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การระบุชนิดทางอนุกรมวิธานของสัตว์กีบที่มีฟันแบบ บูโนเซเลโนดอนต์และแบบโลโฟดอนต์ ที่ค้นพบจากบ่อทรายโคราช

โดย

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โครงการนี้เป็นส่วนหนึ่งของการศึกษาระดับปริญญาตรี

ภาควิชาธรณีวิทยา คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ปีการศึกษา 2560

TAXONOMIC IDENTIFICATION BUNOSELENODONT AND LOPHODONT UNGULATED FROM THE KHORAT SAND PITS

Mr. Tanaprasert Techawong

A Project Submitted in Partial Fulfillment of the Requirements
for the Degree of Bachelor of Science Program in Geology
Department of Geology, Faculty of Science, Chulalongkorn
University Academic Year 2017

การระบุชนิดทางอนุกรมวิธานของสัตว์กีบที่มีฟันแบบบูโนเซเลโนดอนต์และแบบโลโฟดอนต์ที่ค้นพบจากบ่อทรายโคราช

นาย ธนประเสริฐ เตชะวงศ์

โครงงานนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรบัณฑิต
ภาควิชาธรณีวิทยา คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2560

Senior Project Taxonomic identification bunoselenodont and lophodont ungulates from the Khorat sand pits

By Tanaprasert Techawong

Field of study Geology

Senior Project Advisor Kantapon Suraprasit, Ph.D.

Date of Submission..

Date of approval..

....

(Kantapon Suraprasit, Ph.D.)

Senior Project Advisor

ธนประเสริฐ เตชะวงศ์ : การระบุชนิดทางอนุกรมวิธานของสัตวกีบที่มีฟันแบบ
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BUNOSELENODONT AND LOPHODONT UNGULATES FROM
THE KHORAT SAND PITS)
อ.ที่ปรึกษาโครงงานหลัก: ดร.กันตภณ สุระประสิทธิ์, 66 หน้า.

ในจังหวัดนครราชสีมา ภาคตะวันออกเฉียงเหนือของประเทศไทย ซากดึกดำบรรพ์ของสัตว์เลี้ยงลูกด้วยนมจำพวกฟันแบบบูโนเซเลโนดอนต์และโลโฟดอนต์ที่ถูกค้นพบเมื่อปีที่แล้ว (2560) ระหว่างการทำเหมืองบ่อทราย ณ อำเภอพิมายและอำเภอเฉลิมพระเกียรติใกล้กับแม่น้ำมูล โดยการศึกษานี้สามารถให้ข้อมูลเกี่ยวกับอนุกรมวิธานของซากดึกดำบรรพ์ โดยซากดึกดำบรรพ์ของสัตว์มีกระดูกสันหลังที่บ่อทรายแห่งนี้ไม่เคยถูกศึกษามาก่อน ในการวิจัยนี้มีฟันแบบบูโนเซเลโนดอนต์ของสัตว์เคี้ยวเอื้องประกอบไปด้วยฟันกรามล่างซ้าย 3 ชิ้น ฟันกรามล่างขวา 1 ชิ้น และฟันของสัตว์กีบประเภทช้าง ประกอบไปด้วย ฟันกรามน้อยบนซี่ที่ 3 และ ฟันกรามบนซี่ที่ 3 บนพื้นฐานของลักษณะสัณฐานวิทยาของตัวฟันนั้น ซากดึกดำบรรพ์ของสัตว์เลี้ยงลูกด้วยนม 3 ชนิดได้ถูกค้นพบ ได้แก่ กระจง (*Dorcabune* cf. *nagrii* และ *Dorcatherium* cf. *Minus*) และ ช้างตัวเล็ก (*Prodeinotherium* sp.) บนพื้นฐานของการเทียบเคียงเวลาโดยใช้ซากดึกดำบรรพ์ของวงศ์ที่เกี่ยวข้อง ทำให้อายุของกลุ่มสิ่งมีชีวิตเหล่านี้อยู่ในช่วงระหว่าง 14.2 -5.9 ล้านปี (สมัยไมโอซีนตอนกลางถึงสมัยไมโอซีนตอนปลาย) และ มีสภาพแวดล้อมบรรพกาลเป็นแบบป่าไม้ลักษณะพื้นที่ชื้นปานกลาง จากการศึกษาอนุกรมวิธานของซากดึกดำบรรพ์เหล่านี้มีความเป็นไปได้ว่ามีสัตว์กลุ่มนี้มีการอพยพจากประเทศปากีสถานและจีนมายังประเทศไทยในระหว่างสมัยไมโอซีน แต่อย่างไรก็ตาม การค้นพบครั้งนี้เป็นบันทึกครั้งแรกในสมัยไมโอซีนของสัตว์จำพวกกระจงและช้าง ใน ประเทศไทย

คำสำคัญ: กระจง, ช้าง, สมัยไมโอซีนตอนปลาย, โคราช, ประเทศไทย

ภาควิชา.........ธรณีวิทยา......... ลายมือชื่อนิสิต..

สาขาวิชา.........ธรณีวิทยา.........ลายมือชื่อ อ.ที่ปรึกษาหลัก..

ปีการศึกษา.........2560.........

TANAPRASERT TECHAWONG: TAXONOMIC IDENTIFICATION BUNOSELENODONT AND LOPHODONT UNGULATES FROM THE KHORAT SAND PITS.
ADVISOR KANTAPON SURAPRASIT, Ph.D., 66 pp.

In the Nakhon Ratchasima province, Northeastern part of Thailand, fossil mammals bearing bunoselenodont and lophodont teeth were found last year during the sand mining operation in Phimai and Chalermprakiat sand pit near the Mun river. These vertebrate fossils in these sand pits have never been studied before. Therefore, the study can provide information regarding the taxonomic status of fossils. In this study, the material composes of 3 left mandibles and 1 right mandible of bunoselenodont ruminants and isolated P3 and M3 of lophodont ungulates. On the basic of dental morphologies, three mammalian fossils were identified: tragulids (*Dorcabune* cf. *nagrii* and *Dorcatherium* cf. *Minus*) and a small-bodied deinotherid (*Prodeinotherium* sp.). Based on the biochronology achieved from all related taxa, the age of these fauna ranges between 14.2-5.9 Ma (Middle Miocene to Late Miocene) and the paleoenvironments corresponded to mesic/ woodlands. Our taxonomic identification of these fossils suggests Pakistanis and Chinese relatives that possibly migrated to Thailand during the Miocene. However, this discovery represents the first records of Miocene tragulids and deinotherids in Thailand.

KEYWORDS: Tragulid, Deinotherid, Late Miocene, Khorat, Thailand

Department: Geology Student's Signature..

Field of Study: Geology Advisor's Signature...

Academic Year: 2017

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It is an honor for me to work with the DMR team especially Miss Thunchanok Kawinate.This thesis would not have been possible unless all the owners and staffs at Phimai and Chalermprakiat sand pit for allowing me to work on this study.

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I am grateful to thank my colleagues for their helpful encouragement and exclusively Miss Siriwarin ninputza for their cheerful collaboration to work project along together since started the project.

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Finally, many persons who are not mentioned above are also deeply appreciated.

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CHAPTER 1 INTRODUCTION

1.1 Background and Rationale

Vertebrate fossils provide information regarding biological and geological histories for understanding the evolution of past organisms through time. In Thailand, many mammal fossils have never been studied because vertebrate fossils are rare, compared to other fossil types. This research will identify the mammalian fossils recovered from the sand pit, in the layer of unconsolidated sediments. The material used for classification is mostly teeth.

In the Northeastern part of Thailand, fossil mammals bearing bunoselenodont and lophodont teeth have been found during the sand mining operation of the Phimai and chalermprakiat sand pit, a district of Nakhon Ratchasima Province near the Mun river. This is so interesting as the vertebrate fossils in these sand pits have been collected for the first time. Therefore, the study could provide information regarding the taxonomic status of fossils, as well as paleobiogeographical records and paleoenvironments of the Phimai sand pit.

Although no research related to this sand pit has been done, there are some published researches about vertebrate fossils collected nearby from Tha Chang where a lot of fossil mammals were described (see Literature reviews). The Tha Chang sand pit is presumably attributed to the Miocene because of the faunal composition of mammals. We would therefore determine the possible age of the Phimai sand pit based on the characteristics of the mammalian assemblage.

1.2 Objectives

1.To identify bunoselenodont and lophodont mammal fossils.

2.To determine the age of the fossil fauna

3.To reconstruct the paleoenvironments of the locality

1.3 Study Area

Study areas are located at the Phimai and Chalermprakiat sand pit, a district of Nakhon Ratchasima Province, northeastern part of Thailand. The area is 270 km northeast of Bangkok and the location of the sand pit is close to the Mun river. (Fig1.1)

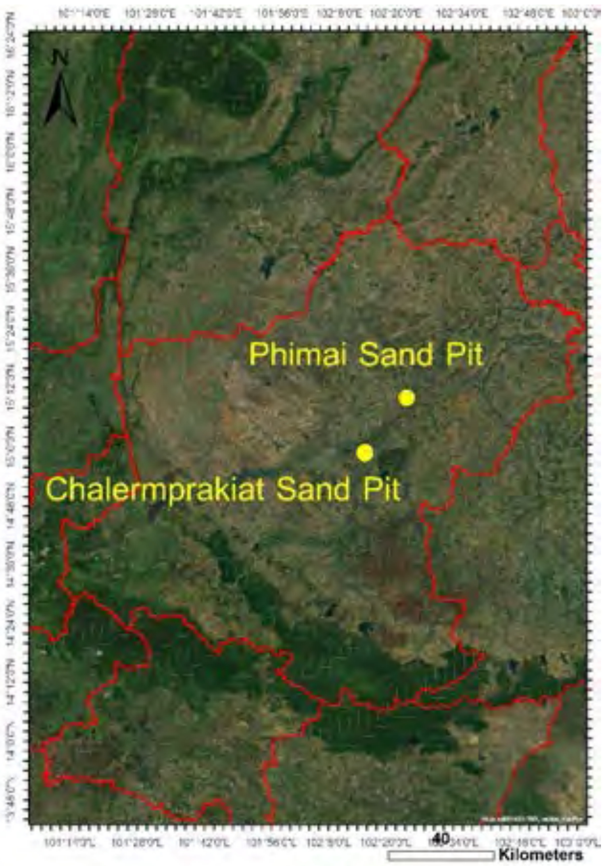

Figure 1.1 A (Left) Map of Thailand showed Nakhon Ratchasima (Red Square) B (Right) Location of Phimai and Chalermprakiat sand pit near the Mun River

1.4 Expected Results

1.Taxonomic allocation of bunoselenodont and lophodont ungulates

2.Biochronology of the fossil fauna

3.Paleoenvironments of the Phimai sand pit

4.Paleobiogeographical records

CHAPTER 2 LITERATURE REVIEWS

2.1 General Geology

The Khorat Plateau is a highland in Northeastern Thailand covering 20,000 km^2. The average elevation is about 200 meters above sea level. The khorat plateau is surrounded by the Mekong on the north and east of the Thai-Loas boundary, the Phetchabun and Phang Hoei Mountain Ranges on the west margin, and the Phanom Dong Rak Mountain Range on the south margin. The Plateau is divided by the Phu Phan Anticlinorium into 2 sub-basins; the northern Ubon-Sakhon Nakhonsub basin and the southern Khorat-Ubon sub-basin. The Khorat Plateau is a part of the Indochina plate bounded by major Tertiary strike-slip faults that contain two-fold belts; the N-S trending Loei-Phetchabun fold belt and NW-SE trending Phu Phan range in the western area (DMR, 2007)

The Khorat sand pits are located at Nakorn Ratchasima Province near the Mun river. The Stratigraphy were studied from two open sand pits in this area; Somsak sand pit, and the Siam sand pit. Both pits were mined with depth around 20-30 meters. Below the top soils is late Mesozoic or early Cenozoic age that qualified to the Phu Thok Formation. These sand pits resemble to fluviatile deposits environment with several sedimentary feature cross-bedding, and with fish, turtle and crocodile fossils. Fossil tree trunks and wood fragments have occurred in these sands. The mammalian fossils collected from this sand unit indicate a late Miocene age for the Somsak sand pit. Fossils include of hominoid primates, *Khoratpithecus piriyai* (Chaimanee et al., 2004), Hipparion, the proboscideans *Prodeinotherium* and *Deinotherium* cf. *indicum*, *Gomphotherium* sp., *Stegolophodon* sp., and a primitive *Stegodon*; the rhinocerotids *Chilotherium*, *palaeosinense*, *Brachypotherium perimense* and *Alicornops complanatum*; pigs *Hippopotamodon* cf. *sivalense* and *Propotamochoerus* cf. *hysudricus*; and the anthracotheres *Merycopotamus medioximus* and *Microbunodon milaensis*. Bovid and giraffid remains are also plentiful. These tektites are related to the extensive tektites remains field that resulted from an impact event dated at 0.8 Ma in Northeastern Thailand (Howard et al., 2003).

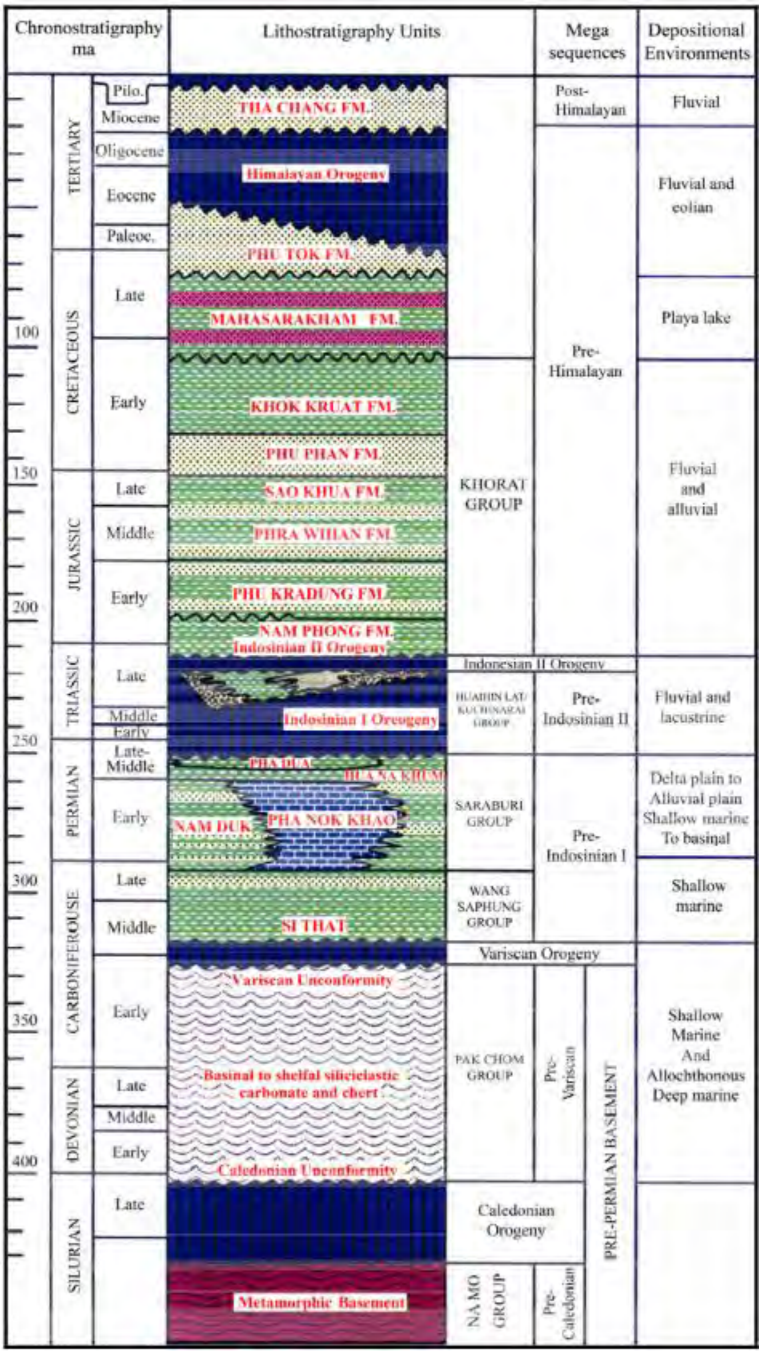

Figure 2.1 Lithostratigraphy in the northeastern region of Thailand and related to tectonic events (Sattayarak, N., 2005 and Chantong, W., 2005)

Biochronology derived from the mammalian fauna of the lower sand layer from Somsak sand pit correlation with the upper Nagri to the lower Dhok Pathan Formations of the Siwaliks. This approximate age interval between 10 to 6 Ma that the Siwalik fossil record has been precisely dated by paleomagnetic studies. The stratigraphic ranges of Siwalik fossil species, based on first and last occurrences, are exactly calibrated and Late Miocene localities in China lack marine intercalations and volcanoclastic sediments compared to biostratigraphy data from the Siwaliks. Therefore, we can determine a more accurate time interval for the lower Somsak sand unit (Chaimenee et al., 2006).

2.2 Tha Chang Sand Pits

The Tha Chang sand pits are located at the latitude of 14°55' to 15°05'North and the longitude of 102°15' to 102°20' East, Nakhonratchasima Province. The fossils are found in the layers of unconsolidated mudstones, sandstones and conglomerates (Chaimanee et al., 2004; Hanta et al., 2008). A private enterprise has opened an area of 80 to 160 square kilometers, mining with the depths of 20 to 40 meters.

A: Geological Background and Chronology

These sand pits are situated near the Mun river and are characterized by fluviatile depositional environments. The stratigraphic sequences are made up by alternated layers of very fine to very coarse sand, clay, silts, and gravels with frequent big tree trunks, logs and wood fragments (Thasod, 2005). The age of the fossiliferous deposits has been estimated around 7.4-5.9 Ma based on the associated mammal fauna (Chaimanee et al., 2006). The geological ages were spitted into the Middle Miocene, Late Miocene, and Early Pleistocene according to the biostratigraphic correlation and the age of fossil apes from Thailand (Nakaya et al., 2003; Saegusa et al., 2005).

On the basis of previous reports, sediments of these sand pits were deposited by high-energy flood pulses contemporaneous with the tektites forming event during mid-Pleistocene at 0.8 Ma (Howard et al. 2003; Haines et al. 2004). Moreover, Interpretation from palynostratigraphical study recommended that the lower horizon (20-25 m below ground surface) of Tha Chang sand pit was deposited during Pliocene/Pleistocene period and the upper horizons (approximately 5-10 m below surface) are

Pleistoncene/Holocene (Bunchalee, 2005). The ages of this sand pit are mixed, probably indicating a reworking process of the area. (Putthapiban et al., 2012)

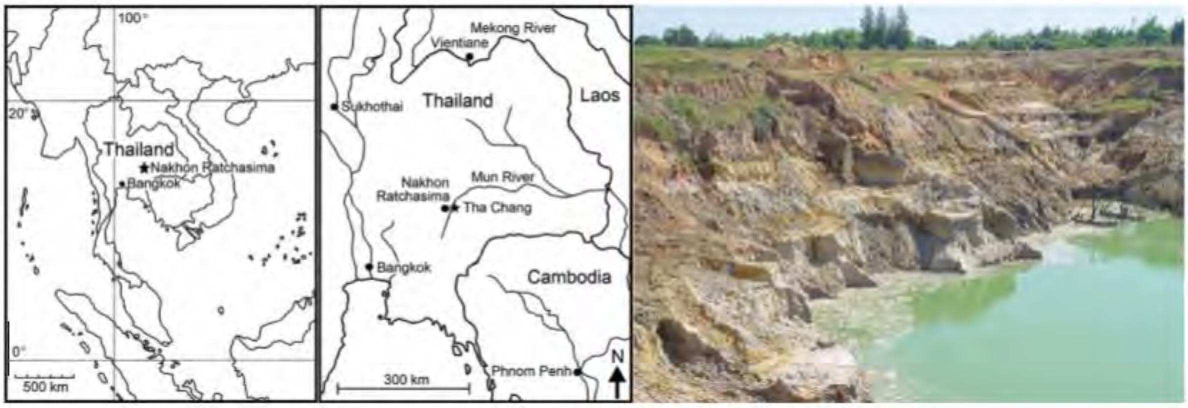

Figure 2.2 Location of Tha Chang sand pit in Chalerm Prakieat District, Nakhon Ratchasima Province, Thailand. A(Left) Southeast Asia with location of Nakhon Ratchasima; B (Center) Location of Tha Chang sand pit; C(Right) Sequence of Miocene fluvial deposits at a Tha Chang sand pit (Deng et al., 2013)

B: Fossil assemblage

The floral assemblage comprises of such as tree trunks identified as cf. *Corypha* (palm), cf. *Terminalia*, cf. *Parashorea* and *Dipterocarps*. Large mammals including proboscideans (*Deinotherium indicum*, *Gomphotherium* sp., *Stegolophodon* sp. and primitive *Stegodon*), anthracotheres, pigs (*Hippopotamodon sivalensis*), rhinocerotids (*Chilotherium palaeosinense*, *Brachypotherium perimense* and *Alicornops complanatum*), bovids, and giraffids (*Sivatherium* sp.) (Chaimanee et al., 2004).

2.3 Proboscidean

Kingdom: Animalia Linnaeus, 1758

Phylum: Chordata Haeckel, 1874

Class: Mammalia Linnaeus, 1758

Order: Proboscidea Illiger, 1811

The mammalian order Proboscidea is notable in every aspect of its biology. Body sizes of the earliest proboscideans were only small to moderate relative to those of other mammals. In the late Cenozoic, the proboscidean become of the largest land vertebrates (Larramendi, 2016). This order, first described by J. Illiger in 1811, involves the trunked mammals. The proboscideans are distinguished by having long and muscular trunks; these features are less developed or absent in the smaller early proboscideans. The largest land mammal today is the African and the largest land mammal in history is proboscidean; *Palaeoloxodon namadicus*. The earliest known proboscidean is *Eritherium* (Gheerbrant, E, 2009). This date from late Paleocene deposits of Morocco as (Figure 2.4). Most families of Proboscidean are now extinct in the end of the last glacial period.

Teeth are also part of the vertebrate skeletons. In proboscideans, the dentition molariform consists of three deciduous premolars; dP2, dP3, and dP4 and followed by three premolars; P2, P3, P4 and molars; M1, M2, M3, in each quadrant (left and right, upper and lower) of the oral cavity. The second upper incisors are enlarged to form tusks. The Proboscidean teeth is Lophodont, molar teeth with 2-3 transverse ridges (Figure 2.5). There are aligned along maxillary/mandible (Fisher, 2018). The third molars are considered fundamental for taxonomic behaviors of proboscideans. They are also generally viewed as related to diet, with high-crowned molars and increases in the number of lophs (lophids, in lower dentition) (Maglio 1973, von Koenigswald 2011).

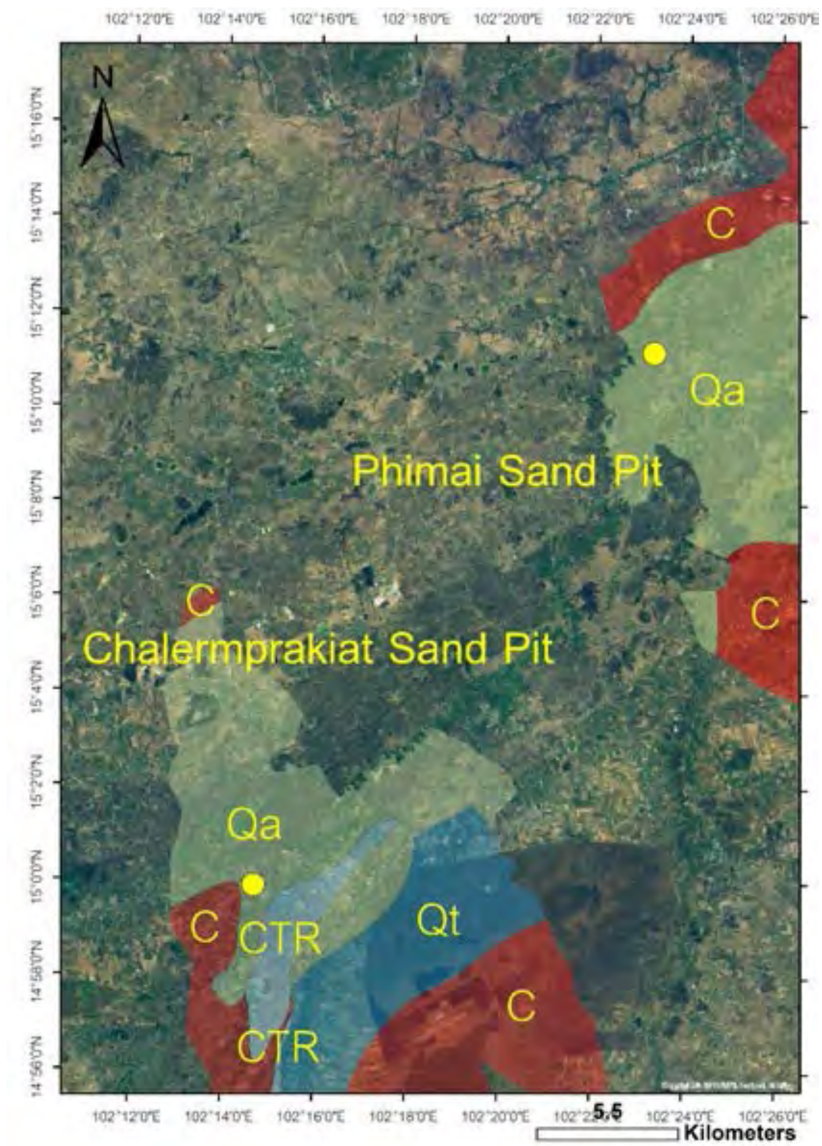

Figure 2.3 Location of Phimai and Chalermprakiat sand pit at Nakhon Ratchasima Province, Thailand with Quaternary Alluvial type of sediments. (Modified from DMR,2007)

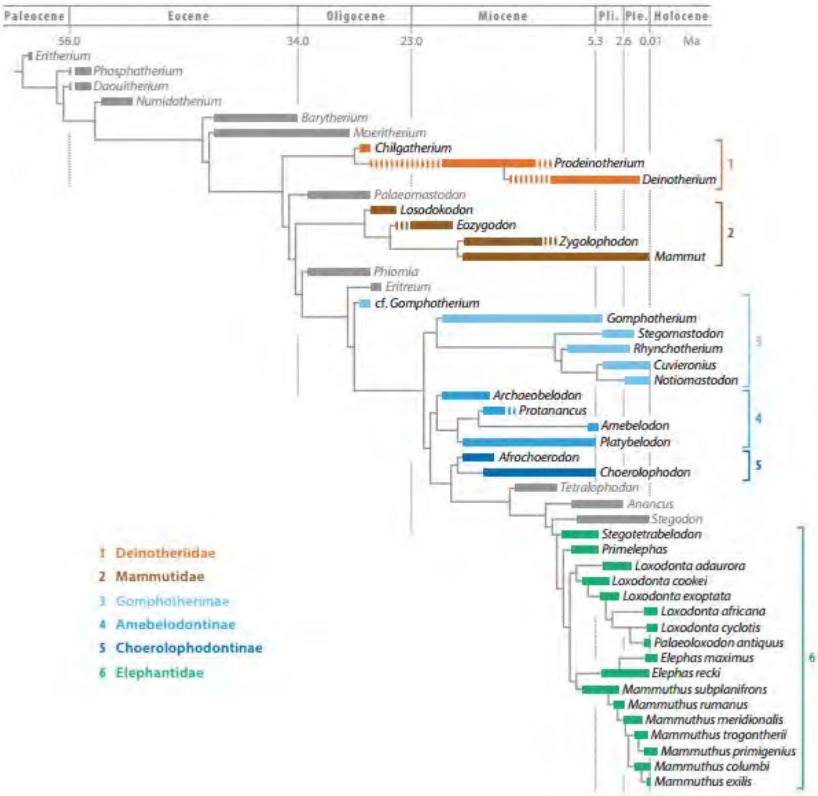

Figure 2.4 Phylogeny of the mammalian order Proboscidea (Fisher, 2018)

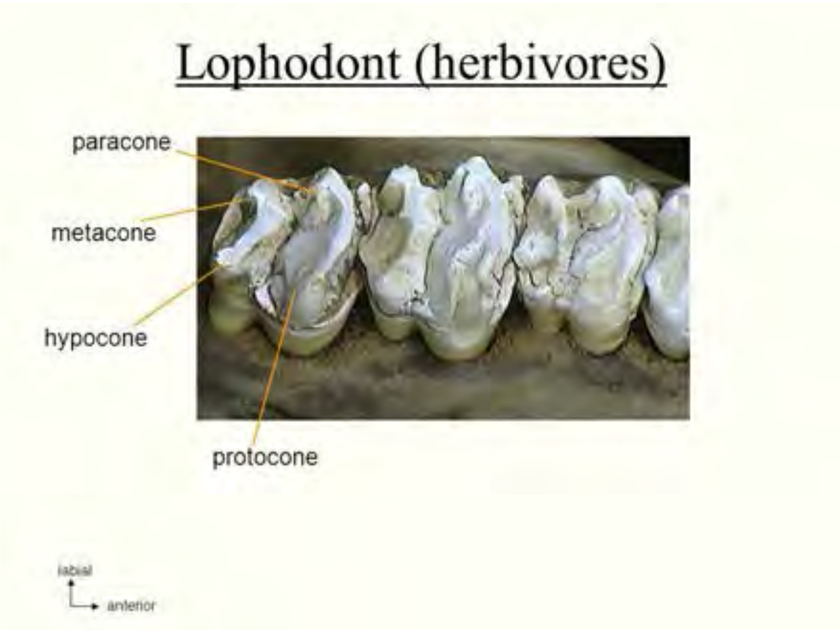

Figure 2.5 Lophodont teeth (http://slideplayer.com by Oswald Davidson)

2.4 Artiodactyla

Kingdom: Animalia Linnaeus, 1758

Phylum: Chordata Haeckel, 1874

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

The even-toed ungulates (Artiodactyla) are ungulates such as horses, whales, dolphins, and porpoises, pigs, antelopes, sheep, goats, peccaries, hippopotamuses, camels, llamas, alpacas, mouse deer, deer, giraffes and cattle. This order, first described by Owen in 1848. The oldest fossils of Ardiodactyla is the early Eocene (about 53 million years ago) that appeared in Europe, Asia, and North America However, it is very difficult to accurate the origin of artiodactyls. The fossils are the earliest of artiodactyls as belonging to the family Dichobunidae; the best-known is *Diacodexis* (Jessica M Theodor & Jörg Erfurt, 2007).

A bunoselenodont morphology is mixed between the budonont appearance that has low-crowned teeth with rounded shape and the selenodont that has primary cusps elongated in an anterior-posterior direction to form crescent- shaped ridges (Figure 2.7). Artiodactyls are divided into 3 suborders; First, Suiformes include the family of Suidae, Tayassuidae and Hippopotamidae and Cetacea. These animals do not ruminate that teeth comprise of bunodont cheek teeth. Second, Tylopoda contains only family of Camelidae that have teeth of Selenodont. The last suborder contains the families Bovidae, Giraffidae, Tragulidae, Moschidae, Cervidae and Antilocapridae that comprise almost of selenodont teeth, some species have mixed between bunodont and selenodont appearances that is called "bunoselenodont". (Lekagul, 1977)

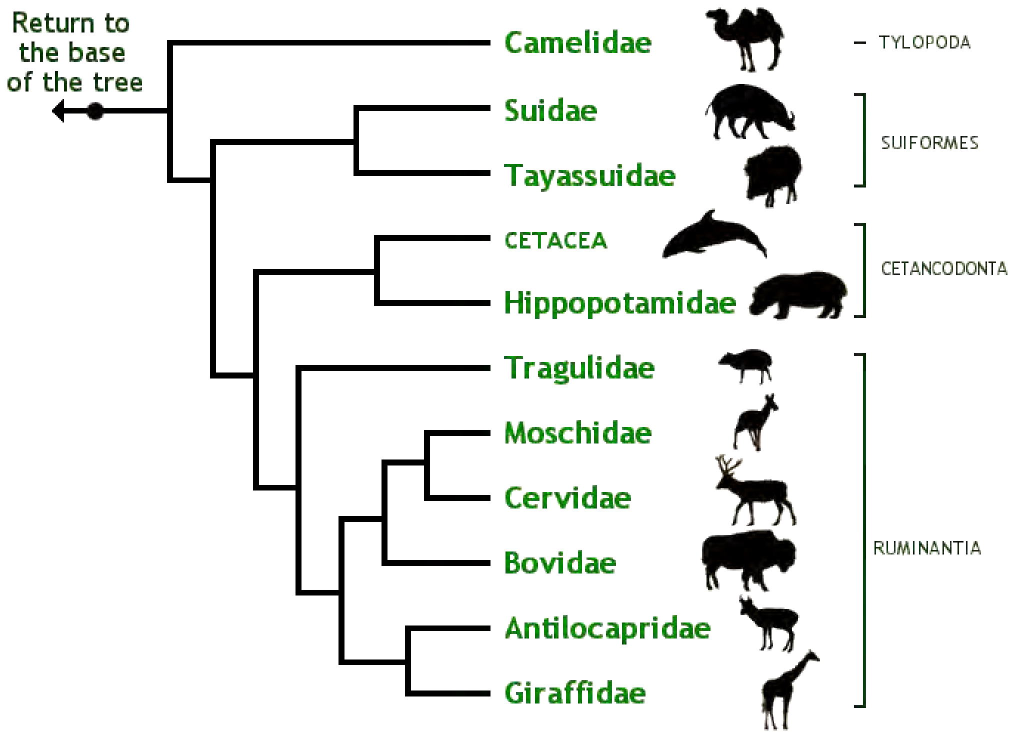

Figure 2.6 Phylogeny of the mammalian order Artiodactyla

(http://bioweb.uwlax.edu)

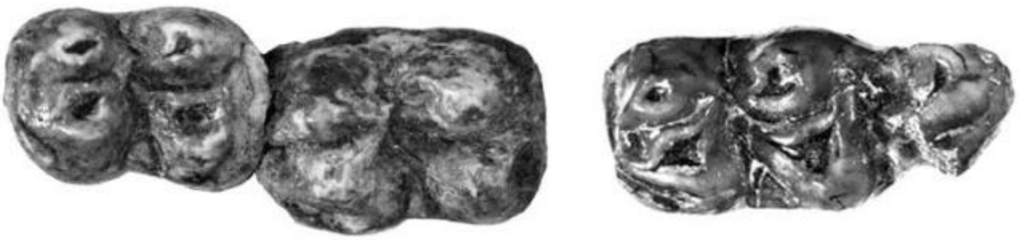

Figure 2.7 Bunoselenodont teeth (Métais et al., 2007)

CHAPTER 3 MATERIAL AND METHODS

3.1 Methodology

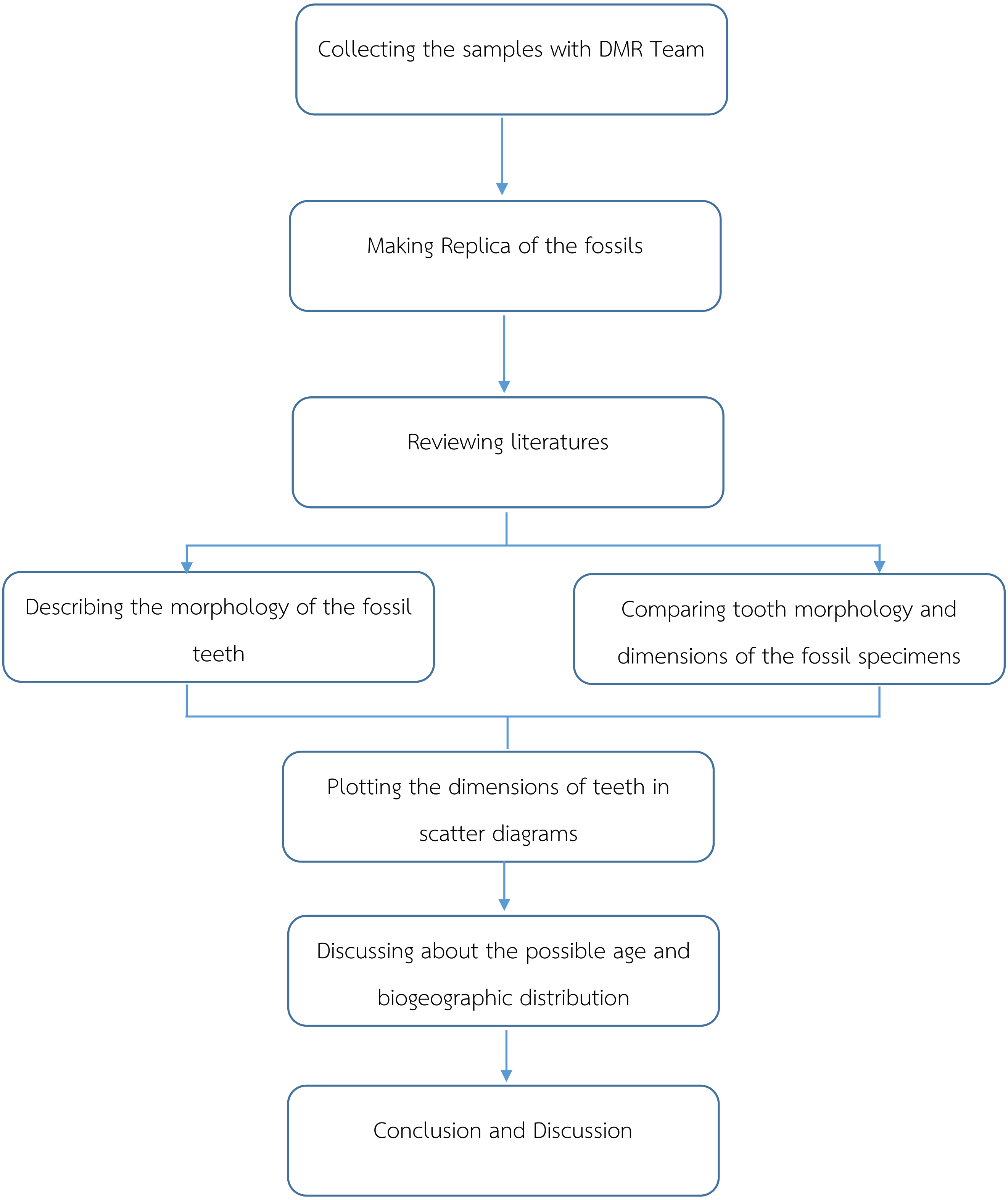

Table 3.1 Diagram show the methodology of Research

We conduct a field excavation in the Phimai and Chalermprakiat sand pits for collecting samples. (Figure 3.1) and take photo and measure the dimensions of specimens by using a Vernier caliper, the nearest 0.01m, using the methods of Göhlich (1998). The lengths and widths of teeth were measured along the anterior to posterior edges and buccal to lingual edges, respectively. Then, we make replica of the fossils for duplicating the samples. (Figure 3.3).

Figure 3.1 Phimai sand pit

Figure 3.2 Example of specimen

Figure 3.3 Example of replica

Next, we review literatures about the geological and paleontological contexts of the sand pit in Nakhon Ratchasima Province. (Chapter 2) and describe the morphology of the fossil teeth (e.g., cusps: protocone, paracone, metacone). The dental nomenclature of lophodont teeth follows Aiglstorfer et al. (2014) and bunoselenodont teeth follows Böhme et al. (2011). (Figure 3.5-3.8) Moreover, we compare tooth morphology and dimensions of the fossil specimens from the Phimai and Chalermprakiat sand pit with those of other related genera from literatures. Finally, we measure tooth lengths and widths to plot in scatter diagrams for comparing with other related genera. (Chapter 4), discuss about the possible age and biogeographic distribution of the species. (Chapter 4), and conclude this study. (Chapter 5)

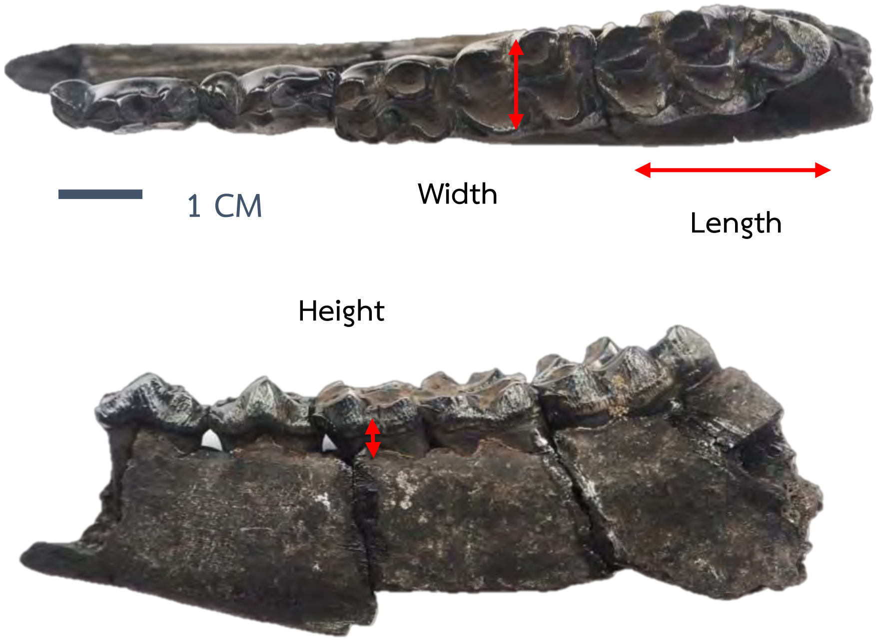

Figure 3.4 Dental Measurement

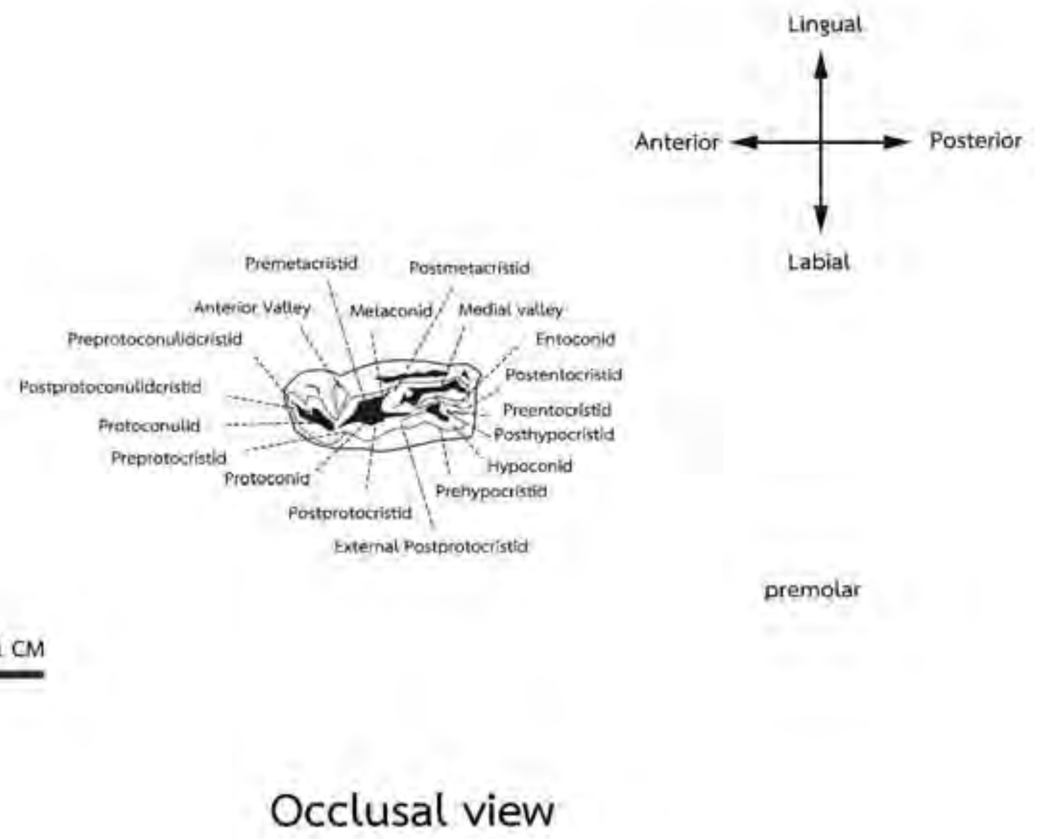

Figure 3.5 Drawing image of tragulid dentition (lower premolar) (modified from Alba et al., 2014)

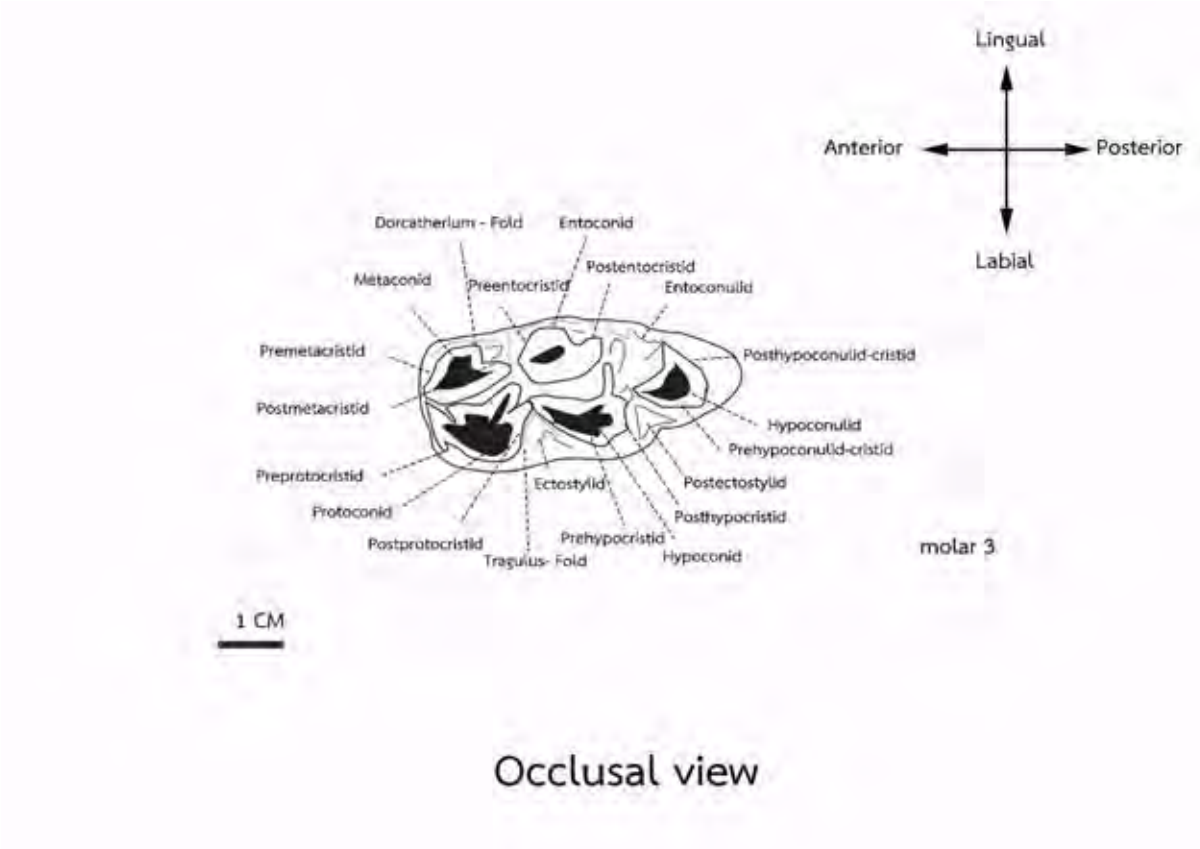

Figure 3.6 Drawing image of tragulid dentition (lower molar) (modified from Alba et al., 2014)

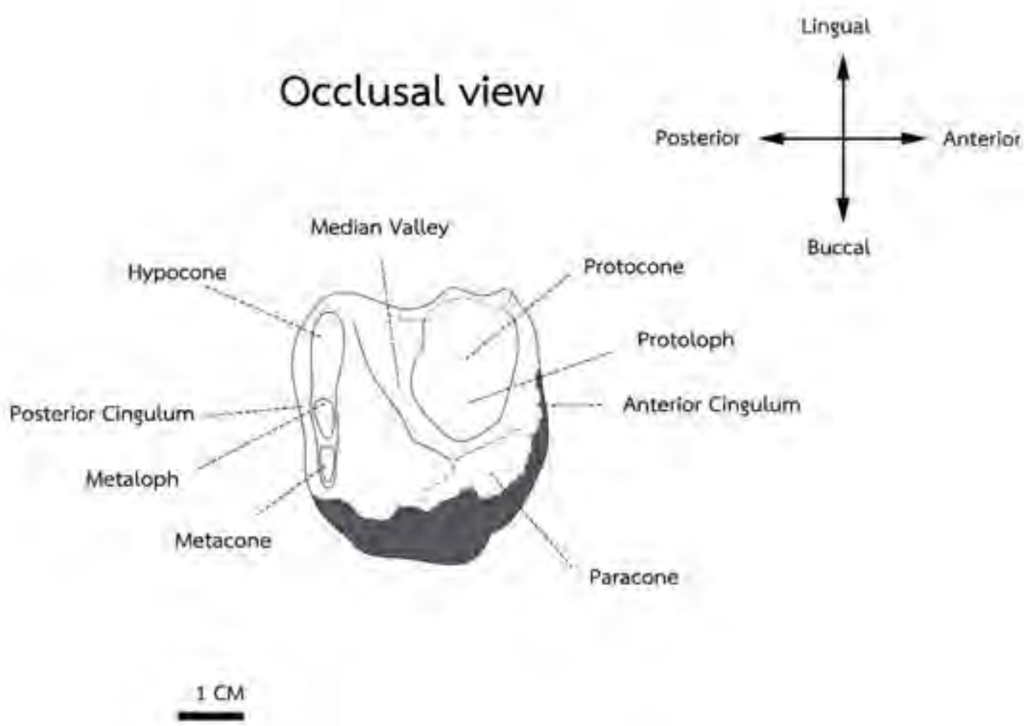

Figure 3.7 Drawing image of deinotheriid dentition (Upper premolar) (modified from Aiglstorfer, M., 2014)

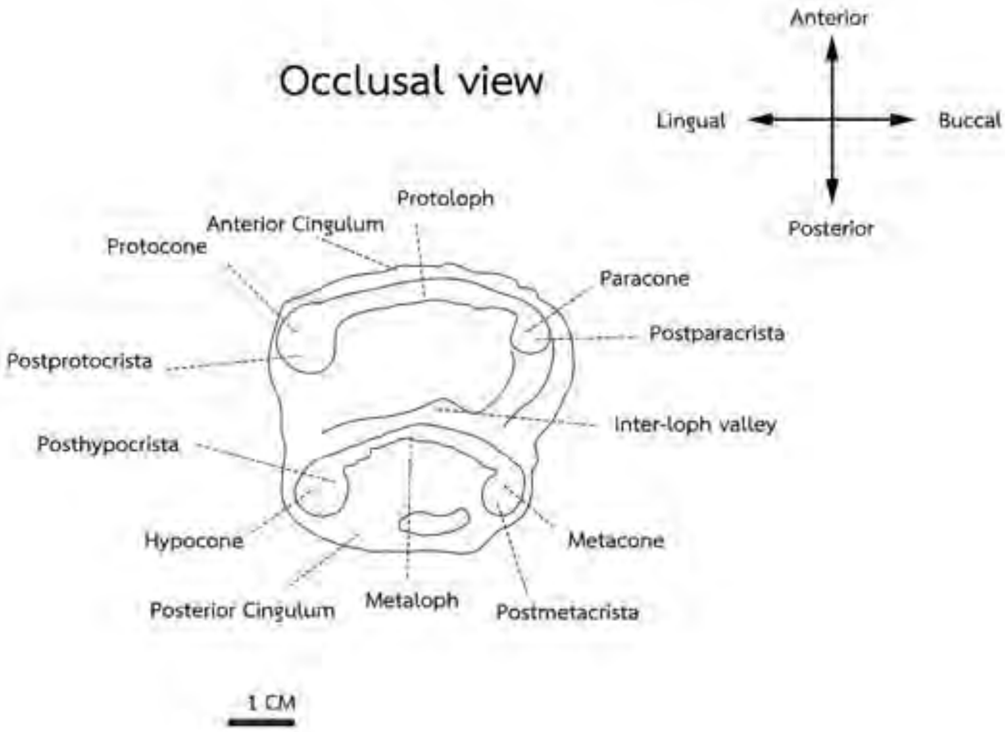

Figure 3.8 Drawing image of deinotheriid dentition (upper molar) (modified from Aiglstorfer, M., 2014)

3.2 Materials

The fossil specimens include 3 left mandibles and 1 right mandible of bunoselenodont ruminants and isolated P3 (upper Third Premolar) and M3 (upper Third Molar) of lophodont ungulates. The specimens number CUF-MB-10 is left hemimandible (lower cheek teeth premolar3 – molar 3) (Figure 3.9-3.11), number CUF-MB-20 is upper dentition (left third premolar) and (Figure 3.12-3.14) and number CUF-MB-21 is upper dentition (left third molar) (Figure 3.15-3.17) that come from Phimai sand pit. The specimens number KKF-17-1 is left hemimandible (lower cheek teeth molar 2-3) (Figure 3.18-3.20), number KKF-17-2 is right hemimandible (lower cheek teeth molar 1-3) (Figure 3.21-3.23) and number KKF-17-3 is left hemimandible (lower cheek teeth molar 1-3) (Figure 3.24-3.26) that come from Chalermprakiat sand pit.

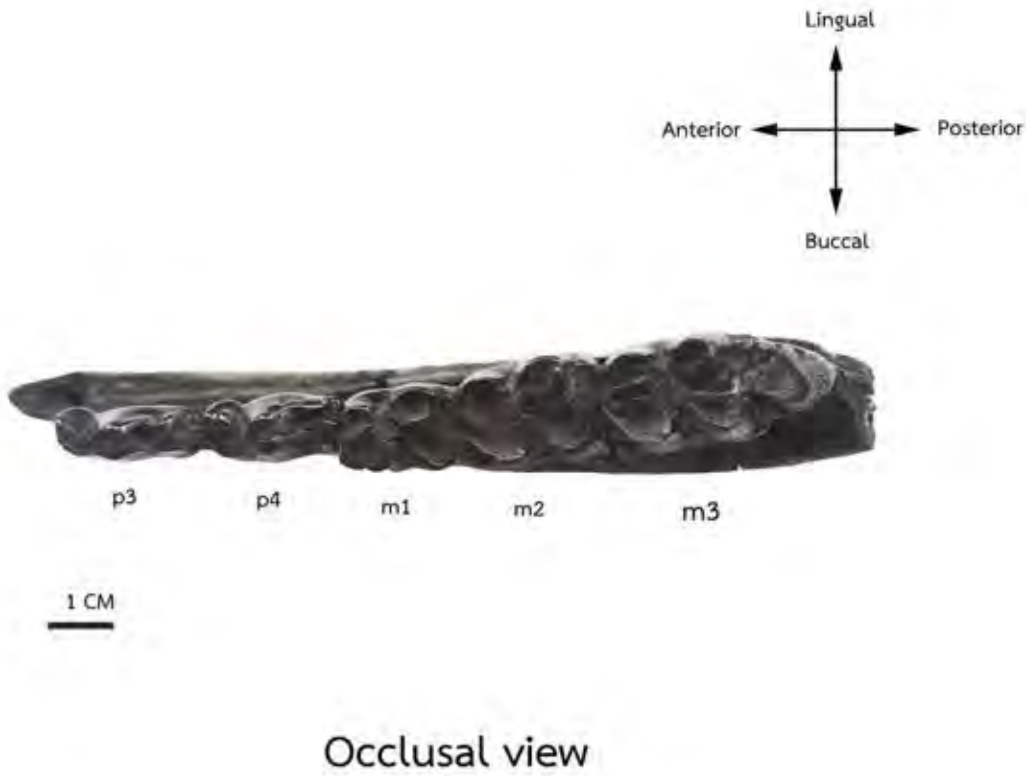

Figure 3.9 Material CUF-MB-10, Occlusal View

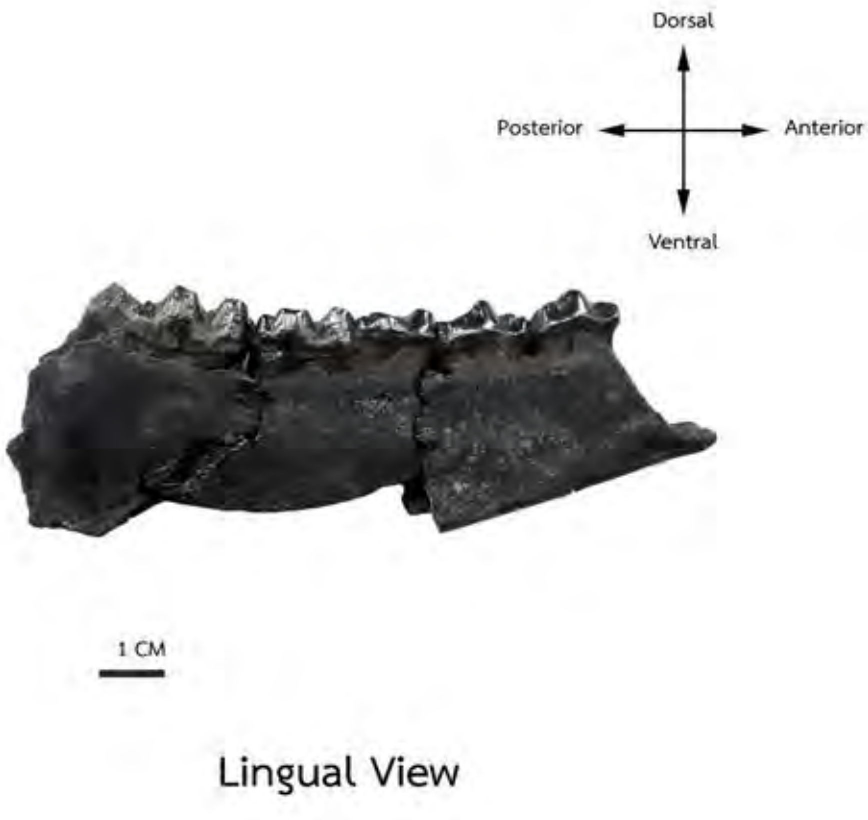

Figure 3.10 Material CUF-MB-10, lingual View

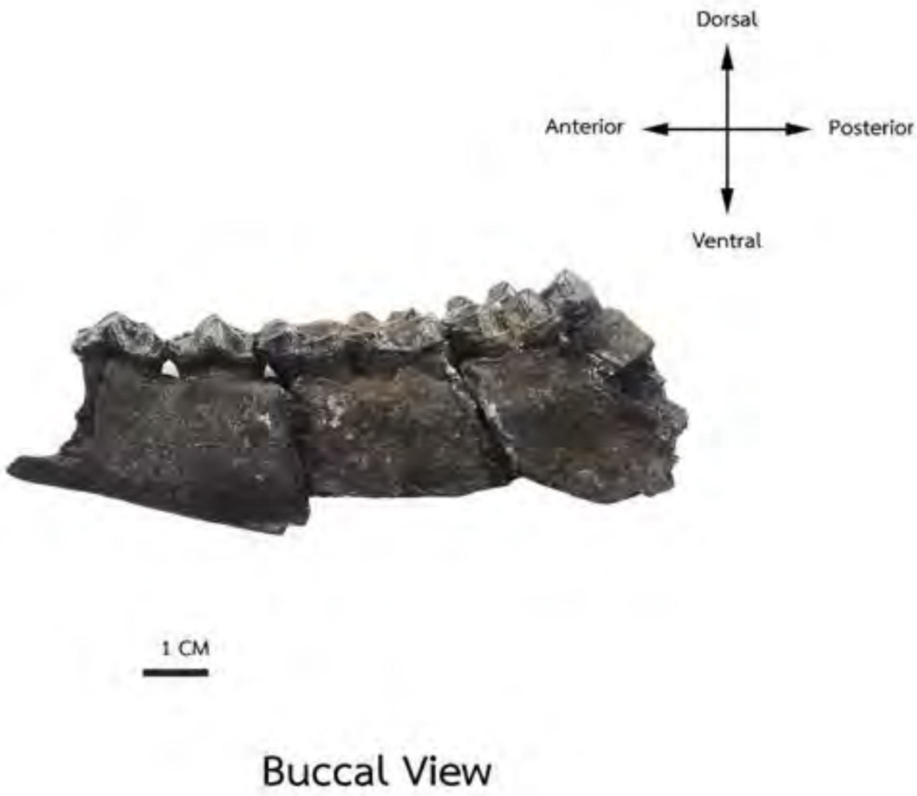

Figure 3.11 Material CUF-MB-10, Buccal View

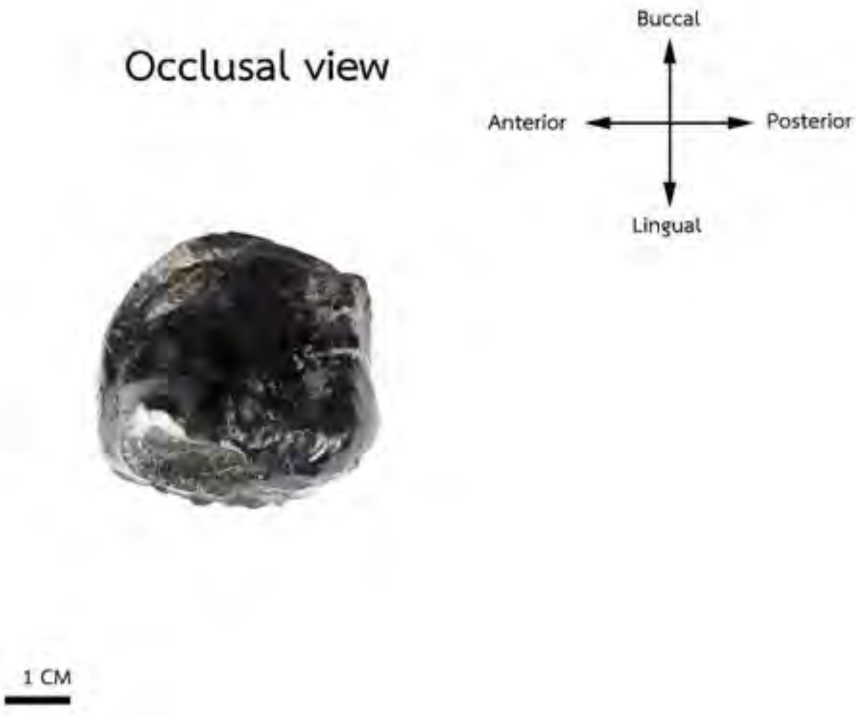

Figure 3.12 Material CUF-MB-20, Occlusal View

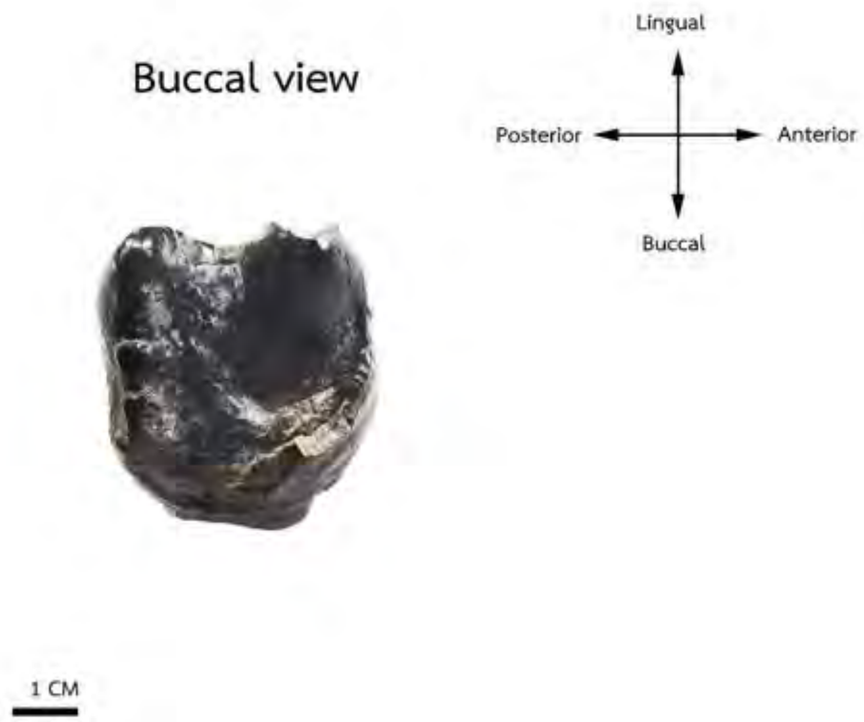

Figure 3.13 Material CUF-MB-20, Buccal View

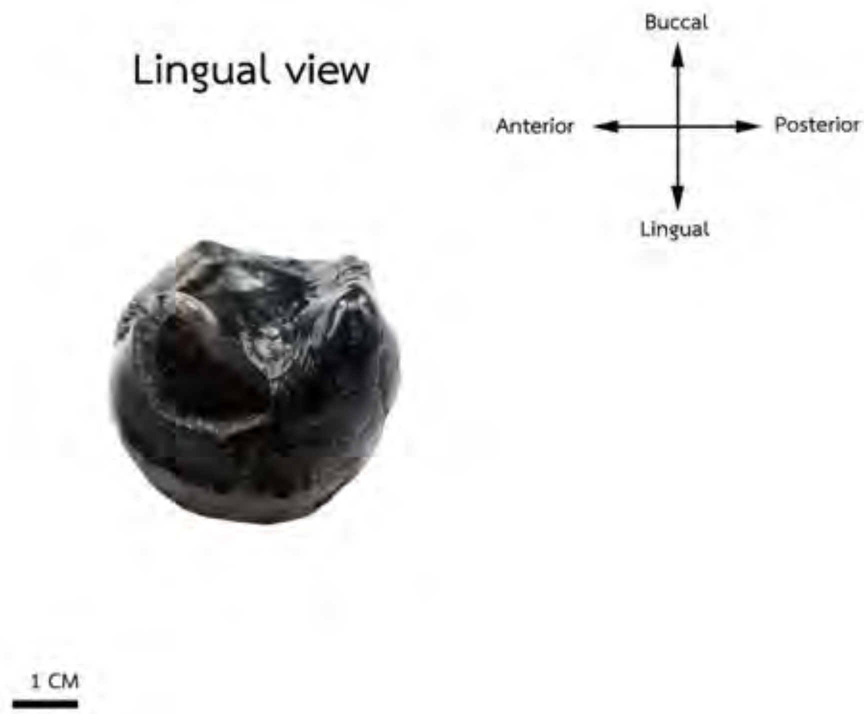

Figure 3.14 Material CUF-MB-20, lingual View

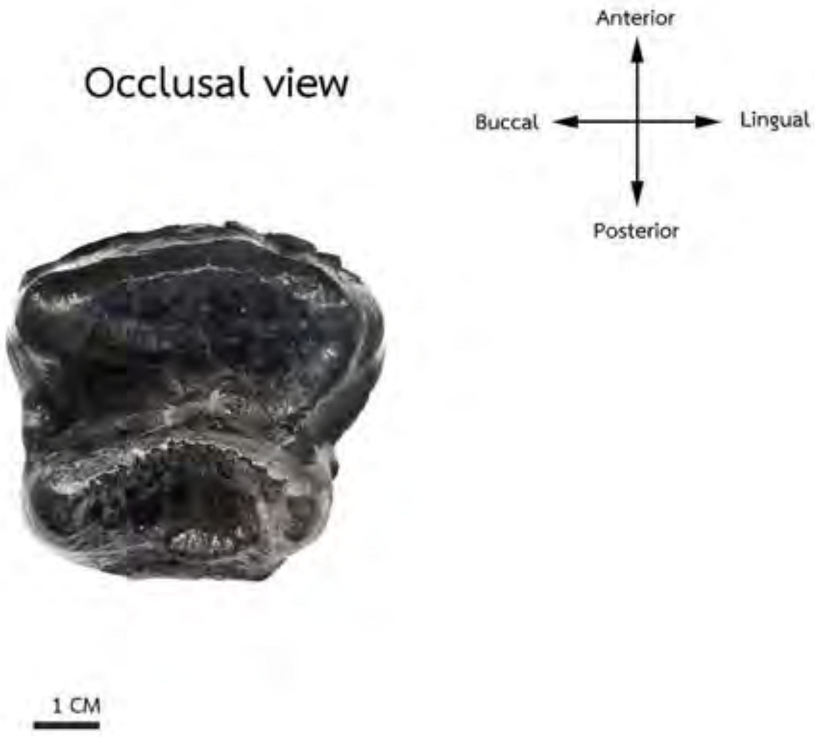

Figure 3.15 Material CUF-MB-21, Occlusal View

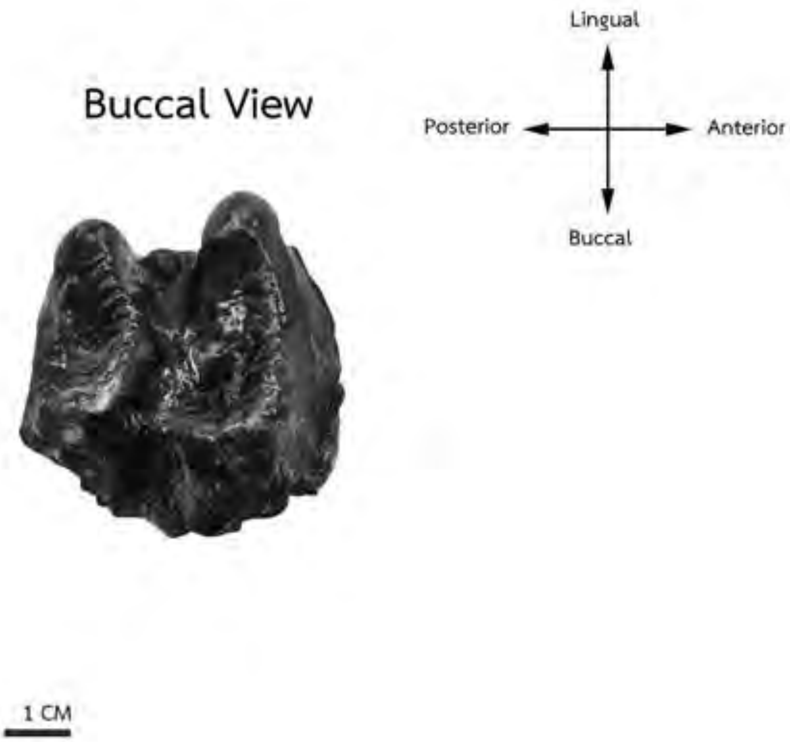

Figure 3.16 Material CUF-MB-21, Buccal View

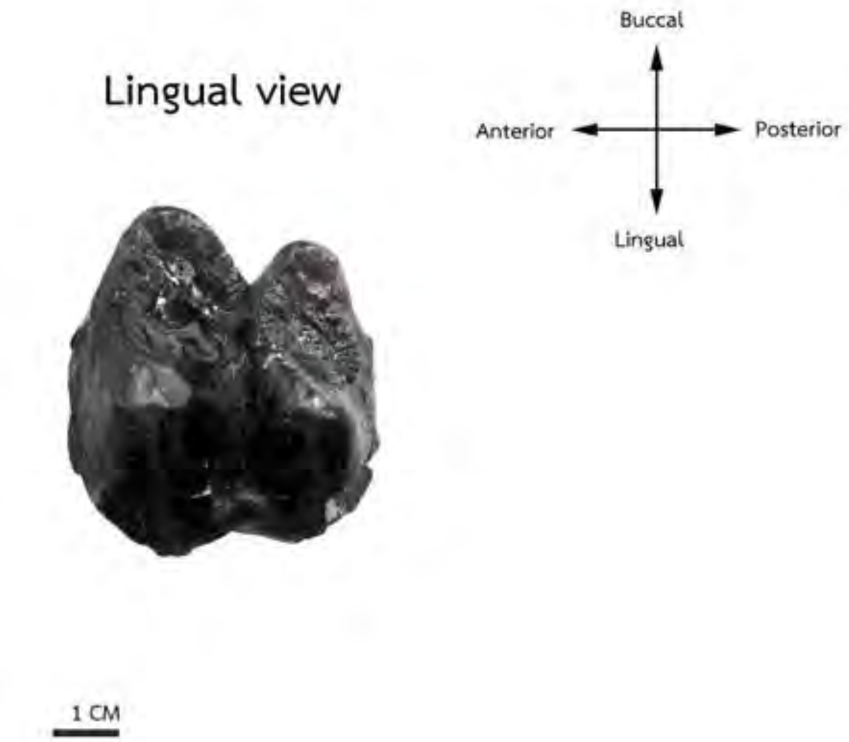

Figure 3.17 Material CUF-MB-21, lingual View

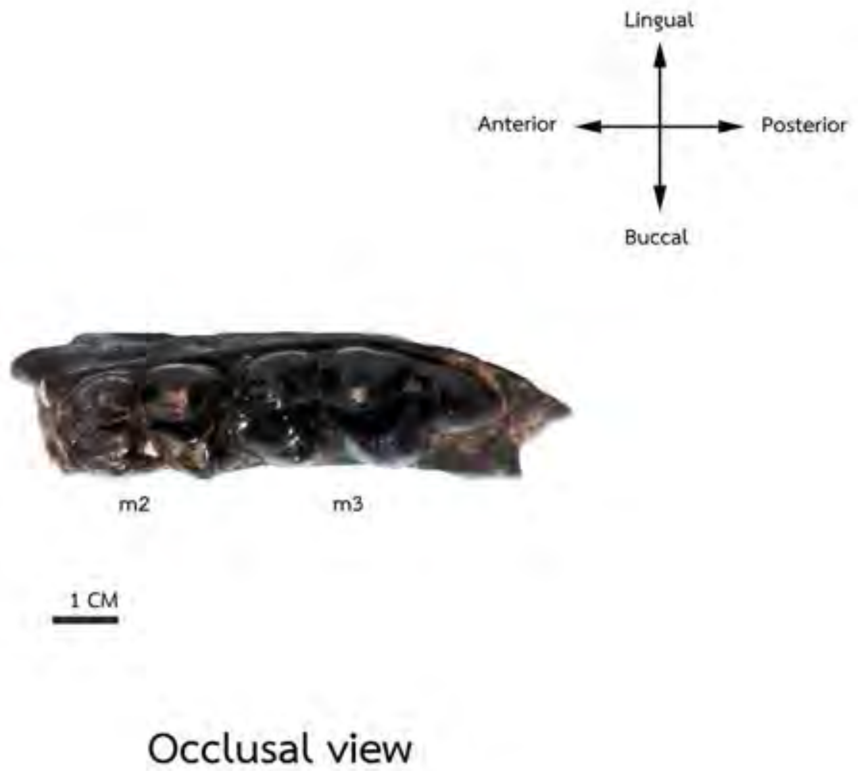

Figure 3.18 Material KKF-17-1, Occlusal View

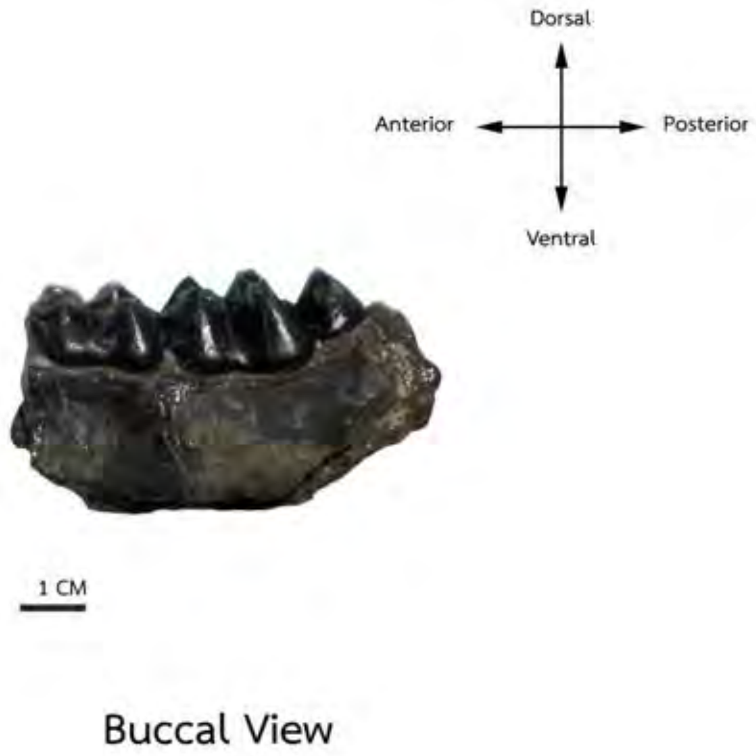

Figure 3.19 Material KKF-17-1, Buccal View

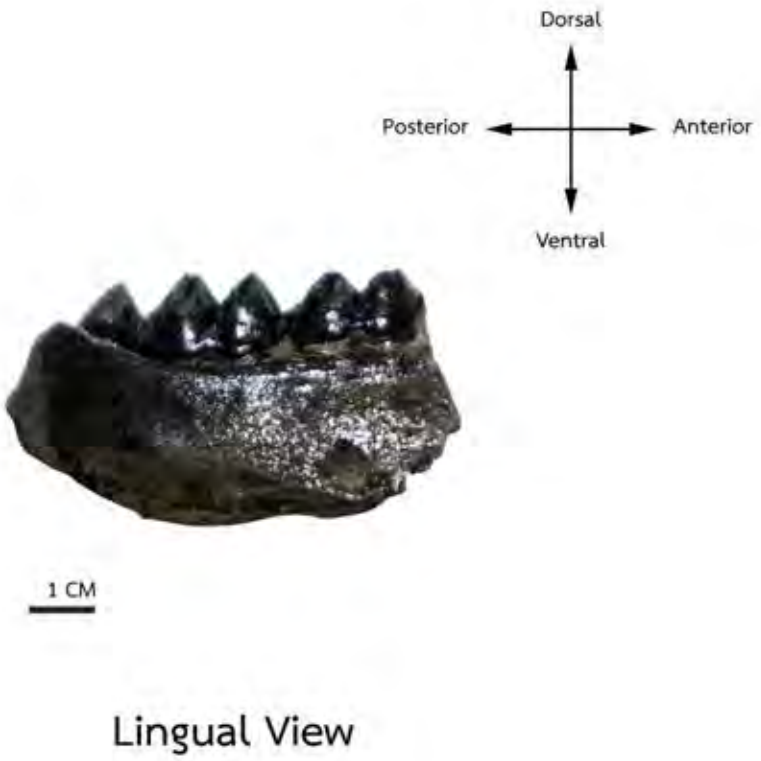

Figure 3.20 Material KKF-17-1, lingual View

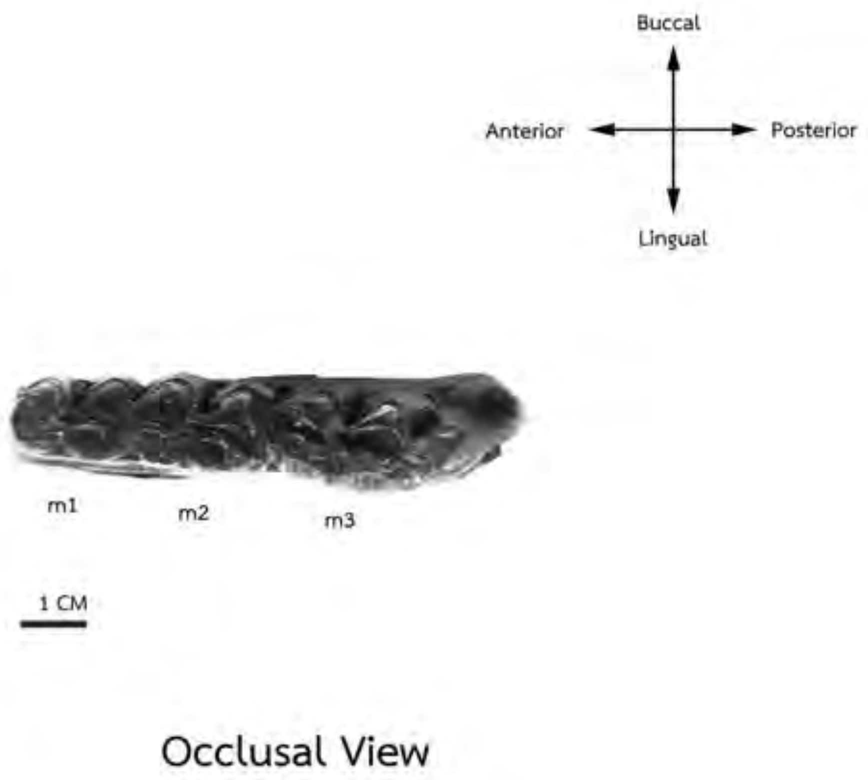

Figure 3.21 Material KKF-17-2, Occlusal View

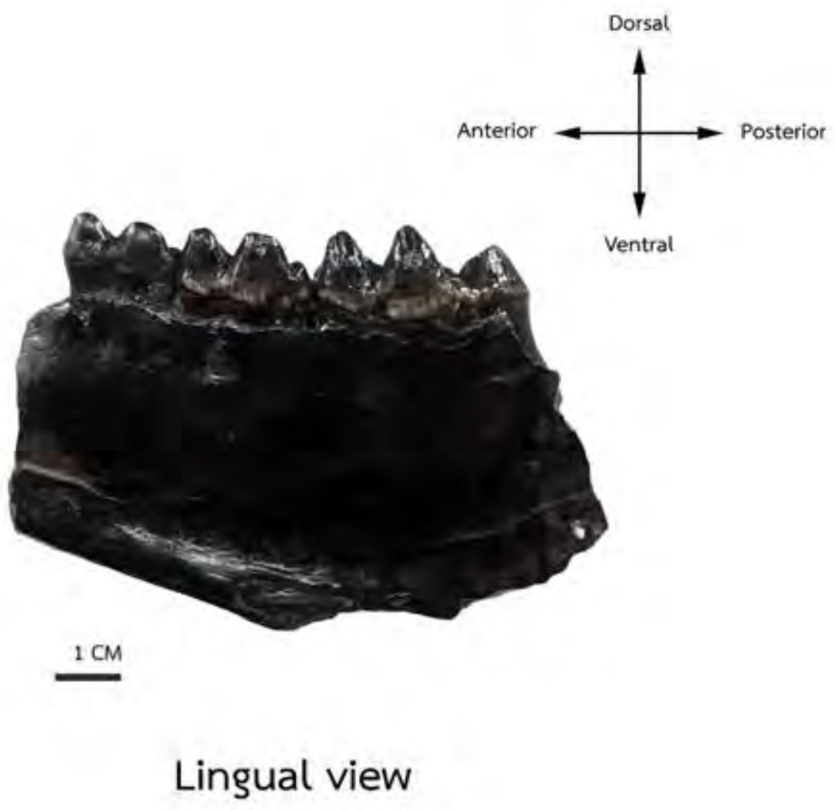

Figure 3.22 Material KKF-17-2, Lingual View

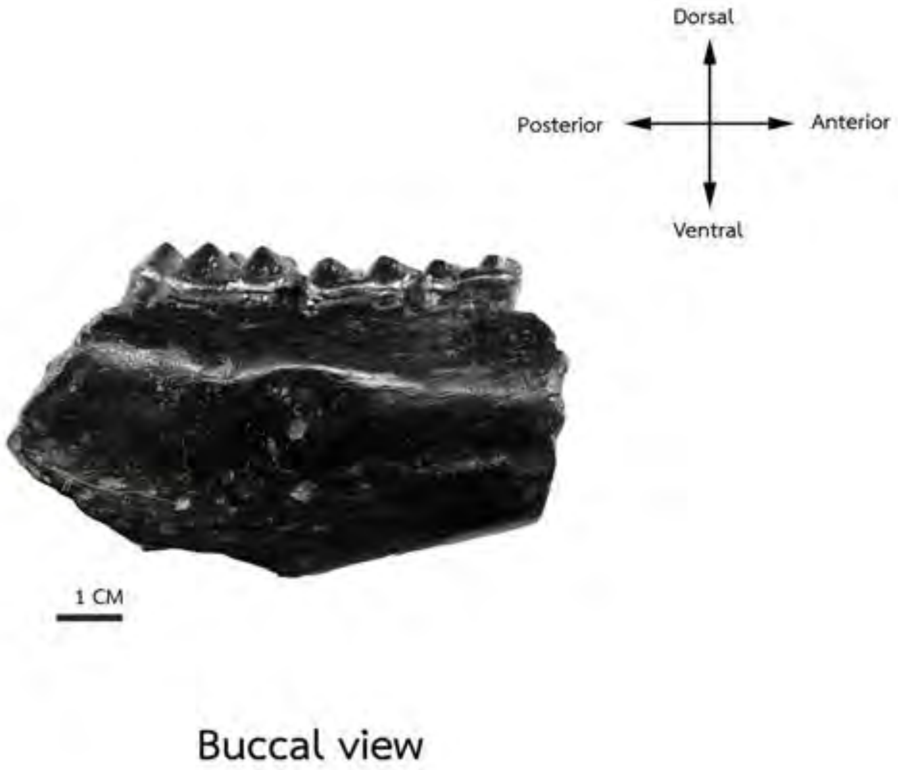

Figure 3.23 Material KKF-17-2, Buccal View

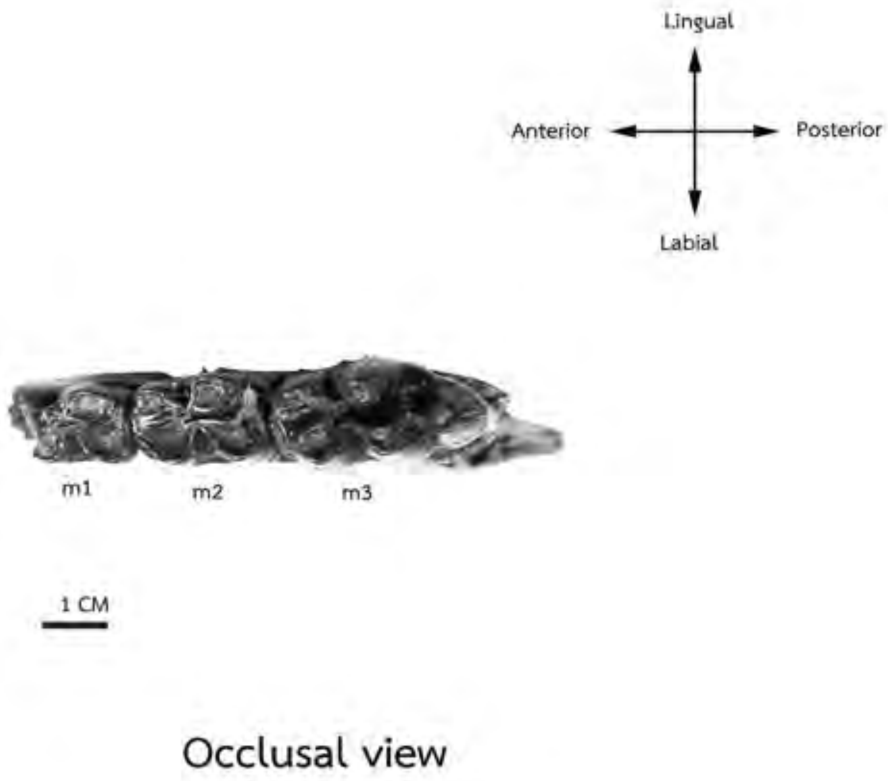

Figure 3.24 Material KKF-17-3, Occlusal View

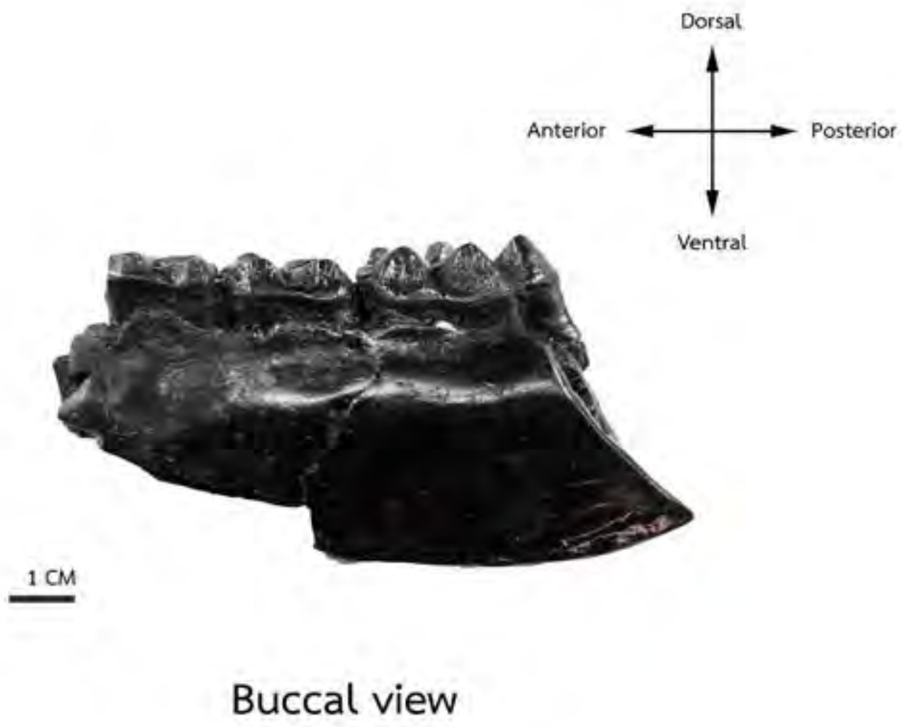

Figure 3.25 Material KKF-17-3, Buccal View

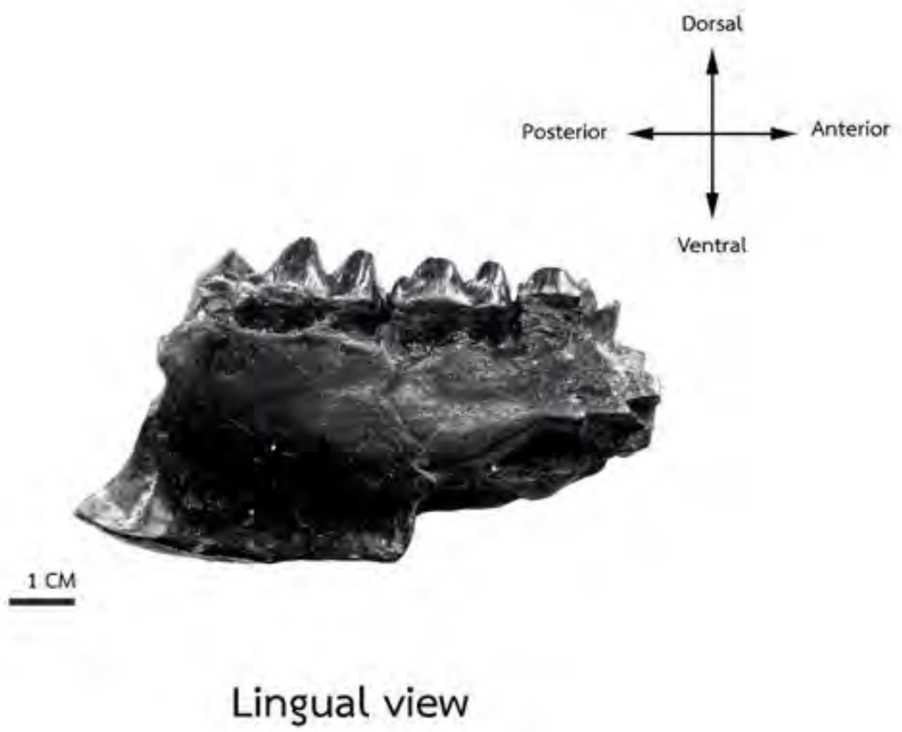

Figure 3.26 Material KKF-17-3, lingual View

3.3 Abbreviation and Definitions

CUF-MB-10 is abbreviated from Chulalongkorn University Fossil (CUF), Mae Lae Boot (MB), 10 is code of specimens

KKF-17-1 is abbreviated from kamol Khorat Fossil (KKF), 17 is the year that got fossil (2017) ,1 is code of specimens

dP2 is deciduous teeth or primary teeth, commonly known as baby teeth (d), P is Upper Premolar if p will be lower premolar, 2 is position of teeth

M2 is upper molar teeth (M). As, m is lower molar teeth, 2 is position of teeth

Bunoselenodont is mixed between the budonont appearance that has low-crowned teeth with rounded shape and the selenodont that has primary cusps elongated in an anterior-posterior direction to form crescent- shaped ridges. (Ungar, 2010)

Lophodont is a tooth consisting of a series of lophs.(Ungar, 2010)

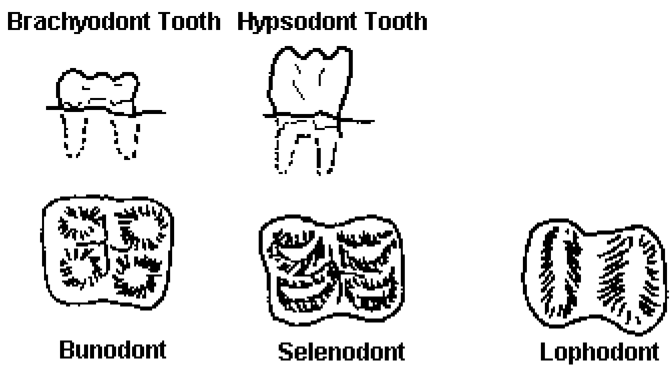

Figure 3.27 Occlusal View of Molar Cusp Types

(http://museum2.utep.edu)

Hemimandible is half of a mandible, the lower jaw. In upper jaw is called maxillary

Cheek teeth is molars and premolars

Buccal is the side of a tooth that is adjacent to the inside of the cheek.

Lingual is the opposite side of buccal that adjacent to the tongue.

Mesial is the direction towards the anterior midline in a dental.

Distal is the opposite side of mesial.

Occlusal the fitting together of the teeth of the lower jaw with the corresponding teeth of the upper jaw when the jaws are closed like the dentist see teeth's patient.

Cusp is called a cone, different cones are identified by different prefixes, the major cone is proto-, para-, meta-, hypo-, and ento-. Minor cusps may have the suffix -ule added to the name such as hypoconule.

Protocone is founding the molars of the upper dentition in Placental and Marsupial vertebrates. It is found in the mesiolingual area of the tooth. (Myers, 2013b)

Paracone a type of cusp in the upper jaw that aligned at mesiobuccal side of the tooth (Myers, 2013b)

Metacone is a cusp on the molars of the upper dentition in hominids. It is found on the distobuccal (premolars/molars) area of the tooth. (Myers, 2013b)

Hypocone is found on the distolingually side of the tooth. It fits into the grooves of the lower dentition and is an adaptation for the overall grinding and tearing of foods using the occlusal (chewing side) of the tooth surface during occlusion or mastication (chewing). (Myers, 2013b)

-id added to the name of a cusp indicates that it is part of a tooth in the lower jaw; for example, a metacone is a major cusp on an upper molar, while a metoconid is on a lower molar

Cingulum is shelf-like ridge around the outside of an upper molar, cingulid on a lower tooth.

Trigon is set of three major cusps is the trigon. Lower teeth is called trigonid as (figure 3.9)

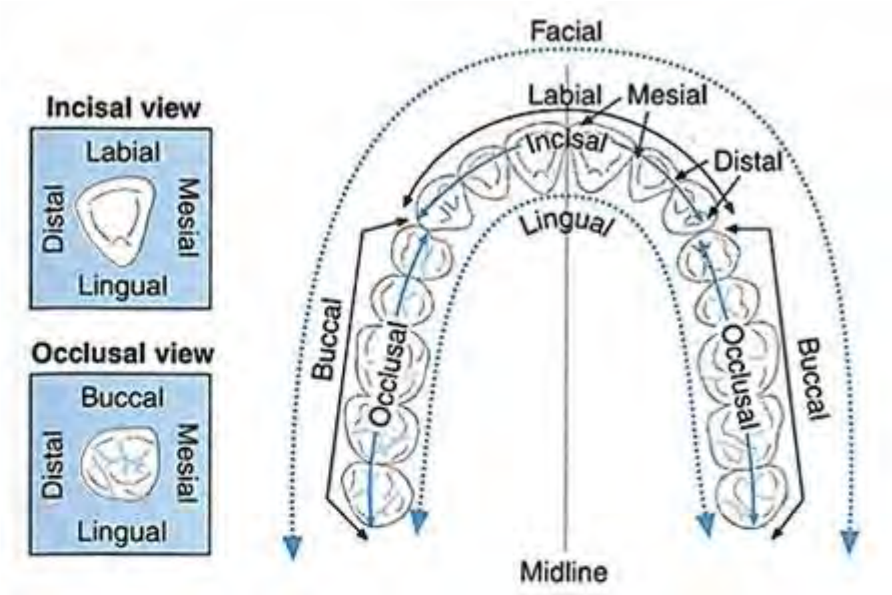

Figure 3.28 Tooth Surface Diagram

(http://chinchilladental.com.au)

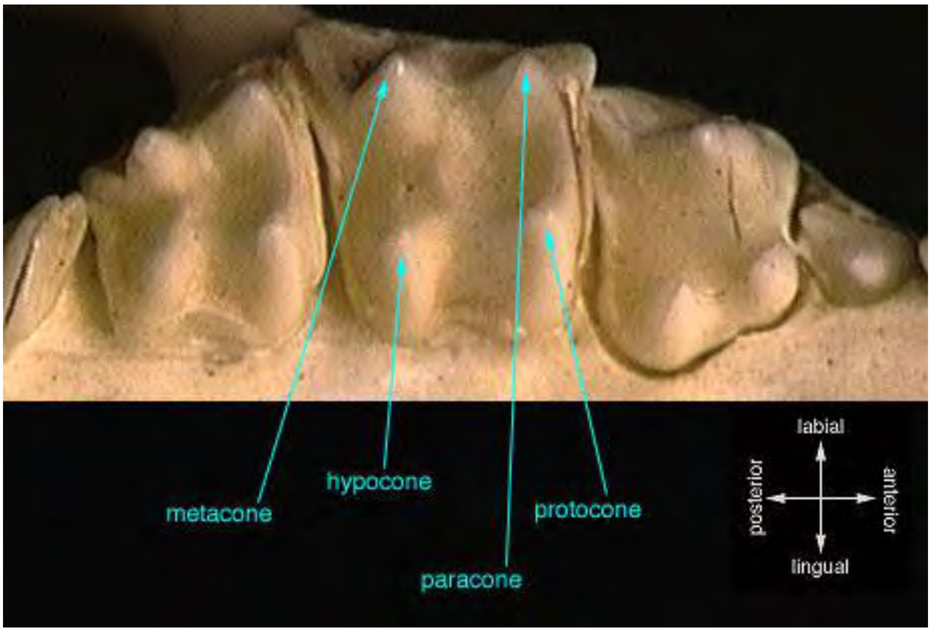

Figure 3.29 Features of the surface of teeth

(https://animaldiversity.org)

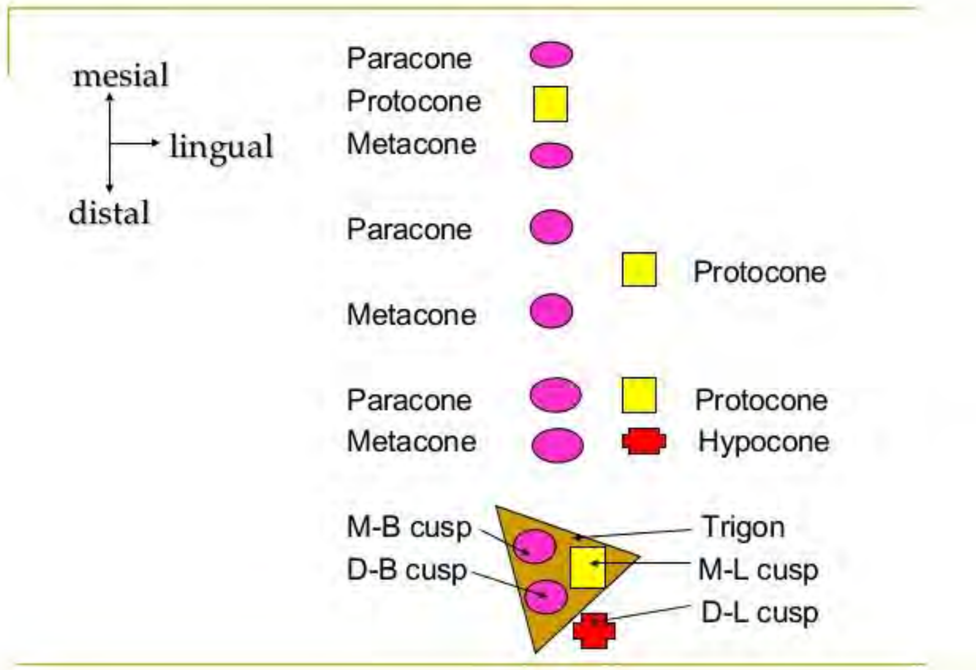

Figure 3.30 Evolution of cusp in Upper molar

(www.indiandentalacademy.com)

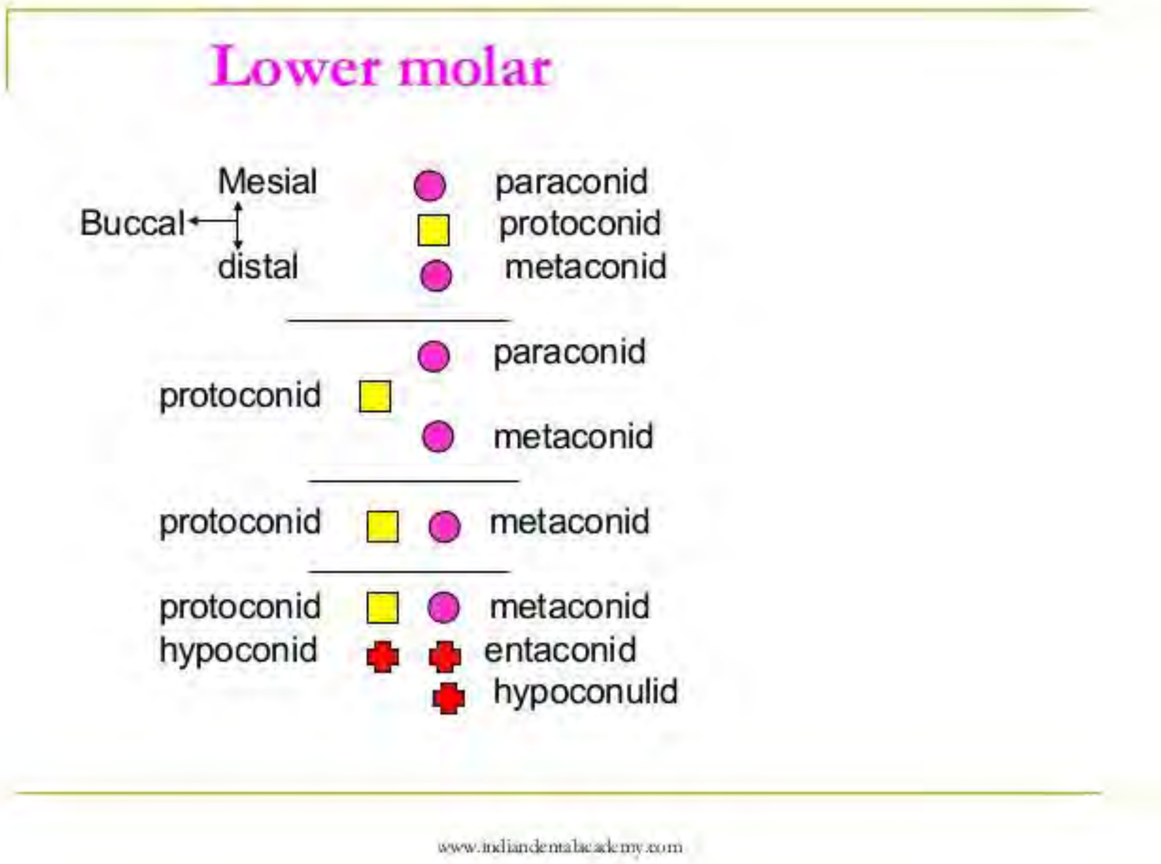

Figure 3.31 Evolution of cusp in Lower molar

(www.indiandentalacademy.com)

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Systematic Paleontology

4.1.1 Bunoselenodont Ruminants

Kingdom: Animalia Linnaeus, 1758

Phylum: Chordata Haeckel, 1874

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

Family Tragulidae Milne Edwards, 1864

Genus *Dorcabune* Pilgrim, 1910

Dorcabune cf. *nagrii* Pilgrim, 1910

Generic Diagnosis (from Colbert, 1935) "A very large tragulid with bunodont teeth. The upper molars are characterized by the isolated parastyle and mesostyle, the prominent cingulum and the rugose enamel. The lower molars are broad, with a wide talonid in the third molar. Protocone pyramidal with two posteriorly directed"

Type species *Dorcabune anthracotherioides* Pilgrim, 1910

Type Specimen GSI B590, a right M3 (Colbert, 1935).

Type Locality Nagri, Chakwal district, the Punjab province, Pakistan.

Diagnosis (from Colbert, 1935) "*Dorcabune nagrii* is smaller than *D. anthracotherioides* with less developed cingula."

Studied specimen CUF-MB-10 Left hemimandible (lower cheek teeth premolar3 – molar 3) (Figure 3.8-3.10, Table 4.2), KKF-17-2 Right hemimandible (lower cheek teeth molar 1-3) (Figure 3.21-3.23, Table 4.1), KKF-17-3 Left hemimandible (lower cheek teeth molar 1-3) (Figure 3.24-3.26, Table 4.3)

Locality Phimai sand pit (CUF-MB-10) and Chalermprakiat sand pit (KKF-17-2, KKF-17-3), a district of Nakhon Ratchasima Province, Northeastern part of Thailand

Studied Stratigraphic Horizon Around 12 meters from surface in sandy clay layer from Phimai sandpit (Figure 4.1) and around 19 meters from surface in medium sand layer from chalermprakiat sand pit (Figure 4.3)

Description

Lower Dentition

p3: The Premolar is tricuspid with the central cusp (protoconid), posterior cusp (hypoconid) and anterior cusp (protoconulid). Their crown is high and the buccolingual side is compressed. The third premolar is worn and completely preserved. The protoconulid is shown distinctly in the anterior lope and well-developed. The enamel is rugose on the buccal side more than lingual side. The protoconid is more protruded than the other cusps. The postprotocristid and the prehypocristid not merge together on the buccal side. Whereas the preprotocristid is partially divided by anteriolingually vertical groove (Anterior Valley). No cingulid is present.

p4: The fourth premolar is tricuspid with anterior, central and posterior cusp that all cusps are compressed in buccolingual side. This premolar is completely preserved and worn. The preprotocristid descends toward anteriorly with the well- developed protoconulid that divided by anterior valley. The enamel is rugose on the buccal side more than lingual side. The entoconid is short, quite less distinct and poorly-developed that ends distolingually close to the posterior valley until opening the lingual wall. The premolar has two anterior cristids, the preprotoconulidcristid and the anterolingual postprotoconulid cristid, another cristid runs posterioly from the protoconid until merging with the prehypocristid. The hypoconid is situated at the posterior portion of crown close to the entoconid. No cingulid is present.

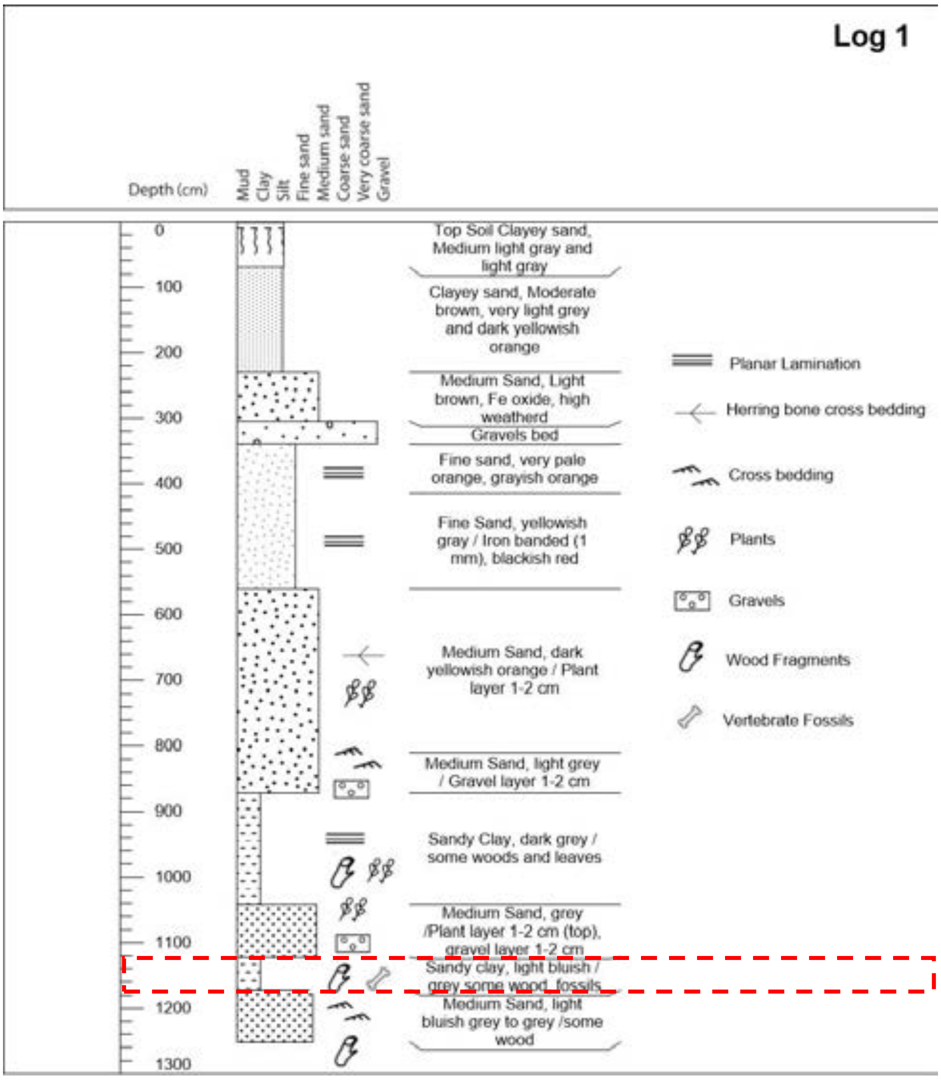

Figure 4.1 Stratigraphic section at Phimai Sand pit (Vertebrate Fossil, Red line)

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m1: The first molar shows a bunoselenodont occlusal morphology with relatively high crown and subrectangular with two lobes which separated by buccal and lingual groove. The ectostylid is present in the anterobuccally traverse. The molar is worn, completely preserved and the buccal wall is rugose. The metaconid has missed by breaking and partially anterior lobe of protoconid also missing (KKF-17-3). The protoconid shows a long preprotocristid that curves toward the anterior until merging with premetacristid. The anterior slope has a well-developed M structure of the *Dorcatherium* and *Tragulus* fold. The *Tragulus* fold is directed to the prehypocristid and the postmetacristid displays cristid *Dorcatherium* fold at the lingual side. The preentocristid descends from the apex of entoconid to the bottom of the valley in lingual side that separates it from the postmetacristid. The posthypocristid extends toward to the distolingual portion of the crown and separate posteriorly from the entoconid, without reaching the ends of the postentocristid by the transverse valley.

m2: In lower second molar displays a bunoselenodont morphology, which is composed with high crown and well-developed cristid. There is a prominent ectostylid in the transverse valley at buccal side. The second molar is worn and completely preserve. The cingulid is present buccally. *Dorcatherium* fold and *Tragulus* fold are present at the metaconid and protoconid, directed posteriorly and representing prominent M shape structure. The trigonid is narrower than the talonid. There is a short and low crest along the lingual side of the entoconid, which almost reach the posterior of the metaconid.

m3: The molar is bunoselenodont and high-crowned teeth. The third molar is worn and completely preserved. The tiny ectostylid and postectostylid is present in the transverse valley. The enamel is rugose especially on the buccal side of m3. There are well-developed of the 'M' structure of the *Dorcatherium* fold that can be seen clearly which formed by the bifurcation of the post-protocristid and the metaconid and *Tragulus* fold on the post-protocristid. The hypoconulid is well-developed, obliquely situated between entoconid and hypoconid. The hypoconulid anteriorly connects to the post- hypocristid which is centrally situated and aligned with the major anteroposterior axis of the crown. The hypoconid is separated from the central lobe by a wide and deep buccal cleft. There is a short and low crest along the lingual edge of the hypoconulid, which does not reach the posterior of the entoconid. The post-entocristid descends from the apex of entoconid to the bottom of the valley that separates it from the posthypocristid.

Figure 4.2 Schematic Drawing of the occlusal surface of the lower check teeth (CUF-MB-10)

Cusp	Length(mm)	Width(mm)	Height(mm)
m3	21.31	11.05	5.91
m2	12.20	10.24	5.06
m1	11.49	9.28	4.15

Table 4.1 Measurement of right hemimandible (mm) KKF-17-2

Cusp	Length (mm)	Width (mm)	Height (mm)
m3	20.94	11.10	4.62
m2	14.76	10.91	3.21
m1	12.90	9.39	3.49
p4	13.16	6.56	6.54
p3	14.05	5.25	6.76
Molar Row	48.16		
Premolar Row	27.37		

Table 4.2 Measurement of left hemimandible (mm) (CUF-MB-10)

Comparison From morphology characteristics and the nearest size in Figure 4.4, *Dorcabune* sp. (Maroon line, highlight in red circle) is closer to *Dorcabune nagrii* (Orange square) in each cusp.

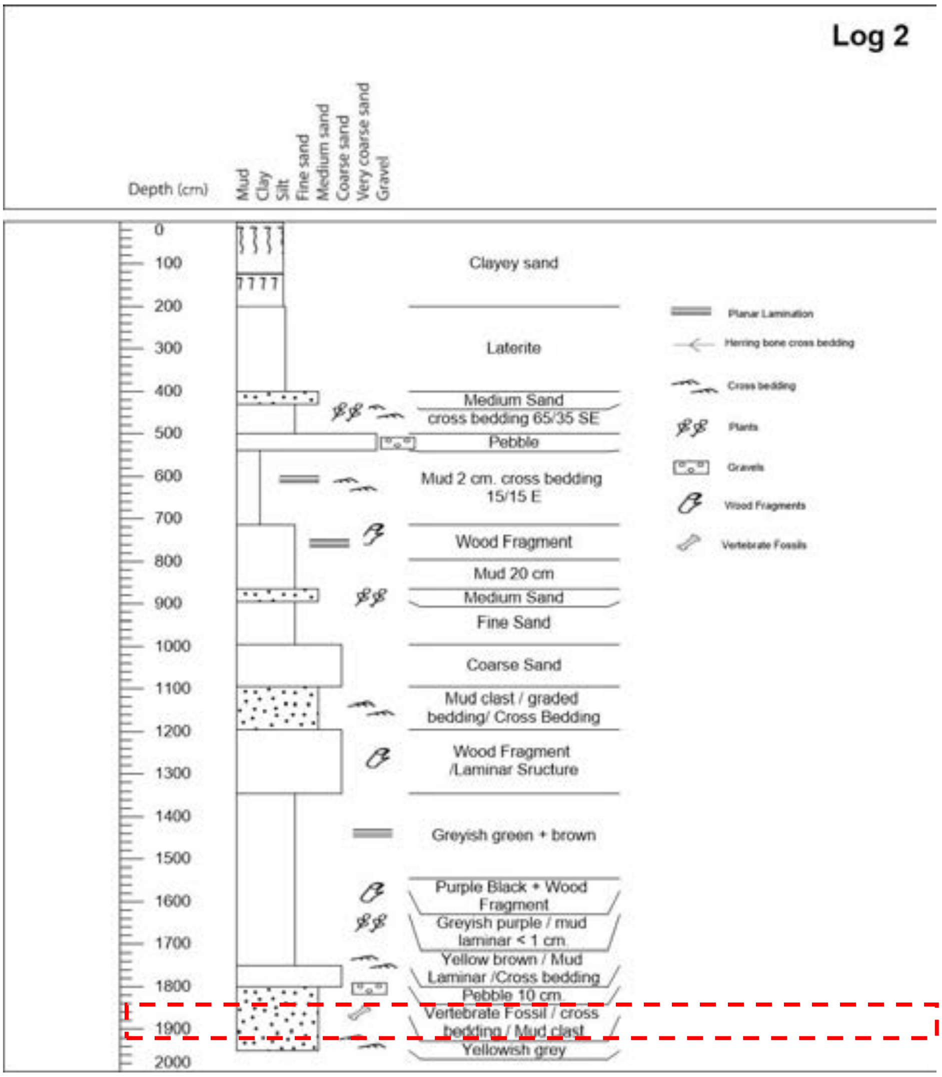


Figure 4.3 Stratigraphic section at Chalermprakiat Sand pit

(Vertebrate Fossil, Red line)

Cusp	Length(mm)	Width(mm)	Height(mm)
m3	21.34	10.63	2.95
m2	12.81	10.26	2.91
m1	9.63	7.86	2.88

Table 4.3 Measurement of left hemimandible (mm) (KKF-17-3)

Distribution The genus *Dorcabune* is known from the Lower Siwaliks of Chinji, the Middle Siwaliks of Nagri, Dhok Pathan Formations and Lower Manchar of Bhagothoro, Pakistan (Pilgrim, 1910, 1915; Colbert, 1935). Moreover, this genus is also known from China (Han. De-Fen, 1974), Myanmar (Tsumaboto et al., 2006) and Vietnam (Prieto et al., 2017) as in Figure 4.7

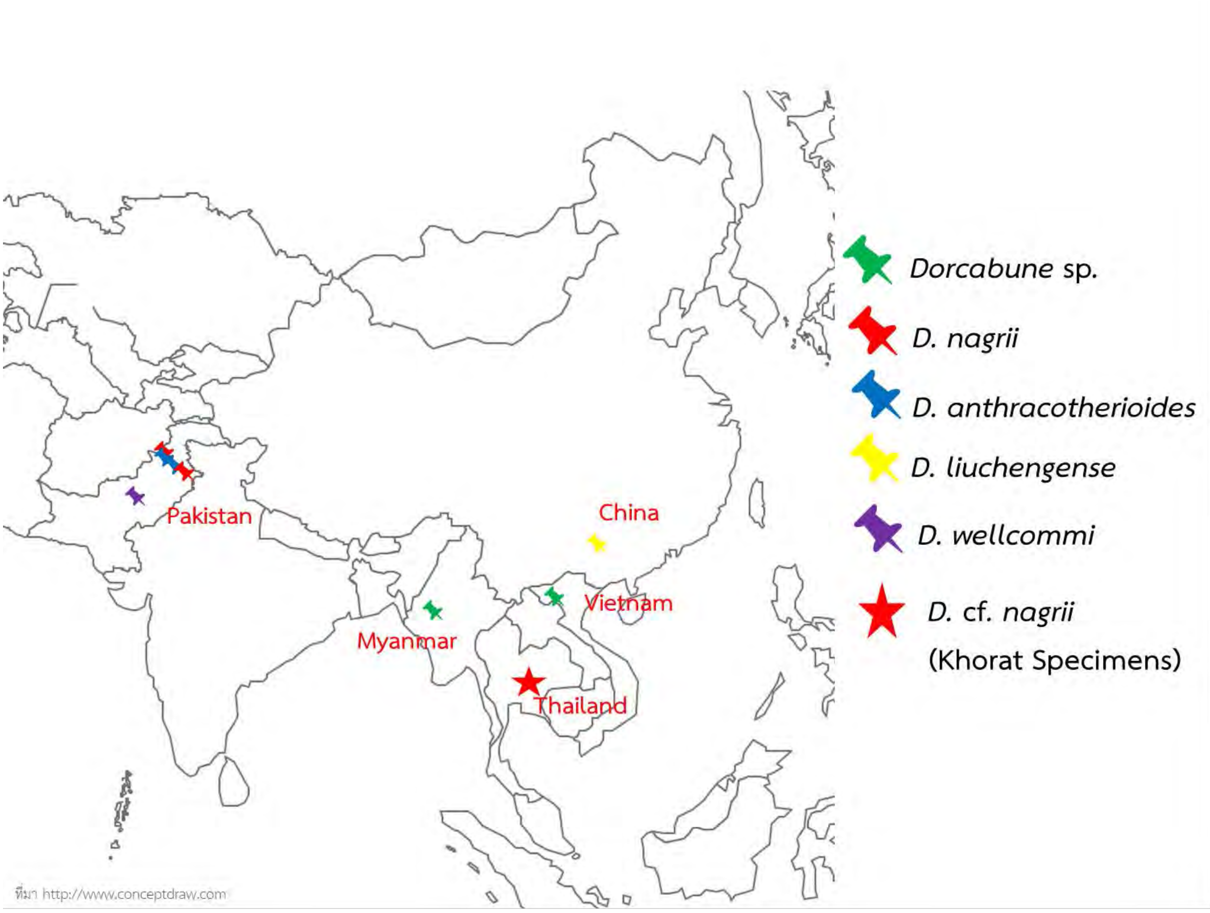
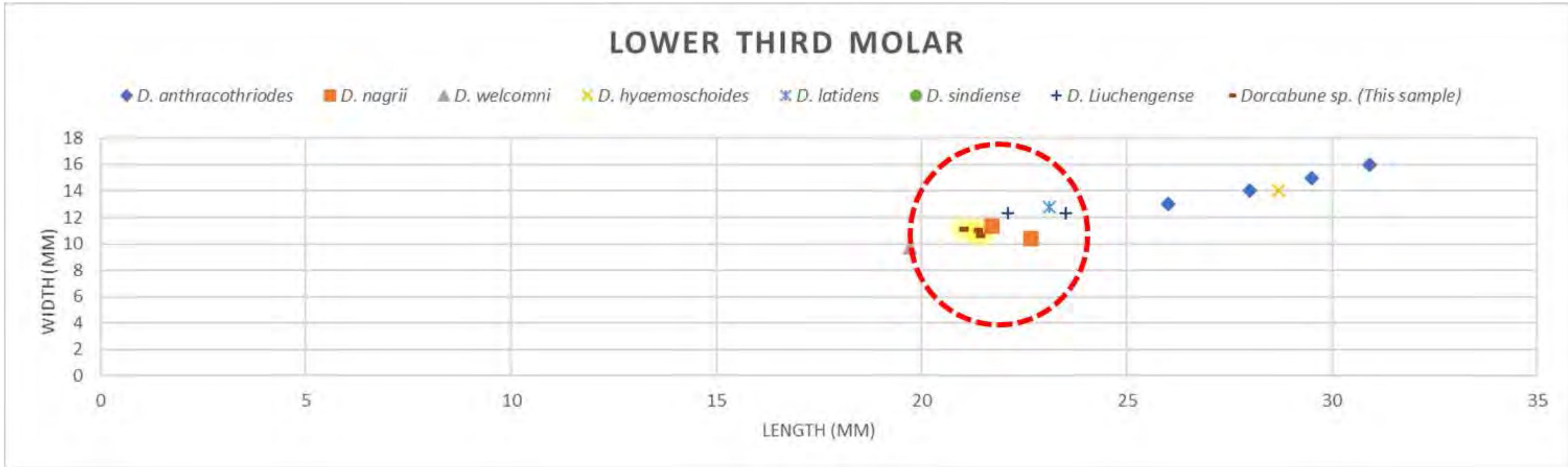
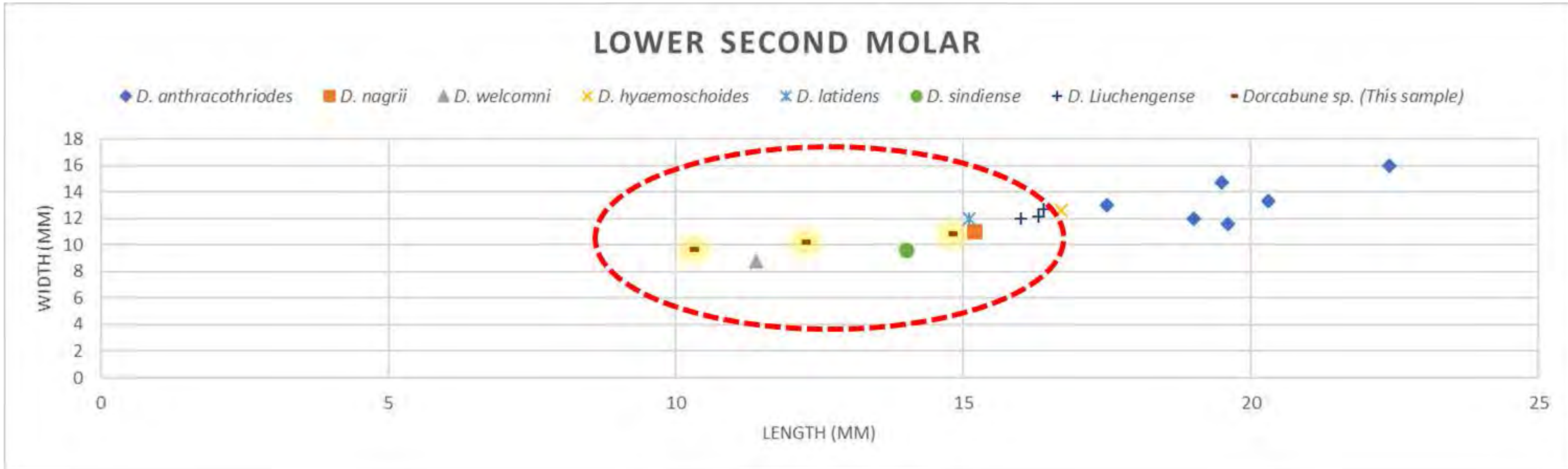


Figure 4.4 Distribution the genus *Dorcabune*


LOWER THIRD MOLAR
D. anthracothriodes
D. nagrii
D. welcomni
D. hyaemoschoides
D. latidens
D. sindiense
D. Liuchengense
Dorcabune sp. (This sample)
WIDTH (MM)
LENGTH (MM)
0
2
4
6
8
10
12
14
16
18
0
5
10
15
20
25
30
35


LOWER SECOND MOLAR
D. anthracothriodes
D. nagrii
D. welcomni
D. hyaemoschoides
D. latidens
D. sindiense
D. Liuchengense
Dorcabune sp. (This sample)
WIDTH (MM)
LENGTH (MM)
0
2
4
6
8
10
12
14
16
18
0
5
10
15
20
25

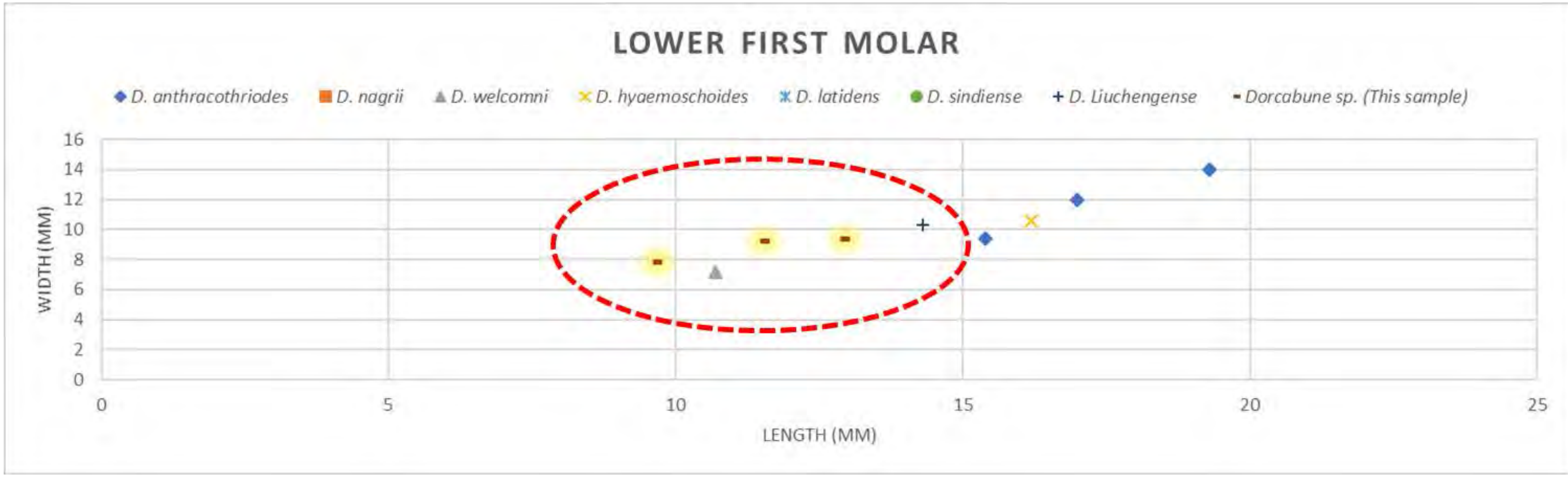


Figure 4.5 Scatter diagram showing dental proportions of the *Dorcabune* sp. (This sample) with related *Dorcabune* in the world of each cusp. Referred data are taken from (Colbert, 1935), (Farooq et al., 2007a, b), (Khan A., 2012), (Khan A., 2013), (L. Ginsburg & J. Morales., 2001) and (Han. De-Fen, 1974)

Kingdom: Animalia Linnaeus, 1758

Phylum: Chordata Haeckel, 1874

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen, 1848

Family Tragulidae Milne Edwards, 1864

Genus *Dorcatherium* Kaup, 1833

Dorcatherium cf. *minus* Lydekker, 1876

Generic Diagnosis (from Colbert, 1935) "A large species of *Dorcatherium*, with strong mesostyle and cingula in the upper molars and well developed accessory pillars in the lower molars."

Type species *Dorcatherium nauii* Kaup, 1833

Type Specimen GSI 195, two upper molars, namely right M1-2 (Colbert, 1935)

Type Locality Hasnot, Nagri, Chinji, Rati Dheri, Bhandar, Vasnal, Bhilomar

Diagnosis (from Colbert, 1935) " A small species of the genus Dorcatherium with sub-hypsodont molar and broad crowned molars having well developed cingulum, rugosity, styles, moderately developed ribs and vestigial ectostylids"

Studied specimen KKF-17-1 Left hemimandible (Lower cheek teeth molar 2-3) (Figure 3.18-3.20, Table 4.4)

Locality Chalermprakiat sand pit, a district of Nakhon Ratchasima Province, northeastern part of Thailand

Studied Stratigraphic Horizon Around 19 meters from surface in medium sand layer from chalermprakiat sand pit (Figure 4.3)

Description

Lower Dentition

<u>m2:</u> In lower second molar displays a bunoselenodont morphology, which is composed bunodont more than selenodont and with low crown and well-developed cristid. There is a

prominent ectostylid in the transverse valley at buccal side. The second molar is worn and completely preserve. The cingulid is not rugose. *Dorcatherium* fold and *Tragulus* fold are present at the metaconid and protoconid respectively, directed posteriorly and representing prominent M shape structure that can see clearly. There is a short and low crest along the lingual and buccal side of the every cuspid that all connect each other.

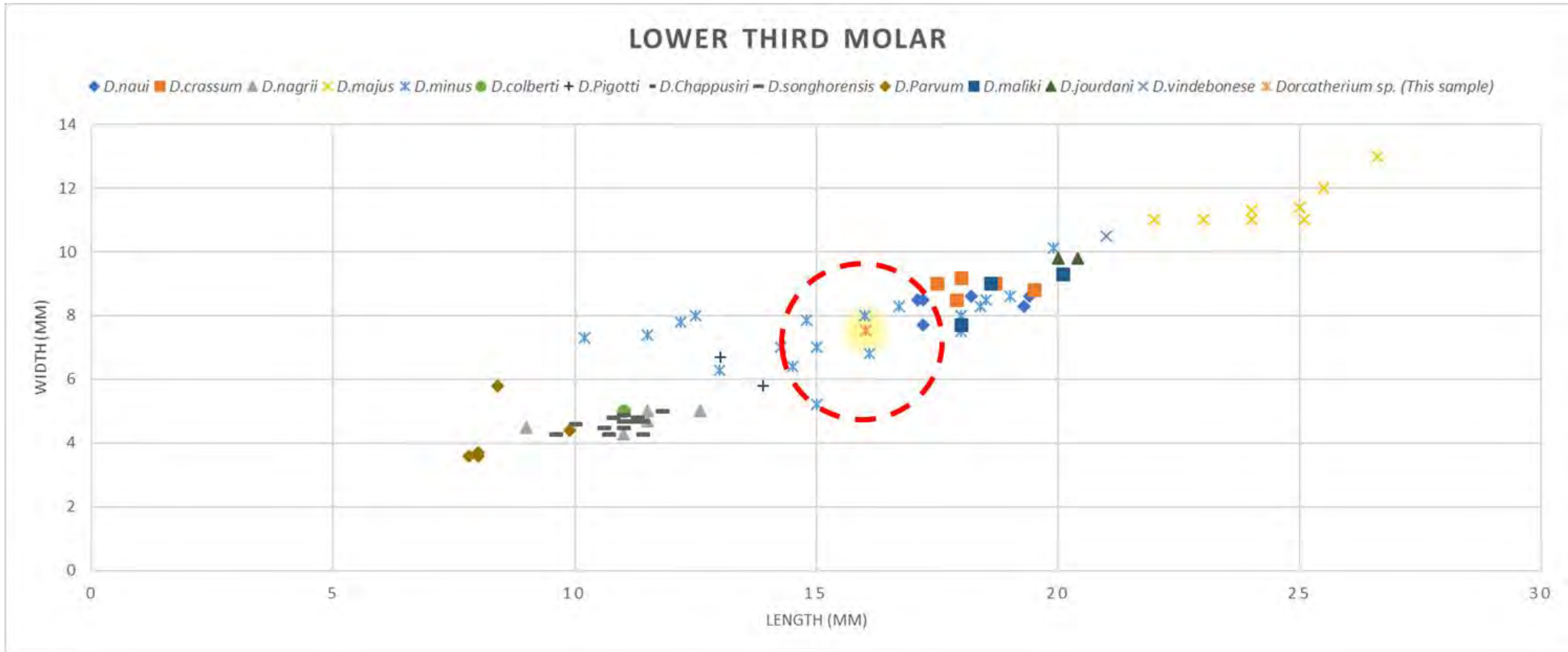
m3: The molar is bunoselenodont and low-crowned teeth which is composed bunodont more that selenodont. The third molar is worn and completely preserved. The ectostylid and postectostylid is present in the transverse valley at the buccal side. The enamel is not rugose. There are well-developed of the ‘M’ structure of the *Dorcatherium* fold and *tragulus* fold that can be seen clearly but less than second molar. The hypoconulid anteriorly connects to the post-hypocristid which is centrally situated and aligned with the major anteroposterior axis of the crown, is connected from the central lobe by a wide and deep buccal cleft.

Figure 4.6 Schematic Drawing of the occlusal surface of the lower check teeth (KKF-17-1)

Cusp	Length (mm)	Width(mm)	Height(mm)
m3	14.57	6.92	2.11
m2	10.17	6.77	3.16

Table 4.4 Measurement of left hemimandible (mm) (KKF-17-1)

Comparison From morphology characteristics and the nearest size in Figure 4.7, *Dorcatherium* sp. (Orange cross(1st) Grey Circle(2nd), highlight in red circle) is closer to *Dorcatherium minus* (Blue cross) in each cusp.


LOWER THIRD MOLAR
D.naui D.crassum D.nagrii D.majus D.minus D.colberti D.Pigotti D.Chappusiri D.songhorensis D.Parvum D.maliki D.jourdani D.vindebonese Dorcatherium sp. (This sample)
WIDTH (MM)
LENGTH (MM)
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30

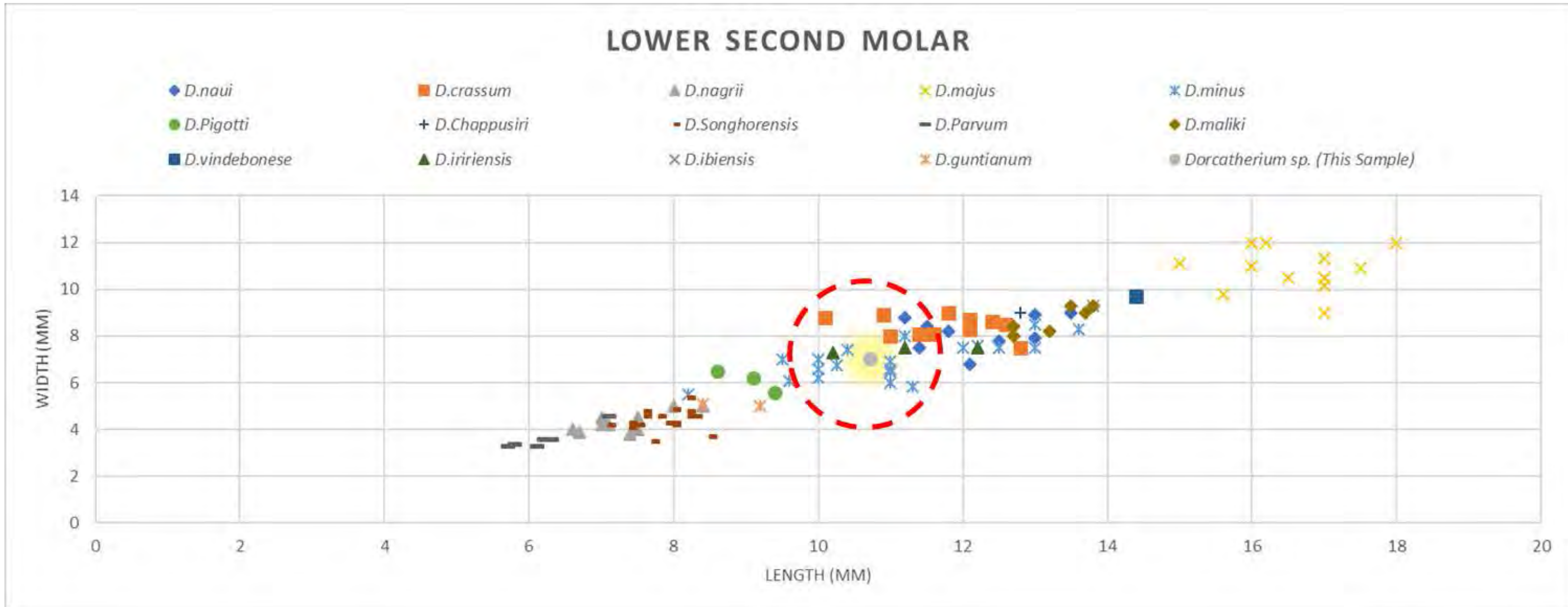

LOWER SECOND MOLAR
D.naui
D.crassum
D.nagrii
D.majus
D.minus
D.Pigotti
D.Chappusiri
D.Songhorensis
D.Parvum
D.maliki
D.vindebonese
D.iririensis
D.ibiensis
D.guntianum
Dorcatherium sp. (This Sample)
WIDTH (MM)
LENGTH (MM)
0
2
4
6
8
10
12
14
0
2
4
6
8
10
12
14
16
18
20

Figure 4.7 Scatter diagram showing dental proportions of the *Dorcatherium* sp. (This sample) with related *Dorcatherium* in the world of each cusp. Referred data are taken from (Colbert, 1935), (Farooq et al., 2007a, b, 2008), (Alba et al., 2011), (Alba et al., 2014), (Czyzewska, 1994), (Khan, M.A., 2005, 2010, 2011, 2012, 2013, 2017), (Gaur et al., 1983, 1992), (IQBAL M., 2011), (West, 1980), (Prasad, 1968), (Vasihat, 1985), (R.K. Sehgal, 2015), (Pilgrim, 1915), (Sankhyan, 1981), (A.N. Trivedy, 1996), (E. Tcherno, 1987), (Hamilton, 1973a), (Thomas et al., 1982), (Whitworth, 1958), (E. Rossner, 2008, 2010, 2013), (Mennecart, 2018), (Morales et al., 2012), (Bayer, 1985), (Kostopoulos D. S. & Sen S., 2016), (Gerraads D., 2005), (Filhol, 1891), (Kaup, 1839a), (Thenius, 1952), (Pickford, 2002), (Quiralte et al, 2008), (Samiullah, 2015), (Hilenbrand, 2009), (Hanta, 2008)

Distribution *Dorcatherium* has been reported from the Europe (Kaup 1833; Arambourg & Piveteau 1929; Rössner 2007, 2010; Hillenbrand et al., 2009), The Africa (Arambourg 1933; Whitworth 1958; Hamilton 1973; Pickford 2002; Pickford et al., 2004; Quiralte et al., 2008; Geraads 2010; Sánchez et al., 2010) and the South Asia (Lydekker 1876; Colbert 1935; Prasad 1970; Sahni et al. 1980; West 1980; Farooq 2006; Farooq et al. 2007b, 2007c, 2008; Khan et al., 2011).

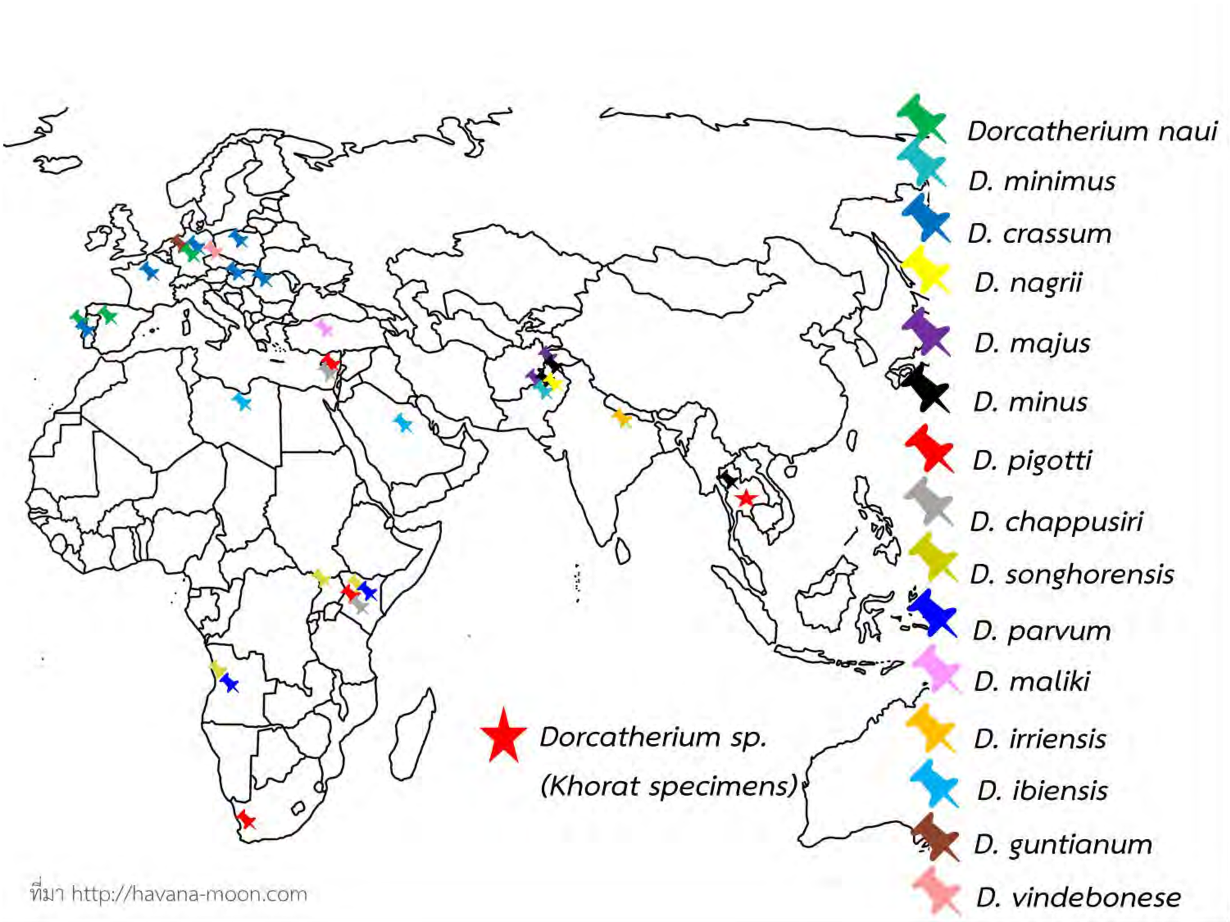


Figure 4.8 Distribution of the genus *Dorcatherium*

Comparison between *Dorcabune* and *Dorcatherium*

Dorcabune sp.	*Dorcatherium* sp.
Tragulus-fold	*Tragulus*-fold
Dorcatherium-fold	*Dorcatherium*-fold
Larger in size	Smaller in size
Pyramidal protoconid	No pyramidal protoconid
Rugose enamel	Smooth enamel
More bunodont	Less bunodont
Brachyodont	Brachyodont (but higher crown ratio)

Table 4.5 Comparison between *Dorcabune* and *Dorcatherium*

4.1.2 Lophodont Ungulate

Kingdom: Animalia Linnaeus, 1758

Phylum: Chordata Haeckel, 1874

Class: Mammalia Linnaeus, 1758

Order: Proboscidea Illiger, 1811

Family: Deinotheriidae Bonaparte, 1841

Genus: Prodeinotherium Ehik, 1930

Prodeinotherium sp.

Type species *Deinotherium bavaricum* Von Meyer, 1831

Type Specimen Lower p3 dext., specimen number BSP AS I 220, a lectotype designated by Gräf, 1957.

Type Locality Georgensgmünd, Bavaria, Germany, MN6 (Göhlich, 1999, p. 166).

Diagnosis (from Harris, 1973) "Small deinotheres. Dental formula for the family; M2–3 with well-defined postmetaloph ornamentation. Skull rostrum turned down parallel to the mandibular symphysis; rostral trough and external nares narrow; preorbital swelling close to orbit; external nares anteriorly positioned and nasal bones with anterior median projection; skull roof relatively longer and wider than in Deinotherium; occiput more vertically inclined; occipital condyles positioned more ventrally than in Deinotherium and level with the Frankfurt plane; paroccipital processes short. Postcranial skeleton graviportally adapted; scapula with well-defined spine and stout acromion and metacromion; tarsals and carpals narrow but not dolichopodous"

Studied specimen CUF-MB-21 Upper Dentition (Left Third Molar) (Figure 3.15-3.17, Table 4.6) and CUF-MB-20 Upper dentition (Left third premolar) (Figure 3.12-3.14, Table 4.7)

Locality Phimai sand pit, a district of Nakhon Ratchasima Province, northeastern part of Thailand

Studied Stratigraphic Horizon Around 12 meters from surface in sandy clay layer from Phimai sandpit (Figure 4.1)

Description

Upper Dentition

M3: The third molar is bilophodont and shape look like trapezoid. The lophs have complete and concave posteriorly. The molar is worn, completely preserved and enamel missing at protocone. The cingulum is on the anterior, buccal, and posterior walls. The protoloph is aligned linguobuccally that wider than metaloph in the same direction. The postparacrista and postparacrista are long, crenulated, pointing posteriorly. The posthypocrista and postmetacrista are short, crenulated, point posteriorly. Anterior and posterior cingulum present, strongly developed; anterior cingulum slightly ascends at protocone forming a small elevation to paracone too and posterior cingulum descends from lingual to buccal side ascending at metacone and hypocone. The weakness of lingual cingulum.

Figure 4.9 Schematic Drawing of the occlusal surface of left third molar

	Length	Width	Height
Teeth	48.36	49.86 (Anterior) 39.12 (Posterior)	19.92

Table 4.6 Measurement of upper dentition (mm) (CUF-MB-21)

P3: The third premolar is bilophodont and subrectangular-shaped. The premolar is worn, incompletely preserved and enamel missing at protocone and hypocone. The cingulum is on the anterior and posterior walls. The protoloph is aligned linguobuccally that narrower than metaloph in the same direction which descends buccally and does not reach to paracone (protoloph incomplete). The metaloph has ascended buccally from hypocone to metacone (metaloph complete). The paracone has missed by fracture and protocone has also broken lingually. Anterior and posterior cingulum present, poorly developed and short. The weakness of lingual and buccal cingulum. There is median valley between hypocone and protocone that curve along anterobuccally side.

Figure 4.10 Schematic Drawing of the occlusal surface of the left third premolar

Teeth	Length	Width	Height
	43.29	41.19	26.45

Table 4.7 Measurement of upper dentition (mm) (CUF-MB-20)

Comparison From morphology characteristics and the nearest size in Figure 4. 11, *Prodeinotherium* sp. (Blue Plus, highlight in red circle) we cannot conclude that came from what species because *Prodeinotherium bavaricum* (Green circle) and *Prodeinotherium hobleyi* (Maroon Line) cannot come from Europe to Thailand without changing the species. So, there is a possibility of *Prodeinotherium* sp. (This sample) can become new species. Moreover, we bring *Deinotherium* to compare with our specimens due to the similar morphology, but size larger than *Prodeinotherium*.

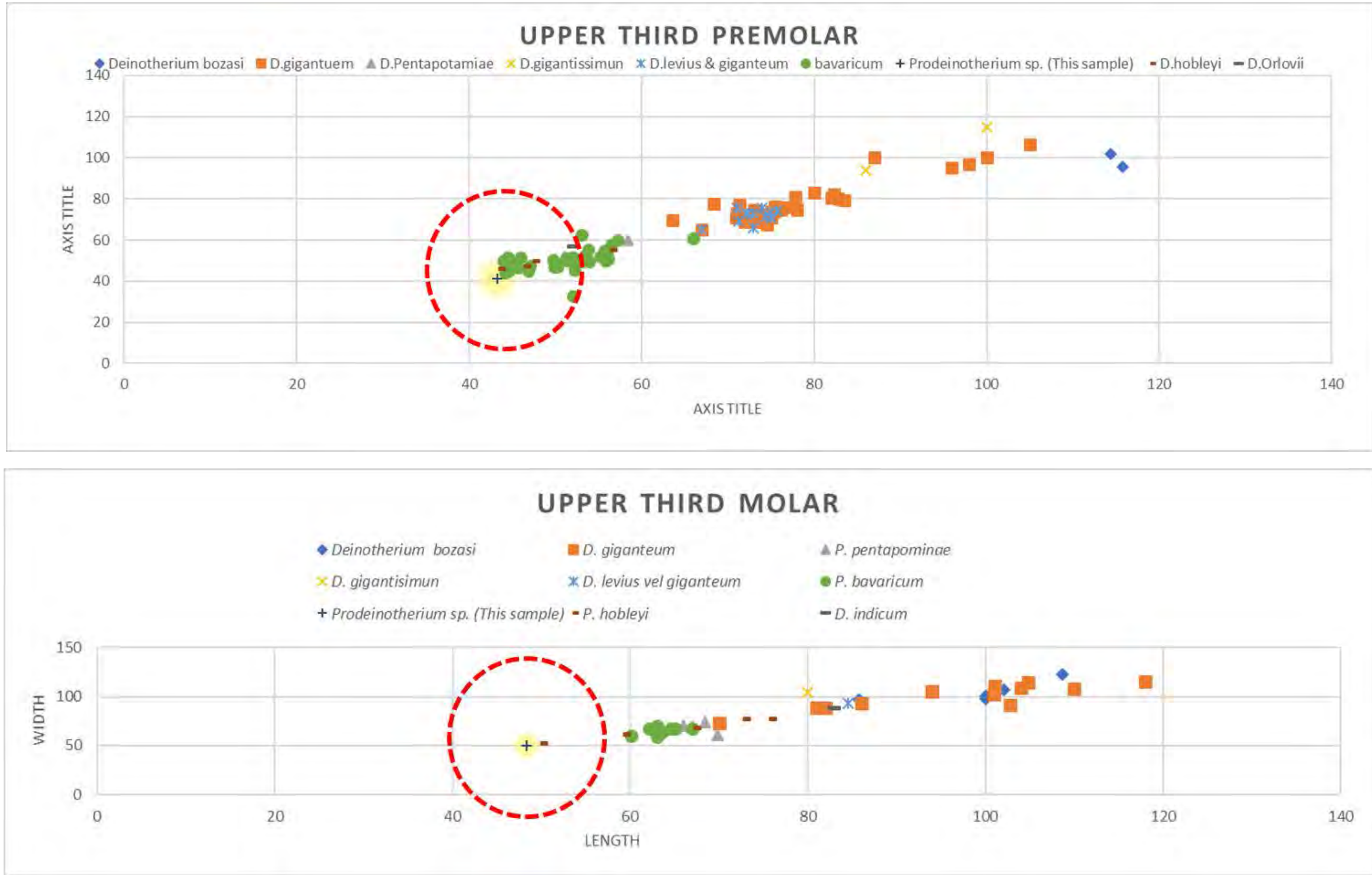


Figure 4.11 Scatter diagram showing dental proportions of the *Prodeinotherium* sp. (This sample) with related *Prodeinotherium* in the world of each cusp. Referred data are taken from (Sankyan, 2014), (Aiglstorfer, M., 2014), (Harris, 1975), (Gerraads D., 2005), (Ataabadi, 2011), (Poulakakis N., 2005), (A.V. Mazo & P. Montoya, 2003), (Athanassiou, A. 2004), (Lydekker, 1980), (Vergiev S., 2012), (M.Gasparik, 1993), (Tsoukala, 1994), (Sanders, 2010), (Gräf, 1957), (Thenius, 1952), (Göhlich & Huttunen, 2009), (Tobien, 1988)

Distribution The genus *Prodeinotherium* is known in Europe from (Mottl, 1969; Huttunen, 2009) (Bakalov and Nikolov, 1962), (Antoine et al., 1997), (Gräf, 1957), (Gasparik, 1993), (Antunes, 1989), (Laskarev, 1944), (Bergounioux and Crouzel, 1962a, b), (Weinsheimer, 1883) (Vergiev S., 2012) and (M. Gasparik, 1993). In Africa (Sanders, 2010) and in Asia (Qiu et al., 2007), (Thasod, 2012), (West et al., 1978), (Tiwari, 2006) and (Sankyan, 2014)

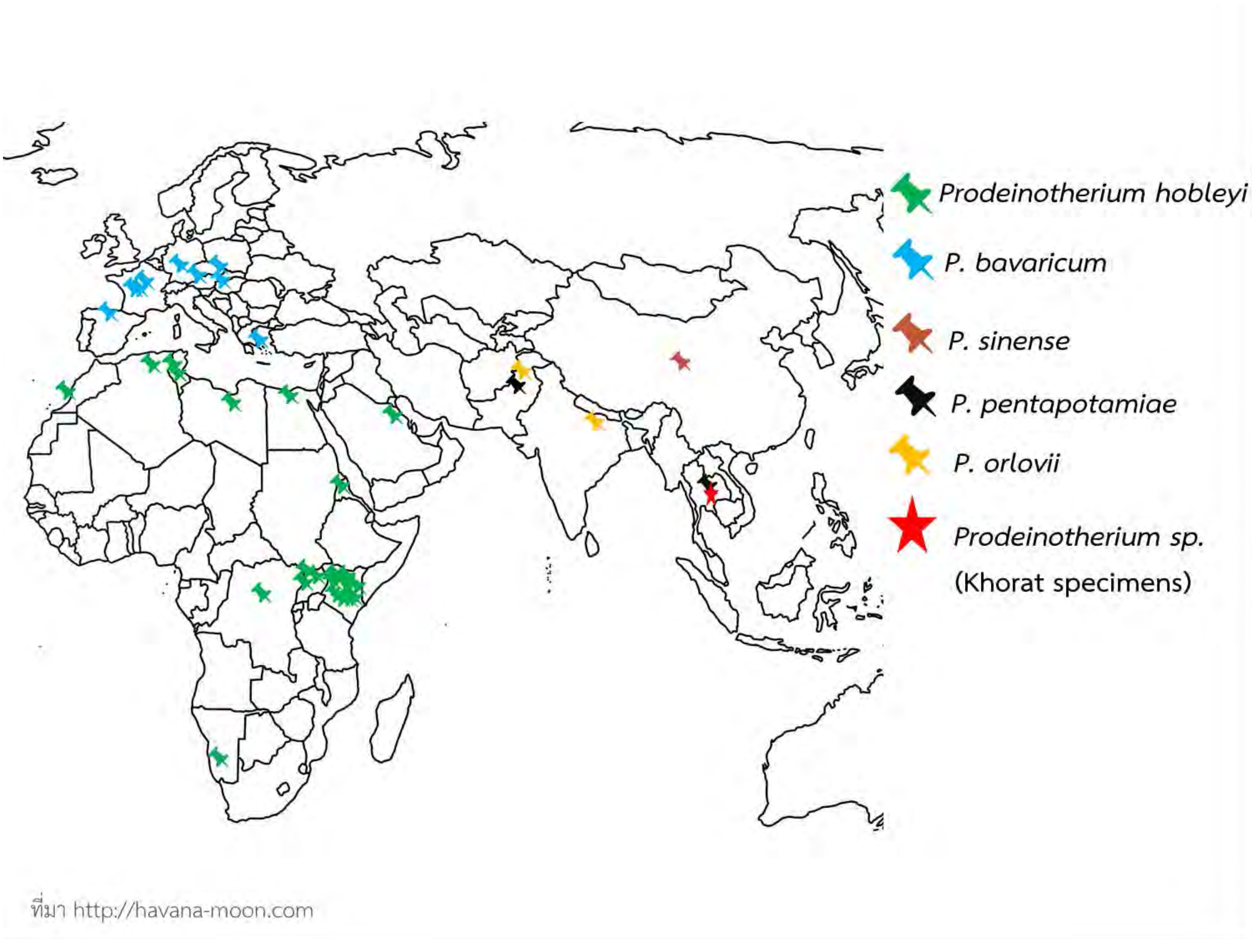


Figure 4.12 Distribution of the genus *Prodeinotherium*

4.2 Discussion

4.2.1 Paleoenvironment

There is a high probability that all species found in these sand pits lived in forest and rivers (Table 4.8). In present, these sand pits are located at the Mun river. So that there is a probability that the main river that has transported all fossils to deposit in this area is a paleo-Mun river. As figure 4.3, Using the carbon and oxygen isotope to find out the paleoenvironment that is mesic/woodland. This table below shows the paleoenvironment in Lower and Middle Siwalik group of a part of Northwestern Himalaya. The deposition of sediments resulted from the meandering fluvial, the river system had high energy. This place had oxidized, warm, humid conditions during deposition (R.K. Sehgal, 2002). From the characteristics of depositing identical and fauna assemblage with similar path of Siwalik group and this study, it is inferred that the paleoenvironments of Khorat sand pits at that time corresponded to mesic or woodland environment.

Dorcatherium cf. *minus*	*Dorcabune* cf. *nagrii*	*Prodeinotherium* sp.
Dorcatherium was a forest dweller. It inhabited the river banks and roamed in nearby forests in search of food (Grizmek, 1972)	*Dorcabune* was probably bush dweller (Vasishat et al. 1978a)	*Prodeinotherium* frequented fresh water lakes and rivers. Vasishat et al. (1978b) stated that it had dentitions suitable for plucking succulent vegetation and it might have inhabited the semi- aquatic zones of the area

Table 4.8 Comparison of Paleoenvironment

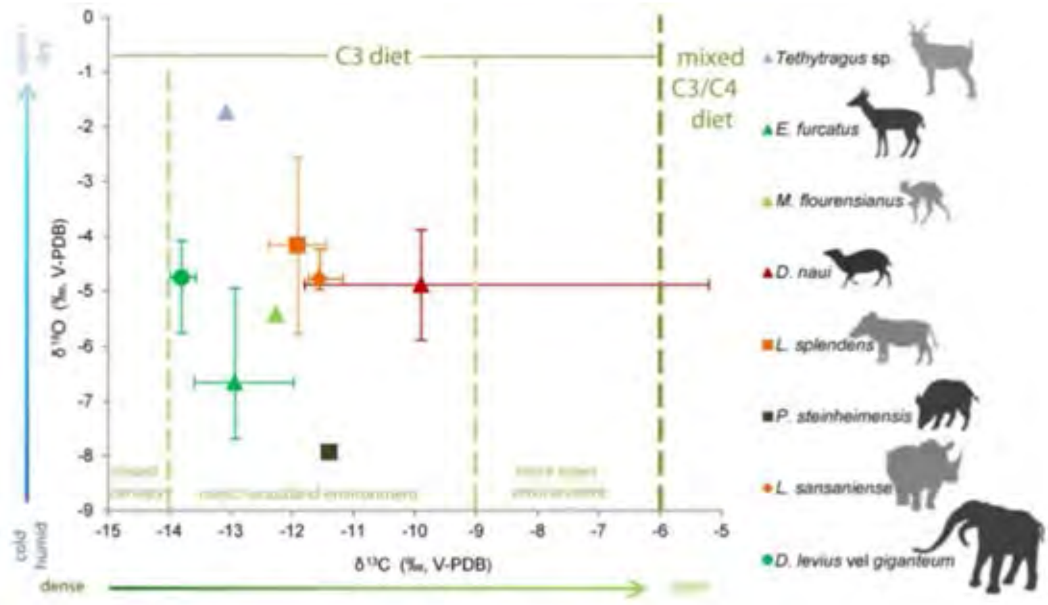


Figure 4.13 Shown the Environment of each species (Aiglstorfer, 2014)

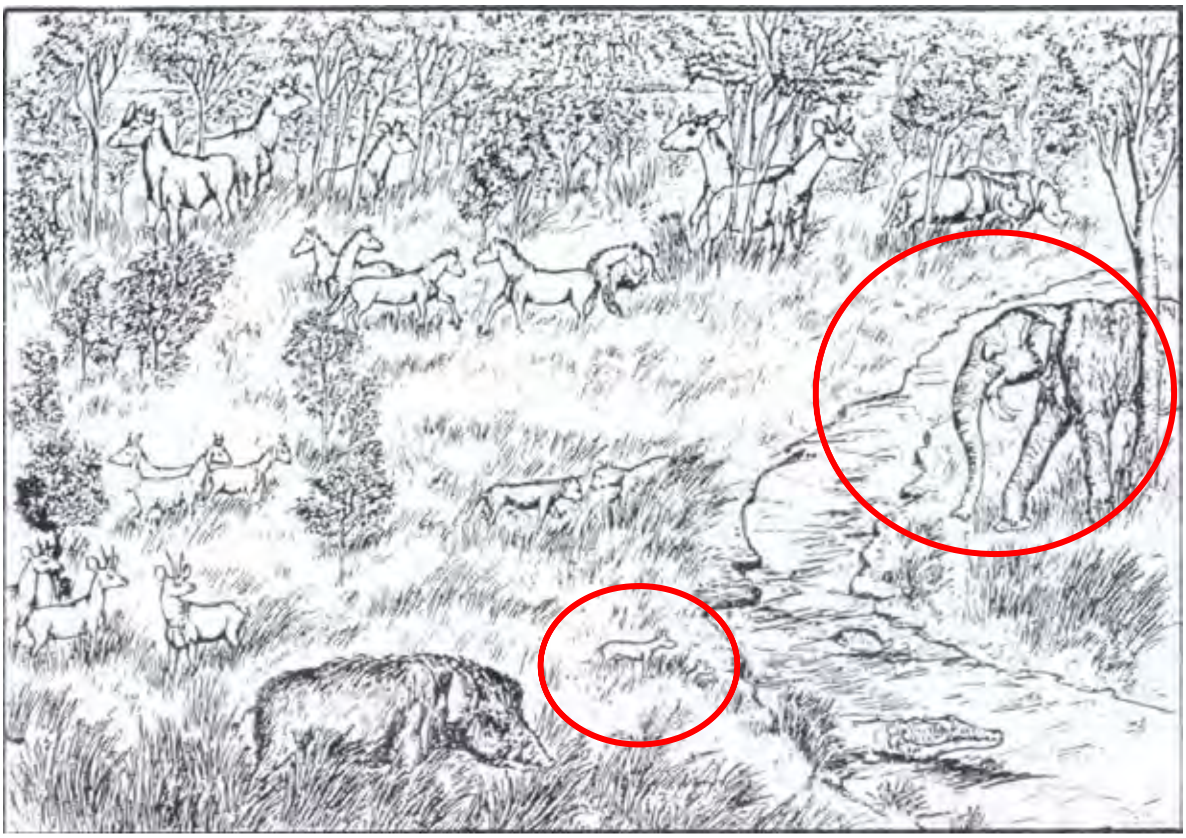


Figure 4.14 Paleoenvironment with *Prodeinotherium* and *Dorcatherium* (Red Circle) (R.K. sehgal, 2002)

Figure 4.15 Paleoenvironment with *Prodeinotherium* and *Dorcatherium* (Red Circle) (R.K. sehgal, 2002)

4.2.2 Ages

From the genera of *Prodeinotherium* around the world, it has 5 species including *Prodeinotherium hobleyi* (23.03-8.5 Ma), *Prodeinotherium orlovii* (23.03-15.7 Ma), *Prodeinotherium bavaricum* (20.5-11.6), *Prodeinotherium pentapotamiae* (11.2-5.9 Ma) and *Prodeinotherium sinense* (7.4-5.9). We gather all ages together of *Prodeinotherium* that in the 23.03-5.9 Ma. Moreover, *Dorcatherium minus* and *Dorcabune nagrii* have the same ages range (14.2-3.4 Ma). We use the intersect ranges between these species that is 14.2-5.9 Ma (Middle Miocene - Late Miocene) (Figure 4.16). If we focus about *Prodeinotherium* in Asia (*Prodeinotherium pentapotamiae* and *Prodeinotherium sinense*), the ages are restricted only to 11.2-5.9 Ma (Late Miocene) has According to the high sedimentation rate of deposition (Putthapiban et al., 2012), all fossils studied here seem contemporaneous

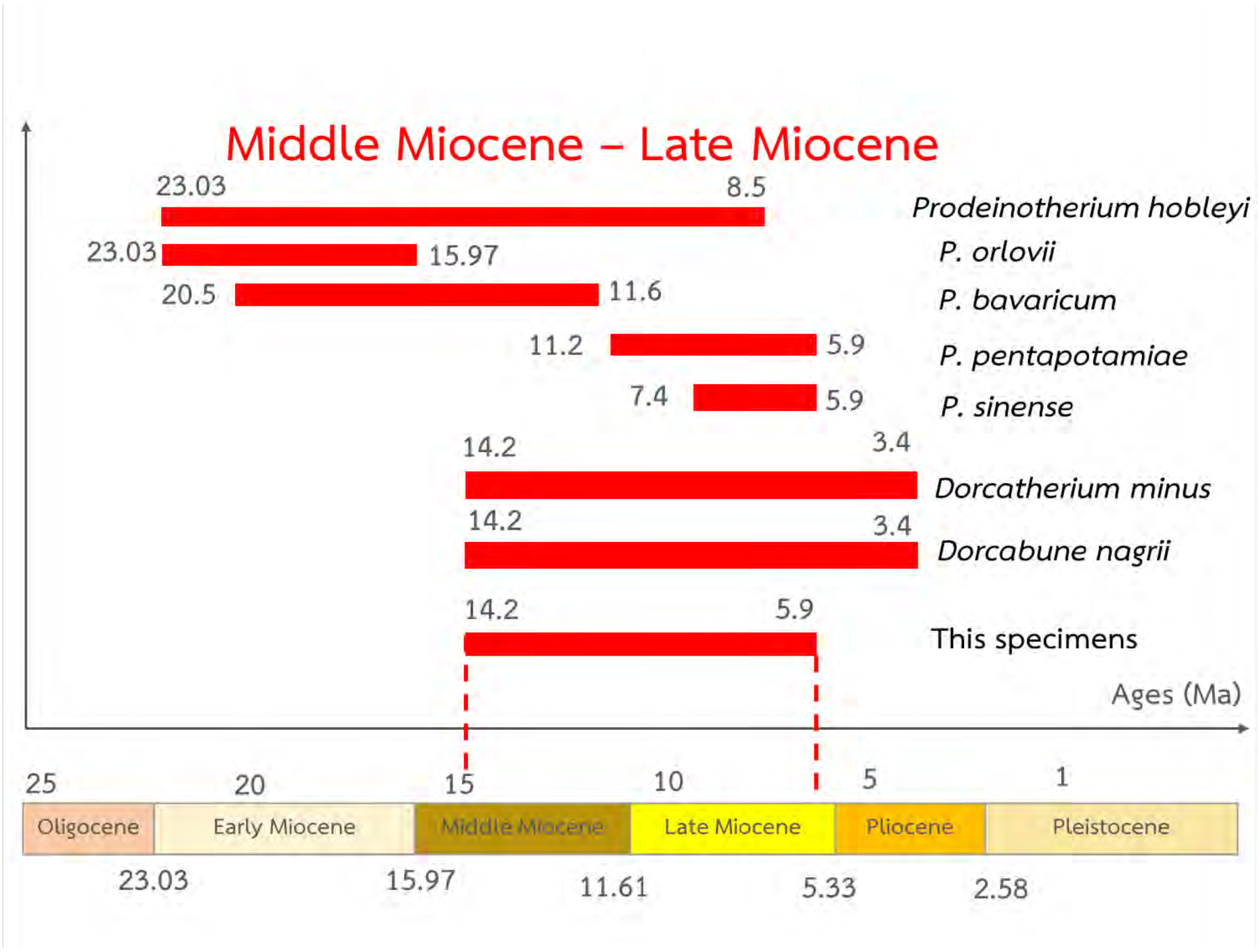


Figure 4.16 Ages range of this specimens

4.2.3 Distribution

From the previous records, we can identify in the map (Figure 4.17). *Dorcatherium* and *Dorcabune* found only at Pakistan and *Prodeinotherium* found at Pakistan, India and China. So, our taxonomic identification of these fossils suggests Pakistanis and Chinese origins that possibly migrated to Thailand during the Miocene.

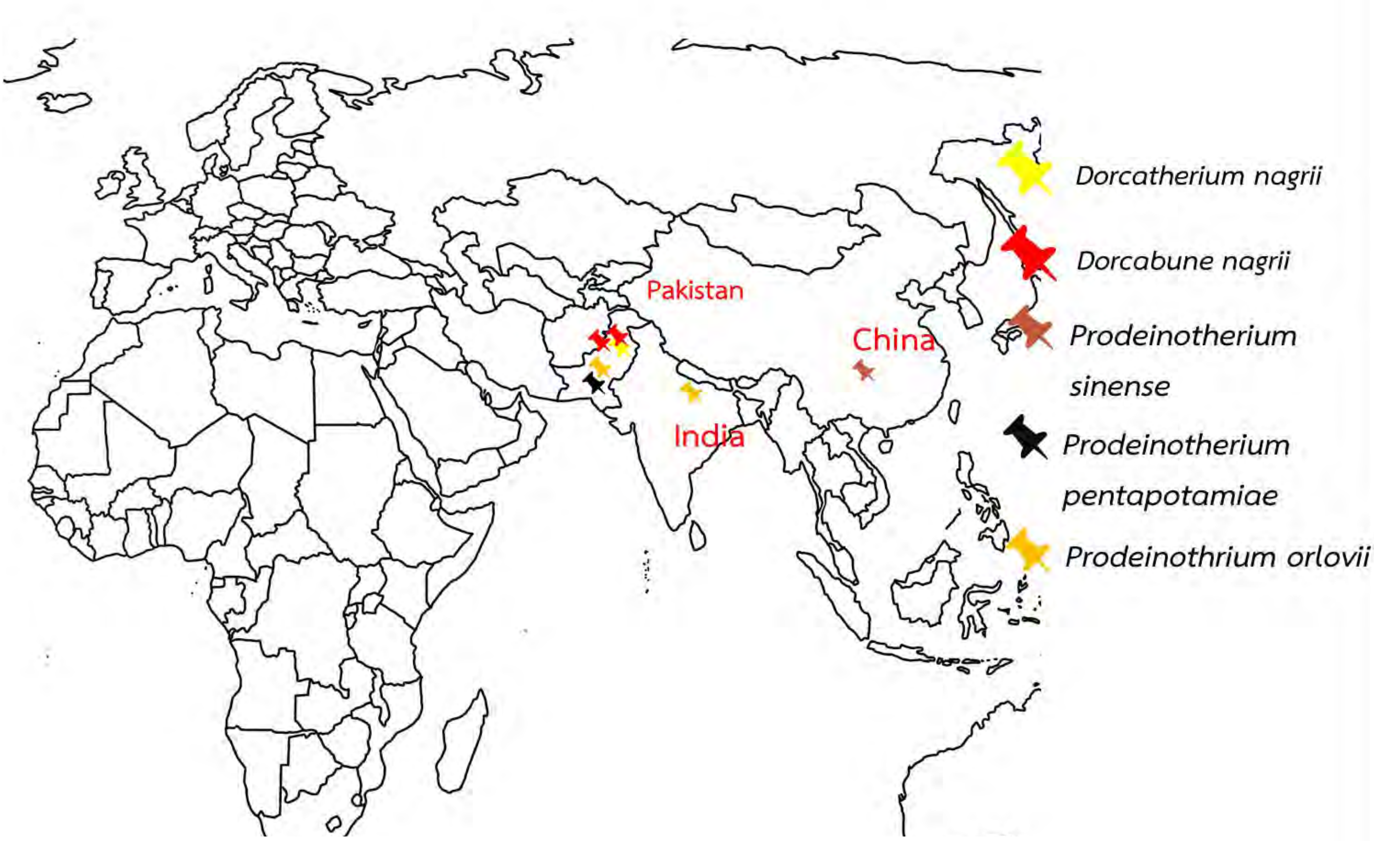


Figure 4.17 Distribution of this specimens

CHAPTER 5 CONCLUSION

5.1 Conclusion

This research provides information regarding the taxonomic status of fossils. The material composes of 3 left mandibles and 1 right mandible of bunoselenodont ruminants and isolated P3 (upper third premolar) and M3 (upper third molar) of lophodont ungulates. On the basic of dental morphologies, three mammalian fossils were identified: bunoselenodont teeth belong to tragulids (*Dorcabune* cf. *nagrii* and *Dorcatherium* cf. *Minus*) (Figure 5.2) and lophodont teeth belong to a small-bodied deinotherid (*Prodeinotherium* sp.) (Figure 5.1). Based on the biochronology achieved from all related taxa, the age of these fauna ranges between 14.2-5.9 Ma (Middle Miocene to Late Miocene) and the paleoenvironments corresponded to mesic/woodlands (Humid area moderate with Airy forest). Our taxonomic identification of these fossils suggests Pakistanis and Chinese origin that possibly migrated to Thailand during the Miocene. However, this discovery represents the first records of Miocene tragulids and deinotherids in Thailand.

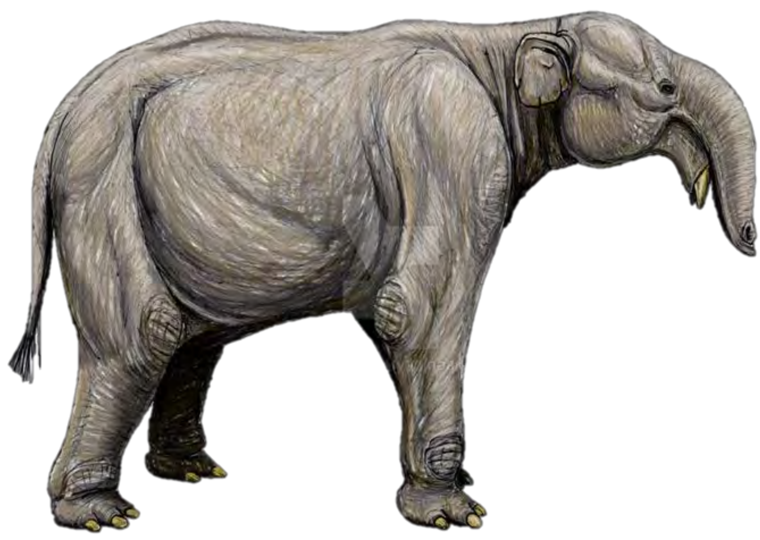


Figure 5.1 Picture of *Prodeinotherium* (https://dibgd.deviantart.com)

Figure 5.2 Picture of *Dorcatherium* (http://dinopedia.wikia.com)

5.2 Future Perspective

In the future, finding new specimens are crucial to confirm tragulids species (*Dorcabune* cf. *nagrii* and *Dorcatherium* cf. *Minus*) and *Prodeinotherium* sp. It is also important to study new specimens from other sands pits in Nakhon Ratchasima. Moreover, additional fossils are also important for more precise chronological determination in the future.

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