis*	TPKP	R	28.20	27.70	12.84	12.20	7.28	12.40
11	TPKPSW147	*Capricornis sumatraensis*	TPKP	R	-	-	-	-	-	-
12	TPKPSW186	*Capricornis sumatraensis*	TPKP	R	-	-	-	11.03	5.95	-
13	TPKPSE29	*Capricornis sumatraensis*	TPKP	L	29.47	28.6	11.93	11.21	7.12	11.73
14	TPKPNE85	*Capricornis sumatraensis*	TPKP	R	26.71	29.15	9.77	9.67	5.70	13.55
15	TPKPSE68	*Capricornis sumatraensis*	TPKP	L	-	-	-	9.92	-	11.31
16	TLA7787	*Naemorhedus griseus*	TL/A1	L	-	-	-	6.35	3.49	-
17	TLA973	*Naemorhedus griseus*	TL/A1	R	20.51	18.19	7.05	6.41	3.71	8.32
18	TLA1019	*Naemorhedus griseus*	TL/A1	R	19.88	-	7.71	6.38	4.25	-
19	TLA1122	*Naemorhedus griseus*	TL/A1	L	-	-	-	7.72	3.70	-
20	TLA1172	*Naemorhedus griseus*	TL/A1	R	19.46	18.51	7.24	7.25	4.12	7.93
21	TLA1604	*Naemorhedus griseus*	TL/A1	L	18.50	20.60	9.86	9.53	1.70	8.00
22	TLA1655	*Naemorhedus griseus*	TL/A1	L	19.74	18.31	5.40	5.64	-	-
23	TLA2250	*Naemorhedus griseus*	TL/A1	R	19.95	19.61	8.61	7.83	5.27	8.54
24	TLA2481	*Naemorhedus griseus*	TL/A1	R	-	-	7.99	8.68	-	9.95
25	TLA2482	*Naemorhedus griseus*	TL/A1	L	-	-	-	6.68	3.53	-
26	TLA2998	*Naemorhedus griseus*	TL/A1	L	-	-	-	5.97	2.75	-
27	TLA3119	*Naemorhedus griseus*	TL/A1	R	22.36	22.65	8.20	8.03	4.51	9.97
28	TLA3440	*Naemorhedus griseus*	TL/A1	L	18.52	19.24	7.30	6.52	3.91	8.42
29	TLA3665	*Naemorhedus griseus*	TL/A1	L	19.28	18.91	8.16	8.13	4.78	9.50

Table 15 Lower m3 of Middle to Late Pleistocene Caprinae measurements (Cont.).

No	Col. Num.	Species	Site/ Area	Side	1	2	3	4	5	6
30	TLA6986	*Naemorhedus griseus*	TL/A1	L	20.16	18.22	8.13	7.77	4.48	-
31	TLA7374	*Naemorhedus griseus*	TL/A1	L	20.95	20.14	8.54	8.79	5.00	8.87
32	TLA7462 +A7463	*Naemorhedus griseus*	TL/A1	L	19.05	20.87	8.32	8.53	-	8.60
33	TLA1176	*Naemorhedus griseus*	TL/A2	L	21.62	21.43	7.94	7.53	4.59	9.04
34	TLA1289	*Naemorhedus griseus*	TL/A2	L	19.83	19.71	7.87	7.14	4.61	8.63
35	TLA131	*Naemorhedus griseus*	TL/A2	L	-	-	-	4.11	-	-
36	TLA2360	*Naemorhedus griseus*	TL/A2	R	19.07	-	7.81	7.66	3.92	8.12
37	TLA411	*Naemorhedus griseus*	TL/A2	L	18.42	16.68	6.62	6.28	3.33	7.59
38	no number	*Naemorhedus griseus*	TL/A2	L	16.25	18.56	6.44	5.45	3.25	7.85
39	TLA196	*Naemorhedus griseus*	TL/A2	L	-	-	7.77	7.13	-	-
40	TLA1931	*Naemorhedus griseus*	TL/A2	R	-	-	7.89	7.07	-	8.59
41	TLA1686	*Naemorhedus griseus*	TL/A2	R	17.21	16.59	6.95	6.30	-	7.74
42	TLA3707	*Naemorhedus* cf. *goral*	TL/A1	L	20.32	18.57	7.54	6.64	4.17	8.81
43	TLA6247	*Naemorhedus* cf. *goral*	TL/A1	L	-	-	-	7.51	4.78	-
45	TLA7788	*Naemorhedus* cf. *goral*	TL/A1	R	21.96	20.33	7.77	7.21	4.64	9.30
46	TLA783	*Naemorhedus* cf. *goral*	TL/A1	L	20.92	21.33	7.92	7.69	4.42	-
47	TPKPSW108	*Naemorhedus griseus*	TPKP	R	-	-	8.18	7.44	-	8.08
48	TPKPSW112	*Naemorhedus griseus*	TPKP	L	19.11	20.25	7.6	7.21	4.16	8.28
49	TR12	*Naemorhedus griseus*	TR	L	-	-	7.25	6.43	-	6.46
50	TR14	*Naemorhedus griseus*	TR	R	19.62	19.14	8.74	7.66	4.42	7.99
51	TR91	*Naemorhedus griseus*	TR	R	-	-	-	-	-	-

BIOGRAPHY

Biography

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