CHAPTER 5

NEOGENE ARTIODACTYLS

5.1 Introduction

This chapter concerns on the classification of some artiodactyls which found in Neogene deposits of Thailand. Artiodactyla is an order of even-toed ungulates which weight bear on third and fourth toes. The astragalus has a double-pulley structure allowing greater flexibility on foot (Macdonald and Norris, 2001). The fossil record of Artiodactyla is found in earliest Eocene, approximately 55 Ma. It is composed of three higher taxonomic categories, suiforms (pig groups), ruminantia (horned-animal group), and tylopod (camel groups) (Carroll, 1987). During Neogene period of Thailand, some group of suiformes and ruminantia were found, but without the tylopod.

The suiforms is composed of family Anthracotheriidae, Suidae, Tayasuidae, and Hippopotamidae. Excluded of Anthracotheriidae, other three family are of Superfamily Suoidea. Suidae is the Old World suids or true pigs. Tayassuidae is New World suids or peccaries. Tayassuidae is restricted to exclusively American forms since the Early Oligocene (Hünermann, 1999). Hippopotamidae is supposed to be evolved from Anthracotheriidae, and not from Tayassuidae (Boisserie *et al*., 2005). Hippopotamidae have not been reported in Thailand, except *Hippopotamus amphibius* which found in Nakhon Sawan and is of Pleistocene. Therefore, the Hippopotamidae would not mention herein this study. The details of other families are in the following sections.

Ruminantia is one of a suborder, of Artiodactyls, which composed of two infraorder, Tragulina and Pecora. Infraorder Tragulina are early ruminants which were hornless. Infraorder Pecora are higher ruminants which has cranial orments such as antler, horn, and ossicone. Tragulina is composed of Amphimerycidae, Hypertragulidae, Gelocidae, Leptomerycidae, and Tragulidae. Amphimerycid was European dweller. Hypertragulids are found in North America. Gelocids inhabited in Eurasia and leptomerycids are immigrants from Asia to North America. Tragulid is of Asian origins. Pecora are composed of Giraffidae, Bovidae, Moschidae, Antilocapridae, Paleomerycidae, Dromomerycidae, and Cervidae. Paleomerycidae and Dromomerycidae are giraffe-like families which are of the Old World and North America, accordingly. Antilocaprids and giraffids were highly diverse during Miocene. Bovids had a large, rapid adaptive radiation in the Miocene and Pliocene. Moschids is musk deer group which more primitive than the cervids, true deer. Cervids under went large radiation in the Pleistocene.

Order Artiodactyla Owen, 1848

Suborder Suiforms

Family Anthracotheriidae Leidy, 1869

Family Suidae

Family Tayassuidae Palmer, 1897

Suborder Ruminantia

Infraorder Tragulina

Family Amphimerycidae

Family Hypertragulidae

Family Gelocidae

Family Leptomerycidae

Family Tragulidae

Infraorder Pecora

Family Giraffidae

Family Bovidae

Family Moschidae

Family Antilocapridae

Family Palaeomerycidae

Family Dromomerycidae

Family Cervidae

The Neogene artiodactyls which reported in this study are composed of anthracotherid, suids, tayassuid, tragulids, and cervid. A cranium of anthracotheriid was found in Nakhon Ratchasima. A number of suids are discovered from Chiang Muan coal mine. Also, one tayassuid was found in this mine. Tragulids were found at Chiang Muan, Mae Soi, Sop Mae Tham, Na Sai, and Mae Lai which is outside the studied area. Cervids are from Chiang Muan and Mae Lai. These Neogene mammalian fossils include 5 families, 10 genera, 13 species, listed as the following.

Family Anthracotheriidae Leidy, 1869

Subfamily Bothriodontinae

Merycopotamus sp.1

Family Suidae Gray, 1821

Subfamily Tetraconodontinae

Parachleuastochoerus sinensis

Conohyus indicus

Subfamily Suinae

Hippopotamodon cf. *hyotherioides*

Indeterminated gen. *et* sp.

Family Tayassuidae Palmer, 1897

Pecarichoerus sp.

Family Tragulidae Milne-Edwards, 1864

Siamotragulus haripounchai

Dorcatherium minus

Dorcatherium sp. 1

Dorcatherium sp. 2

Dorcatherium sp. 3

Family Cervidae Gray, 1821

Stephanocemas rucha

Stephanocemas sp.

5.2 Anthracotheriidae

Anthracotheres are one of the suiform ungulates. Body sizes range from small, terrier-size to large hippopotamid-size. Some advanced forms of anthracotherids, such as *Merycopotamus*, resemble the modern hippopotamus. The limb bones are heavy and relatively short (Black, 1978). In Africa, the Anthracotheriidae family ranges from Early Oligocene to Late Pliocene or Early Pleistocene. In Europe, the family ranges from Middle Eocene to Early Miocene. In

Asia, the family is Late Eocene in Pondaung in Myanmar and Krabi in Thailand. No Oligocene fossils are yet known. However, a number of Miocene and Pliocene forms were found in the Siwalik Group in Pakistan. The family became extinct in the Pleistocene.

5.2.1 Major Lineages of Neogene Anthracotheriidae

The family Anthracotheriidae has three subfamilies, Anthracotheriinae, Microbunodontinae, and Bothriodontinae. Anthracotheriinae forms are large anthracotheres and are characterized by having accessory cuspids on the mesial cingulum on the upper molar; no diastema between canine, C, and lower first premolar, P_1; elliptical symphysial section. Lower canines were large, directed vertically, and had circular section (Leidy, 1869; Lihoreau, 2003). The Microbunodontinae generally have small, transversally compressed upper canines. Their lower canine wears mesially in contact with the lower third incisor, I_3 (Lihoreau, 2003). The Bothriodontinae have small and large species and are characterized by the upper canine showing premolariforms in primitive forms and being circular in derived forms. They show mesosyle loop on the upper molar, which has a closed transverse valley, crescentiform cuspid, pentacuspid, and tetracuspid on upper molar, The family has four and five toes (Scott, 1940; Lihoreau, 2003).

Family Anthracotheriidae Leidy, 1869

Subfamily Anthracotheriinae, Leidy, 1869

Subfamily Microbunodontinae Lihoreau, 2003

Subfamily Bothriodontinae Scott, 1940

5.2.2 Dental Terminology and Measurement

The dental terminology and measurement are referred to Lihoreau (2003). The terminology of upper molar are composed of protocone (Pr), paraconule (Pa'), paracone (Pa), metacone (M), metaconule (M'), parastyle (Ps), mesostyle (Ms), metastyle (Mts), transverse (V), rib (C), proparacrista (1), postparacrista (2), prometacrista (3), postmetacrista (4), preparacristule (5), preprotocrista (6), postprotocrista (7), lingual postprotocrista (8), premetacristule (9), and postmetacristule (10) (Figure 5.1). The terminology of lower molar are composed of protoconid (P), hypoconid (H), hypoconulid (H'), metaconid (M), entoconid (E), preprotocristid (1), postprotocristid (2), prehypocristid (3), posthypocristid (4), mesio-lingual metacristid (5), disto-lingual metacristid (6), premetacristid (7), postmetacristid (8), mesio-lingual entocristid (9), disto-lingual entocristid (10), preentocristid (11), prehypocristulid (12), and posthypocristulid (13) (Figure 5.1). A molar length is measured mesio-distally and molar width measured bucco-lingually (Figure 5.2).

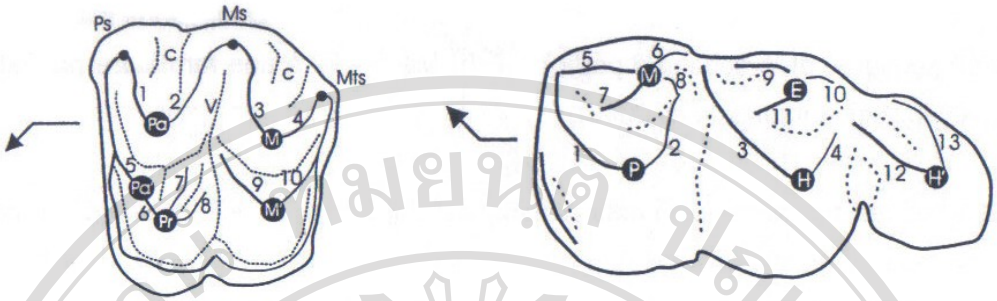

Figure 5.1 Dental terminology of Anthracotheriidae, upper molar on the left and lower molar on the right (Lihoreau, 2003) protocone (Pr), paraconule (Pa'), paracone (Pa), metacone (M), metaconule (M'), parastyle (Ps), mesostyle (Ms), metastyle (Mts), transverse (V), rib (C), proparacrista (1), postparacrista (2), prometacrista (3), postmetacrista (4), preparacristule (5), preprotocrista (6), postprotocrista (7), lingual postprotocrista (8), premetacristule (9), and postmetacristule (10) (Figure 5.1). The terminology of lower molar are composed of protoconid (P), hypoconid (H), hypoconulid (H'), metaconid (M), entoconid (E), preprotocristid (1), postprotocristid (2), prehypocristid (3), posthypocristid (4), mesio-lingual metacristid (5), disto-lingual metacristid (6), premetacristid (7), postmetacristid (8), mesio-lingual entocristid (9), disto-lingual entocristid (10), preentocristid (11), prehypocristulid (12), and posthypocristulid (13) (Figure 5.1). A molar length is measured mesio-distally and molar width measured bucco-lingually.

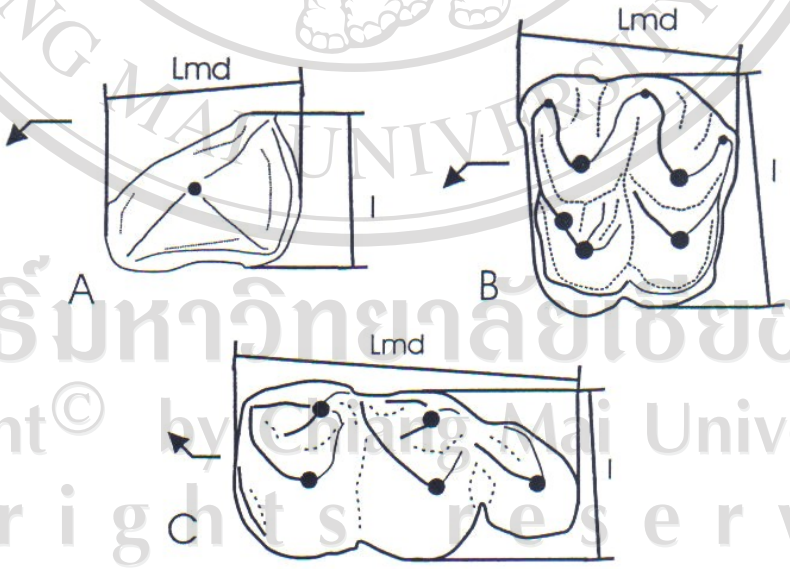

Figure 5.2 Dental Measuring of Anthracotheriidae, A) upper premolar, B) upper molar, and C) lower molar (Lihoreau, 2003).

5.2.3 Results

Family Anthracotheriidae Leidy, 1869

Subfamily Bothriodontinae Scott, 1940

Genus *Merycopotamus* Falconer and Cautley, 1847

Diagnosis: medium-sized anthracothere, oblique facial crest contact with marked facial tuberosity, large canine fossa, tympanic bulla compressed antero-posteriorly, two accessory cuspid on disto-buccal crest on upper premolar; upper molar selenodont and tetracuspids, molar width broader than length; loop or divided mesostyle, symphysis edge concave ventrally and maximum dorso-ventrally breadth at center, one accessory cuspid on mesio-lingual crest on lower premolar, no premetacristid, prehypocirstid and preentocristid reach lingual edge, hypoconulid aligned on baccal side (Falconer and Cautley, 1836, 1847; Lihoreau, 2003).

Type species: *Merycopotamus dissimilis* Falconer and Cautley, 1836

***Merycopotamus* sp. 1**

Figures 5.3A-5.3C

Diagnosis: Upper molars having a separated mesostyle with a remnant of the mesostyle between the bases of the postparacrista and premetacrista, which are aligned in a U-shape pointing buccally to distobucally. No small crest developed from the preparacrista, postparacrista, premetacrista, or postmetacrista. Tha Chang *Merycopotamus* differs from all previously known species of *Merycopotamus* in having the most

Figure 5.3 Cranium of *Merycopotamus* sp.1, specimen no. RIN776, left P^3–M^3 and right M^{1-3}, A) left lateral, B) dorsal, and C) ventral view. The remaining of skull is 236 millimeters.

posterior position of the major palatine foramen opening at P^{2-3}, a lobe-like naso-frontal suture, a single supraorbital foramen with a distinct groove in front of it, and a lack of the contact between nasal and lacrimal bones. Differs from *M. nanus* and *M. medioximus* in having a more posteriorly positioned maxillo-palatine suture. Further differs from *M. nanus* in having a nearly separated mesostyle on upper molars and a more elevated superior margin of the orbit. Further differs from *M. medioximus* in lacking the short crests from the buccal styles on upper molars, and possibly having a slightly more clearly divided mesostyle.

Material: RIN776, a cranium with left P^3–M^3 and right M^{1}–^{3}

Description: Cranium—The cranium is nearly complete and well preserved, lacking only the anterior end of the snout, the basioccipital, and parts of the parietal bones (Figure 5.3A). The remaining length along the midline is 236 millimeters. The cranial sutures are incompletely fused. The dorsal aspect of the skull is flat, gently slopes anteriorly, and has a marked sagittal crest. The snout is trapezoidal in cross section. The infraorbital foramina open above the border of P^3 and P^4 and are located halfway between the dorsal and ventral edges of the maxilla. The frontal bone has a shallow depression between the orbits. The nasal bones become broader posteriorly and form a lobe-like shape at the naso-frontal suture. The two supraorbital grooves (one on each side) are short (~13.0 millimeters) and positioned at the level of the anterior border of the orbits (Figure 5.3B). The braincase is somewhat rounded. The palate has a nearly constant inner width, with the left and right tooth rows parallel (Figure 5.3C). The maxillo-palatine suture is V-shaped, points anteriorly, and has its apex of V is located at the level of the mesial part of M^2. The major palatine foramina open at the mesial part of P^3 on the left side and the distal part of P^2 on the right side.

The lacrimal bone is rectangular and lies vertically. It is separated from the nasal bone by the maxilla and the frontal (Figure 5.3A). The lacrimal groove runs horizontally at the anterior edge of the orbits. The orbits have a gap at the posterior edge and are slightly elevated above the cranial roof. The zygomatic bone is robust and has a well-developed facial tubercle. The facial crest inclines gradually posterolaterally from the maxilla toward the zygomatic arch. The external auditory meatus lies between the postglenoid and the mastoid processes, and opens dorsolaterally. The glenoid fossa is very shallow. The tympanic bulla is broken, but it shows an oval outline. As for the occipital bone, only the left paroccipital process is intact. The paroccipital process is semicircular in cross-section and is compressed anteroposteriorly.

Dentition—The only teeth preserved are left P^3–M^3 and right M^1–^{3} (Figure 5.3C). The teeth are selenodont and brachydont. The enamel is finely wrinkled. The occlusal outline of P^3 is trapezoidal. The tooth has three crests running from the main cusp. The distobuccal crest is the longest and bears two accessory cusplets. There is a basin at the distolingual part of the crown (Figure 5.3C). P^4 is bicuspid. No small crest is developed from the mesial and distal styles. The buccal cusp is larger than the lingual cusp, with longer crests. The mesial crests of both buccal and lingual cusps extend buccally to become continuous with the mesial cingulum. Three accessory cusplets are developed on the distal cingulum (Figure 5.3C). The M^1s are worn flat, retaining only the cervical portion of the crown. The molar morphology is well preserved on M^2 and M^3. They increase in size from M^{1-3}. M1 is much smaller than M^2 and M^3 (Figure 5.3C). Each molar has four V-shaped cusps. The paracone and metacone are nearly fully separated. A remnant of the mesostyle is present between the bases of postparacrista and premetacrista. The transverse valley opens lingually

and is closed buccally by a remnant of the mesostyle. The parastyle is rounded. The metastyle is relatively much reduced. The cingulum is well developed along the mesial and distal margins but is vestigial along the lingual margin of M^2. The lingual cingulum is more prominent at the protocone on M^3. The lingual cingulum on right M^3 is better developed than that of the left M^3. Comparative dental measurements are provided in Table 5.1.

Conclusions and discussions—*Merycopotamus* is composed of three species, *M. nanus*, *M. medioximus*, and *M. dissimilis*, from primitive to advanced form according. The primitiveness is the looped mesostyle and reduced to separated in advanced form. The Tha Chang *Merycopotamus* is most similar to *M. medioximus* which has partially divided mesostyle. However, the Tha Chang *Merycopotamus* skull is distinguished from all previously known species by the position of the major palatine foramen, the shape of the naso-frontal suture, the number of the supraorbital foramen, and the lack of the contact between the nasal and lacrimal bones. The major palatine foramen opens more posteriorly in Tha Chang specimen, $P^{2–3}$, (Figure. 5.3C) than in other species, P^1–P^2 in *M. nanus*, P^1 in *M. medioximus*, C–P^1 in *M. dissimilis.* In the latter three species, there seems to be an evolutionary trend in the position of the major palatine foramen, with geologically younger species having a more anteriorly positioned foramen. In this aspect, it is interesting that Tha Chang *Merycopotamus* shows a more posterior position of the major palatine foramen than even the oldest species, *M. nanus*. The shape of the naso-frontal suture is unique in Tha Chang specimen, being lobe-like (Figure 5.3B). This suture forms an acute angle

Table 5.1 Dental measurement of *Merycopotamus* sp.1, in millimeters

Teeth	**Breadth**	**Length**
Left P^3	16.24	19.76
Left P^4	19.66	17.10
Left M^1	22.44	19.98
Left M^2	27.28	26.36
Left M^3	28.02	26.68
Right M^1	21.02*	18.78+
Right M^2	27.66	25.64
Right M^3	28.46	28.18

Remarks: * = estimated, += remaining length

in *M. nanus* and a rounded shape in *M. medioximus* and *M. dissimilis*. The lobe-like shape in Tha Chang *Merycopotamus* seems to be slightly more derived from the rounded shape in the latter two species. Tha Chang *Merycopotamus* has a single supraorbital foramen with a distinct groove in front of it (Figure 5.3B). In contrast, the other three species have numerous small supraorbital foramina. In Tha Chang specimen, the lacrimal bone is separated from the nasal bone by an anterior extension of the frontal (Figure 5.3A). On the other hand, the other three species have a contact between the lacrimal and nasal bones, which is interpreted as a derived character (Lihoreau *et al*., 2004).

In addition to the above-mentioned features, Tha Chang *Merycopotamus* differs from *M. nanus* in having a nearly separated mesostyle on upper molars (Figure 5.3C) contrasting the continuous, loop-like mesostyle in the latter. However, the mesostylar region in Tha Chang *Merycopotamus* still retains some remnant of the ridge that connects the bases of the postparacrista and premetacrista, so that it is not so completely separated as in the youngest species, *M. dissimilis*. In this aspect, Tha Chang *Merycopotamus* appears more similar to *M. medioximus*, though it might be slightly more derived than the latter. The mesostyle in Tha Chang *Merycopotamus* may be slightly more clearly divided than in *M. medioximus*. Because only a single specimen has been assigned to Tha Chang *Merycopotamus*, individual variation in this feature cannot yet be assessed for Tha Chang *Merycopotamus*. Tha Chang *Merycopotamus* is distinguished from *M. medioximus* by lacking the short crests that emerge from the buccal styles in the latter.

Tha Chang *Merycopotamus* resembles *M. medioximus* in that the superior margin of the orbit is slightly elevated beyond the dorsal surface of the skull

(Figure 5.3A). This is an intermediate condition between the more primitive *M. nanus* and more derived *M. dissimilis*. The former has the orbit at a lower position on the lateral aspect of the skull, and the latter shows the superior margin of the orbit much higher elevated beyond the dorsal surface of the skull. This is probably an adaptation to an aquatic lifestyle as was evolved independently in hippopotamids; it suggests that Tha Chang *Merycopotamus* was adapted to aquatic environments to a similar degree as the early late Miocene species *M. medioximus* but to a lesser degree than the late late Miocene to Pliocene species *M. dissimilis*. In *M. nanus* and *M. medioximus*, the maxillo-palatine suture reaches the mesial border of M^1. On the other hand, the V-shaped maxillo-palatine suture in Tha Chang *Merycopotamus* does not extend anteriorly beyond the mesial border of M^2 (Figure 5.3C) as in *M. dissimilis*. In this feature, Tha Chang *Merycopotamus* differs from *M. medioximus* and is similar to the more derived species, *M. dissimilis*.

Tha Chang *Merycopotamus* has a mixture of primitive and derived character states compared to other *Merycopotamus* species. Consequently, it is difficult to place the new species smoothly in the time successive lineage of *Merycopotamus* in the Indian subcontinent from *M. nanus*, middle Miocene, through *M. medioximus* (early late Miocene) to *M. dissimilis* (late late Miocene to Pliocene). If we regard the morphology of the mesostyle as an important character in *Merycopotamus* evolution, one possible hypothesis is that *M. medioximus* or a slightly more derived form emigrated from the Indian subcontinent to Thailand in the early late Miocene, and became specialized into a new species, Tha Chang *Merycopotamus*, probably by isolation from the other populations in the west. In this case, characters such as the position of the major palatine foramen, the contact between the nasal and

lacrimal bones, and the number of the supraorbital foramen are regarded as having been reversed to primitive conditions secondarily. As another possibility, the primitive cranial characters in Tha Chang *Merycopotamus* might suggest that this species evolved from some unknown, more ancestral form, apart from the known species of *Merycopotamus*. In this case, the relatively high position of the orbit, the nearly divided mesostyle, the lobe-like naso-frontal suture, and the relatively posterior position of the maxillo-palatine suture may have evolved independently in Tha Chang *Merycopotamus*. Because the skull described in this study is the only specimen of Tha Chang *Merycopotamus* with reliable locality information, it may be premature to make a conclusion on the phylogenetic relationships of the new species. At present, the former hypothesis is preferred, which does not postulate a long, hidden lineage from an unknown ancestor to Tha Chang *Merycopotamus*.

It is difficult to precisely estimate the geological age of the fossils discovered in the Tha Chang sand pit 8. To our knowledge, only the skull of Tha Chang *Merycopotamus* and some stegolophodons have ever been collected in the Tha Chang sand pit 8 with reliable locality information. The stegolophodons are more primitive than *Stegodon* in northern China, suggesting that the Tha Chang Sand Pit 8 is older than 6 Ma. A relatively well-preserved mandible of a large hominoid, *Khoratpithecus piriyai*, is said to have come from Tha Chang Sand Pit 8 according to the fossil dealer who bought the mandible from local villagers. Based on other mammalian fossils from the Tha Chang area, the age of the fossiliferous deposits in the Tha Chang Sand Pit 8 have been estimated to be 9–7 Ma (Chaimanee *et al*., 2004), and later, 7.4–5.9 Ma (Chaimanee *et al*., 2006). As mentioned above, almost all of the fossils lack precise field information. It is probably impossible to precisely know the

localities of these fossils, though localities may sometimes be inferred through circumstantial evidence such as interviews with local villagers. There is also a possibility that different sand pits in this area may have yielded fossils of different ages. However, the mammalian fossils can be largely sorted into three assemblages of different geological ages, that is, the Middle Miocene, latest Miocene, and Early Pleistocene faunas (Nakaya *et al*., 2003a, b; 2007). Based on the *Stegolophodon* specimens and circumstantial evidence like interviews with local villagers, the age of *M. thanchangensis* from the Tha Chang Sand Pit 8 can be inferred to be late Miocene. If Tha Chang *Merycopotamus* was evolved from *M. medioximus* (10.6–8.1 Ma), the age might be the latter part of the late Miocene.

Type locality: Tha Chang Sand Pit No. 8, Tha Chang Sub-district, Chalerm Phrakiet District, Nakhon Ratchasima Province.

5.3 Suidae

Suidae is one of a family within the suborder Suina. Their assignment to the order Artiodactyla is based on the pattern of dentition which was complete tooth-formula, 3I 1C 4P 3M, and characters of the skull and the limbs (Hünermann, 1999).

Suid limbs are quite slender and short. The third and fourth metapodials are strengthened and mainly functioned. The rudimentary second and fifth digits do not touch the ground, but may assist on walking on soft ground. The first metapodials and digits in manus and carpus are not ossified. Trochlea tali and caput tali of the suoidean astragalus form a laterally open angle, causing a knock-kneed construction of the hind limbs (Hünermann, 1999).

The family Suidae was by far the most successful group of suoids during the Neogene. The Neogene witnessed a great diversification of suids in the Old World, with the evolution of six subfamilies and over 30 genera (Pickford, 1993). The suids are often considered to be useful for intercontinental and for local and regional biostratigraphy. This is because they were often colonizing new territories with other mammals. As a result of this, diverse subfamilies and genera arose in several continents and became useful biostratigraphic datums (Pickford, 1993).

5.3.1 General morphology of dentition

The cheek teeth of Suidae are more or less bunodont. The canines are enlarged and tusk-like, with the incisors also sometimes a tusk-like form. There is considerable sexual dimorphism in their canines. In males, the upper canines are large and curve upwards and outwards, with a rounded section, whereas the lower canines are more slender, with a more sharply triangular section. Only two sides of the section are coated with enamel and ever-growing. In females, both upper and lower canine are small, and become rooted. The lower incisors are chisel-like appearance. The upper incisors are smaller and curved (Figure 5.4). The permanent molars of suids have four main cusps with subsidiary cusps around them, giving a complex appearance. Permanent third molars have additional cusps at the distal end of their crowns (Figure 5.5) (Hillson, 2005).

5.3.2 Major lineages of Suidae

In the classic classification of Colbert (1935), five subfamilies were recognized within the family Suidae. The characteristics of each subfamily is as follows:

1) Subfamily Hyotheriinae Cope, 1988

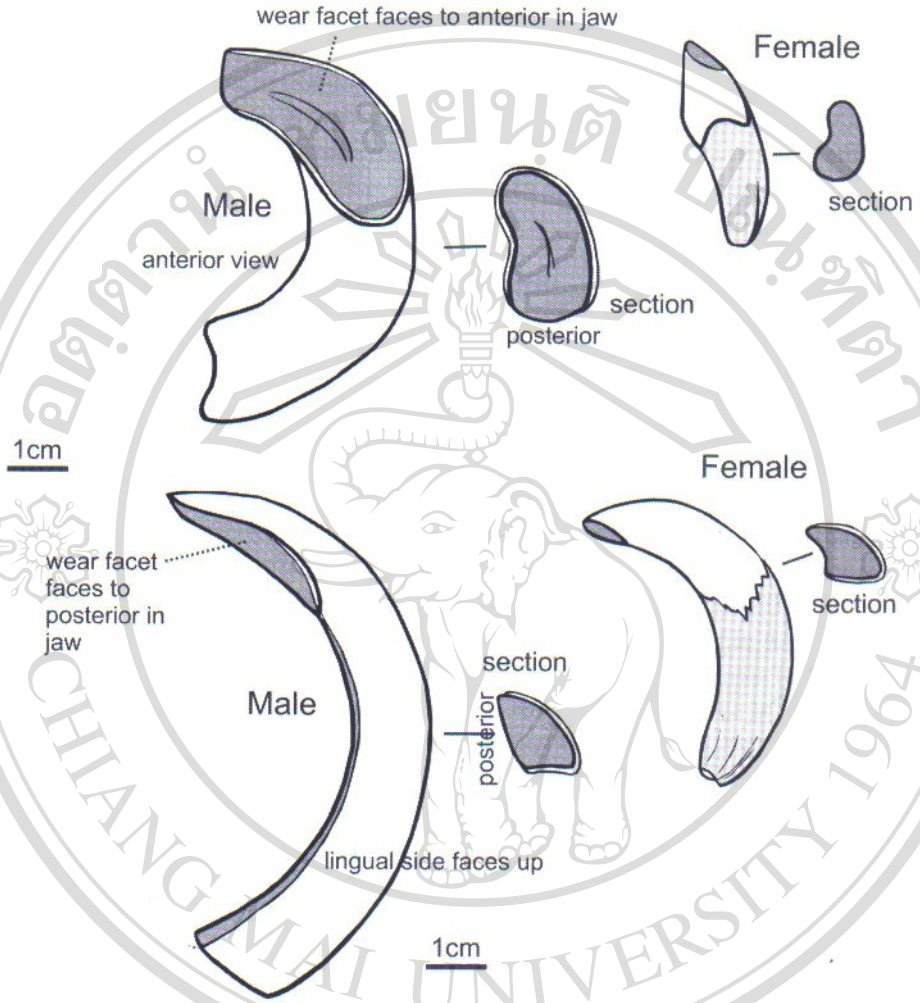

Figure 5.4 Canine morphology of *Sus*, or pig, of the family Suidae (Hillson, 2005).

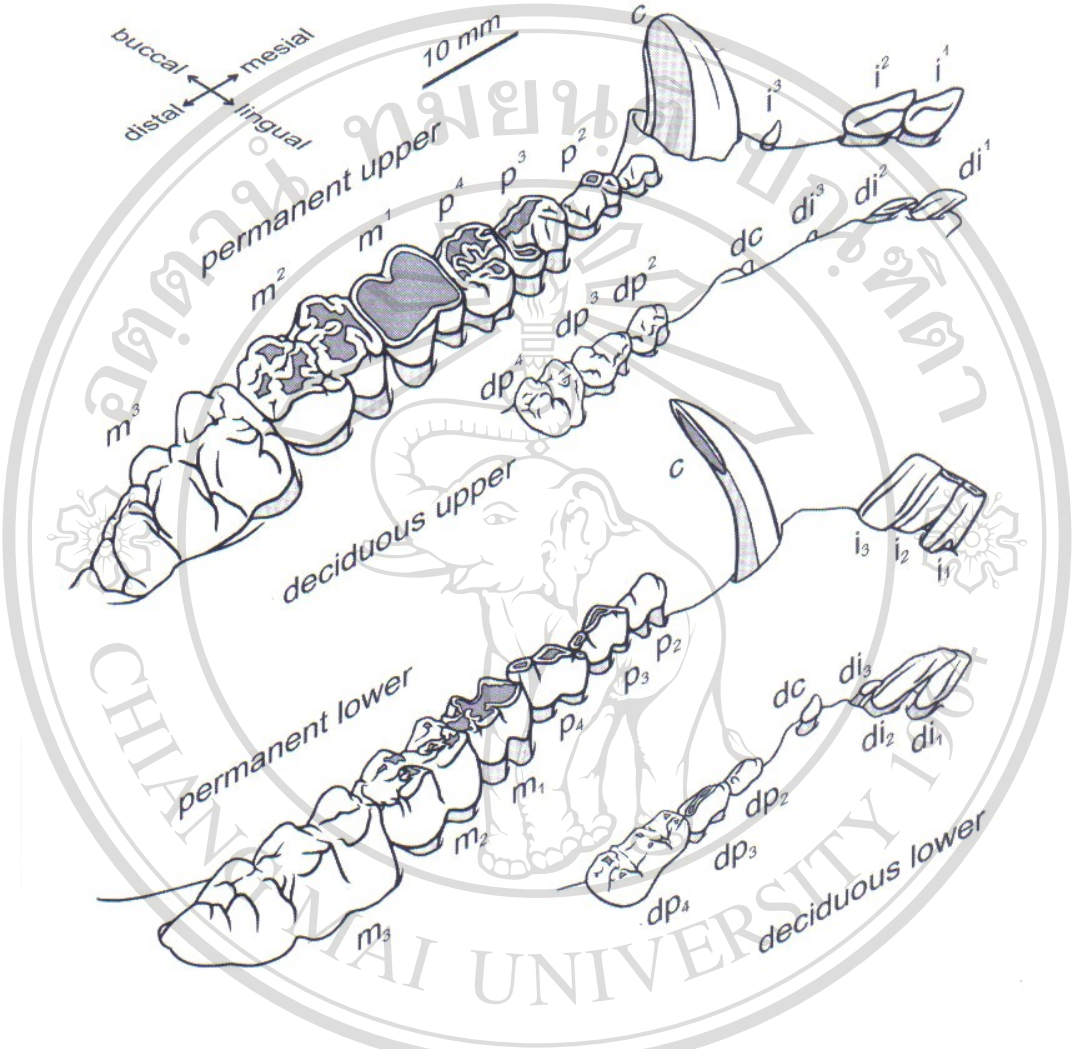

Figure 5.5 General morphology of teeth of *Sus*, or pig, of the family Suidae; upper right and lower left dentitions shown by permanent and deciduous (Hillson, 2005).

This subfamily is small pigs that had simple bunodont molars. The canine is nearly vertical and a scrofic type. Tympanic bullae are ovoid and directed horizontally. The snout was short (Colbert, 1935). Hyotherines are the oldest known suids, occurring from the Late Oligocene, MN1, to the Early Miocene, MN9, in Europe. It is considered to be the ancestral group which later gave rise to all other subfamilies of pigs (Pickford, 1993). It spread to Asia and is known from the Indian subcontinent and from China. However, its evolution is poorly known.

2) Subfamily Listriodontinae Simpson, 1945

This subfamily has a molar structure very similar to Hyotheriinae, but shows an evolutionary trend toward great size in one lineage and the development of a prominent lophodont. Other important characters are the retired distal margin of the palatines, elongated diastema, spatulate premaxillae, laterally flaring canine flanges, and broad, but short, neurocranium. This subfamily first appeared in Europe during, or just prior to, zone MN04 (Pickford, 1993).

3) Subfamily Tetraconodontinae Simpson, 1945

The tetraconodonts were moderately long-snouted, although they did not possess long diastema. Their sagittal crest was retained or enlarged and their zygomatic arch was moderately flared. U-shaped posterior choanae open behind M^3. The lower border of the zygoma was directed downwards and backwards from its root. So, in side view, the M^{2-3} are not visible (Pickford, 1988). They have great enlargement of posterior premolars relative to molars (Pickford, 1993).

Tetraconodontinae was emerged from Hyotheriinae during MN05 or

early Middle Miocene which about 16 Ma (Agustí *et al*., 2001). An early record from India is probably evidence for an eastern origin for this subfamily.

4) Subfamily Suinae Gray, 1821.

Suinae has a number of genera that have many variations. It is characterized by elongation of the skull, complication of cheek teeth, and various developments of canine tusks.

Pickford (1984) assigned subfamily Sanitheriinae to a new family called Sanitheriidae. This subfamily was not considered in this study. Pickford added two subfamilies that evolved in Africa, Kubanochoerinae and Cainochoerina, to Colbert's family Suidae that is based on Siwalik fossils. Kubanochoerinae is an endemic group. The origin of Cainochoerinae is not certainly known at present (Pickford, 1993). Therefore, it was not included in this study.

5.3.3 Dental Terminology and Measurement

The dental terminology and measurement of tetraconodontinae teeth follow Thaung-Htike *et al*. (2005). BL is base line, L=mesio-distal length, W=bucco-lingual width, W1=first lobe width, W2=second lobe width, W3=third lobe width of M3/ (Figure 5.6).

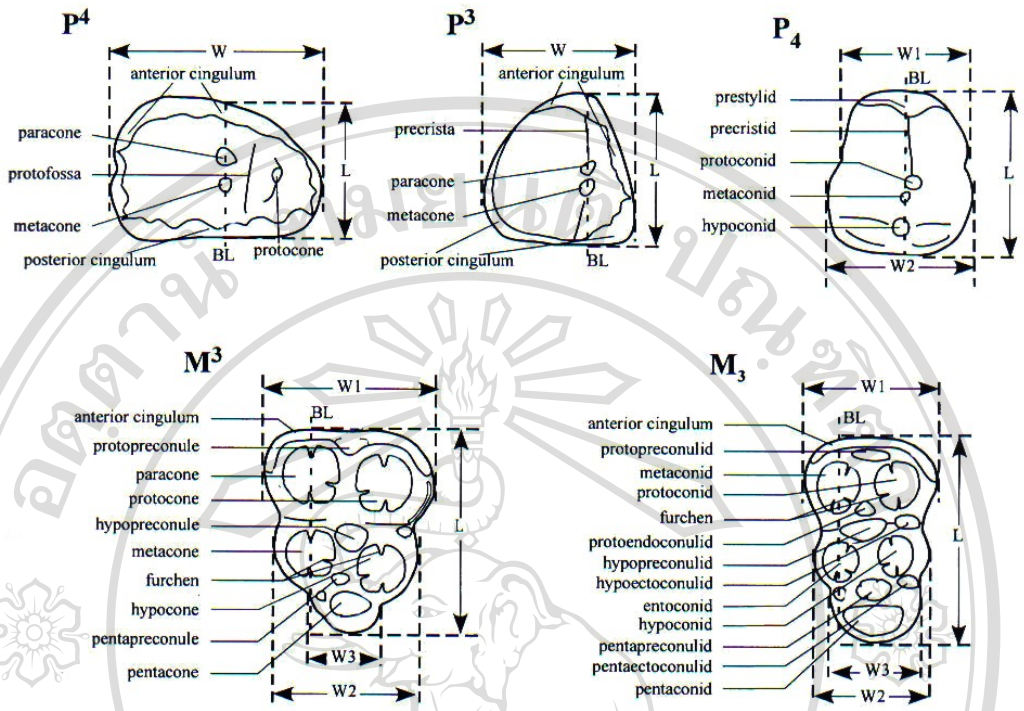

Figure 5.6 Dental measuring of suid, P^4, upper fourth premolar; P^3, upper third premolar; P_4, lower fourth premolar; M^3, upper third molar, and M_3, lower third molar (Thaung-Htike *et al.*, 2005).

5.3.4 Results

Family Suidae Gray, 1821

Subfamily Suinae Gray, 1821

Genus *Hippopotamodon* Lydekker, 1877

Diagnosis: *Hippopotamodon* is a giant Suinae in which the males have large flaring canines. Molar enamel is thin. Molars are simple with well-developed furchen plan. In the lower molar, crown of labial cusps is lower than lingual ones. P^4 has posterior accessory cusp which almost as large as two main labial cusps. Posterior choanae is U-shaped and opens immediately behind M^3. P_4 has prominent innenhugel, or cleft. Anterior cingulum and anterior accessory cusplet is moderately high. Diastema between C-P_1-P_2 are short. Dorsal surface are broad and flat.

Type species: *Hippopotamodon sivalense* Lydekker, 1877

Hippopotamodon* cf. *hyotherioides Schlosser, 1903

Figures 5.7A-5.7C

Diagnosis: The upper central incisors are mesio-diatally short and labio-lingually inflated. The tooth crowns are tall. Lingually, there is a valley up with a tall isolated lingual cusplet. The distal edge of the crown is beaded. The lingual side is scoop-shape, high, and narrow. It is mesiodiatally short and labiolingually inflated. The distal ridge in inclined and is longer than the mesial side. The central ridge on the lingual surface is wide and low. The lingual cingulum is separated from the rest of the

Figure 5.7A *Hippopotamodon* cf. *hyotherioides*, specimen no. CMu10-1'01, A) right mandible and symphysis with left canine and P^4-M^3, scale bar = 50 mm, B) fragment of right I^1, C) right M^2, and D) right P^3, scale bar = 20 mm.

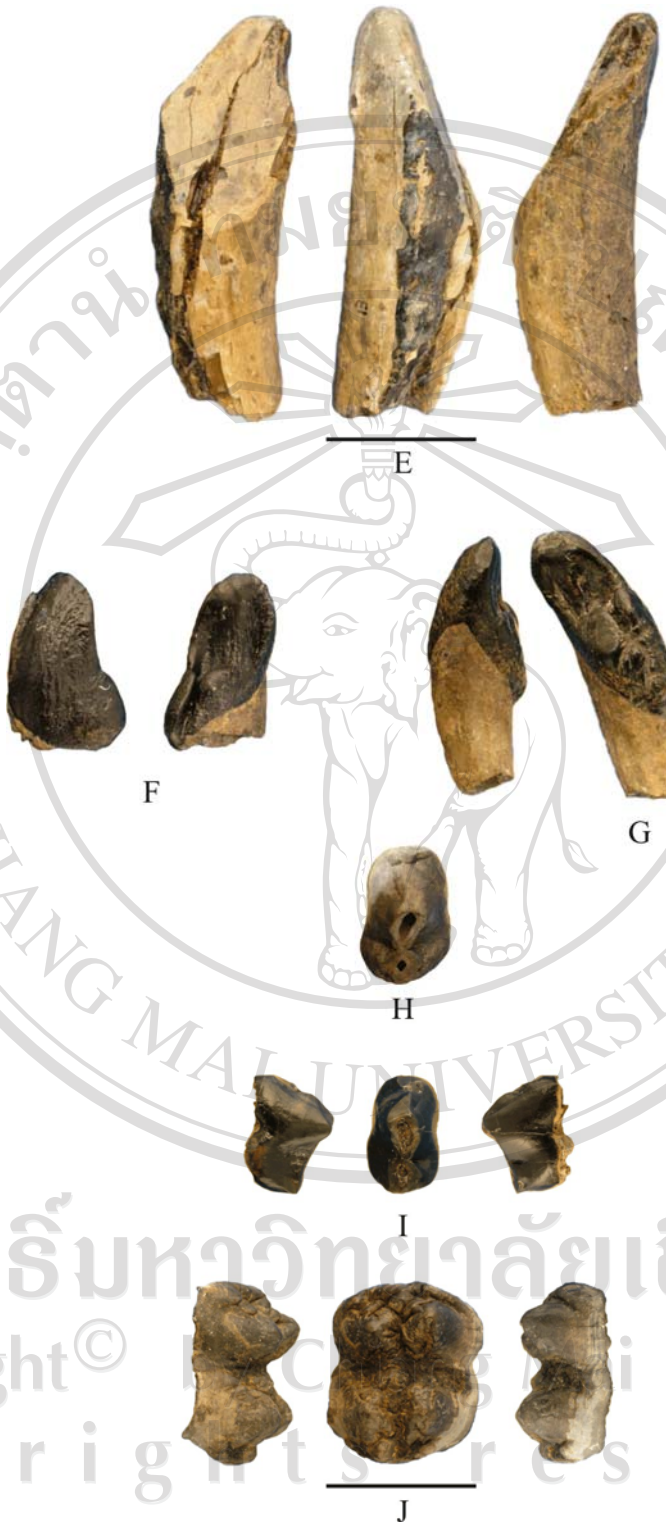

Figure 5.7B *Hippopotamodon* cf. *hyotherioides*, E)CMu13, F) CMu050521-10, G) CMu107, H) CMu3-12’05, I) CMu6-12’01, and J) CMu6-412’02, scale bar = 20 mm.

Figure 5.7C K) *Hippopotamodon* cf. *hyotherioides*, SMT7-51'00, Ka, right M_1, Kb, right P^3, Kc, left M^3, L) SMT7-32'99, M) SMT12-24'99, and N) SMT510507-03, scale bar = 20 mm.

Figure 5.7D O) *Hippopotamodon* cf. *hyotherioides*, SMT11-4’99, P) SMT7-49’00, Q) SMT7-10’01, R) SMT12-36’00, S) SMT7-1’01, Sa, right I^1 and Sb, right M^3, scale bar = 20 mm.

crown by a deep groove and it is beads at its mesial and distal ends (Pickford and Liu, 2001).

The second and third upper incisors are more symmetrical than the first. They are triangular in lingual view, with a prominent central swelling which wide at the base and narrows apically. The margins of the crown are beaded as is the lingual cingulum, which closes a small valley distally (Pickford and Liu, 2001).

The lower central incisor is mesiodistally narrow and libiolingually enlarged with a prominent central rib. P_2 is rather small and narrow in proportion. It has tall anterior and posterior accessory cusplets which are about two-third the height of the main cusp. Between the main cusp and the anterior and posterior accessory cusps, there are additional cusplets growing out of the mesial and distal crests, giving the tooth a multi-cusp appearance (Pickford and Liu, 2001).

The main central cusp of P_4 is divided into an exterior and an interior cusp that are equal in size. The latter stands generally a little bit behind the former, and not in a straight line. There is a small cusplet between the two main cusps. The talonid is relatively large and simple. The posterior root is bifid. Diastema between P_1 and P_2 reaches 20 millimeters in length. The talonid of M_3 is relatively long and broad, about one third of the total length (Yingjun *et al*., 1985).

Description: specimen no. CMu050625-01, it is a right mandible with partial left side. It has embedded roots of right canine and first and second premolar. It is composed of lower third premolar to third molar, P_3-M_3. The teeth are least worn, except M_1 which is considerably worn. P_3 is thick and has one main cusp, innenhugel or cleft. Accessory cusplets aligned distally behind the protoconid. Anterior crest has high slope and much higher than posterior crest. P_4 is thick and has marked

innenhugel. Metaconid is well-developed and placed disto-lingually behind protoconid. Talonid is lower than protoconid and metaconid and is well separated from previous two cusplets. Labial cingulum of P_4 is distinct and developed at distal half part. P_3 is higher crown than P_4. The size of molar teeth is increased from M_1 to M_3. The molar composed of four basic cusplets, protoconid, metaconid, entoconid, and hypoconid with well-developed median and posterior cusplets. Enamel is thick. Posterior cingulum is more marked than anterior cingulum. M_3 has simple talonid and is placed medially.

Other isolated teeth of the same individual are I^1, P^3, and M^2. Right upper first incisor, I^1, is thick and broken, but retains most parts except the tip. Lingual cingulum is well developed.

P^3 is inflated on its labial wall. Paracone is slightly larger than metacone. These two cusps are aligned linearly on the posterior crest. Postero-lingual fossa is well-developed. Anterior cingulum continues to the lingual cingulum. P^3 outline is rather triangular. The lingual cingulum is not well-developed in SMT7-51'00.

M^2 has a rectangular shape with a bunodonty cusp and shallow furchen. Anterior cingulum is better developed than the post cingulum and extends from lingual to labial corner. Labial wall is steeply sloped while the lingual wall has a gentle and broad slope.

Other isolated teeth

The upper first incisor, I^1, of specimens CMu050521-10, CMu107, and SMT7-49'00 is labio-lingually thick and convex labially. Lingual rib is developed with marked lingual cingulum. I^1 of Sop Mae Tham is relatively larger than teeth of

Chiang Muan. The crowns of SMT7-1’01 and SMT12-36’00 are much worn, reaching a cervix.

I^2 of specimen SMT11-4’99 is mesio-distally broad and has a much lower crown than I^1. Lingual cingulum is beaded and well-developed.

C (CMu13) is large and strongly curved with an oval wear surface.

M^2 of specimen CMu6-412’02 is the least worn tooth and has wrinkled enamel. Furchen is shallow, though shallower in worn specimen SMT7-32’99. In the Sop Mae Tham specimen, the anterior cingulum is developed distally for half the tooth length, or at the entoconid base.

M^3 (SMT7-51’00 and SMT7-1’01) are slightly worn, less wrinkled, and very shallow furchen. Anterior cingulum are prominent, thick with small cusplets developed at lingual corner. Lingual cingulum closed median valley. Talon are simple and placed labially.

I_2 (SMT7-10’01) is high-crowned, labio-lingually thick. Labial wall considerably curved. Lingual rib is strong protruding from apex to cervix. On lingual view, the tooth curved mesially.

P_2 (CMu6-12’01) and P_3 (CMu3-12’05) are considerably worn, having strong protoconid and separating from talonid. The median cusp placed more distally. P_2 is a reduced form of P_3. Anterior cingulum is absent on P_2.

M_1 (SMT7-51’00) is rectangular shaped. Anterior cingulum is not prominent. Furchen is shallow. Enamel is thick. Median and posterior cusplets are well-developed.

M_3 (SMT12-24'99 and SMT510507-03) are considerably worn showing very thick enamel. Anterior cingulum is reduced. Talonid are medially placed.

Discussion: Judging from P_4, which shows a marked innenhugel or cleft, two main cusps suggest that it belongs to the Dicorphochoerini tribe. The Dicoryphochoerini was diversified during Late Miocene and includes *Microstonyx, Hippopotamodon,* and *Propotamochoerus*. *Microstonyx* has the same dental morphology as *Propotamochoerus* but the two are separated by size. The largest *Propotamochoerus, P. provincial*, was the size of the smallest *Microstonyx* (Made *et al*., 1992). Therefore, *Microstonyx* is not considered here.

P4 of Chiang Muan specimen has prominent innenhugel with well-developed cusplet between protoconid, metaconid, and hypoconid. Anterior cingulum is about half of the height of the main cusp and posterior cingulum is considerably higher, two third of the crown height. Lingual cusps of molar teeth are relatively higher than the labial ones. These characters suggest these Chiang Muan specimens are of *Hippopotamodon*. Though, Chiang Muan specimen has distinct labial cingulum on P_4 which absent in *Propotamochoerus* and *Hippopotamodon*. From the plot of tooth width against the lenth of M^3, its size is overlap with *Propotamochoerus hysudricus* and *Hippopotamodon hyotherioides*. However, it is considered to be close to *H. hyotherioides* with relatively smaller than *H. hyotherioides* (Figure 5.8).

Hippopotamodon currently has two species, *H. hyotherioides* and *H. sivalense*. *H. sivalense* had larger size (Pickford, 1988). It was common in the upper half of the Nagri Fomation, Siwalik Group which range from about 10 to 7 Ma and almost always associated with *Hipparion* (Pickford, 1988). Its range is very similar to

that of *Propotamochoerus hysudricus* and *Microstonyx* (Pickford, 1988). Another species, *H. hyotherioides*, was found from Xiaolongtan (Kaiyuan), Yunnan province, China (Pearson, 1928, Pickford and Liu, 2001). It was closely related to *H. sivalense* which from deposits of similar age, but apparently smaller. It was probably migrated from the south for example Indian subcontinent (Pickford and Liu, 2001).

Materials: CMu10-1'01 (right mandible with P_3-M_2 and erupting M_3, right P_3, right M^2, and fragment of right I^1), CMu13 (right upper canine), CMu6-412'02 (left M^2), CMu3-12'05 (right P_3), CMu6-12'01 (right P_2), CMu050521-10 (right I^1), CMu107 (left I^1), SMT7-51'00 (right P^3, right M_1, and left M^3), SMT11-4'99 (left I^2), SMT7-32'99 (left M^2), SMT12-24'99 (right M_3), SMT7-49'00 (right I^1), SMT7-1'01 (right I^1 right M^3), SMT12-36'00 (right I^1), and SMT7-10'01 (right I_2). Abbreviation CMu stand for Chiang Muan and SMT for Sop Mae Tham area.

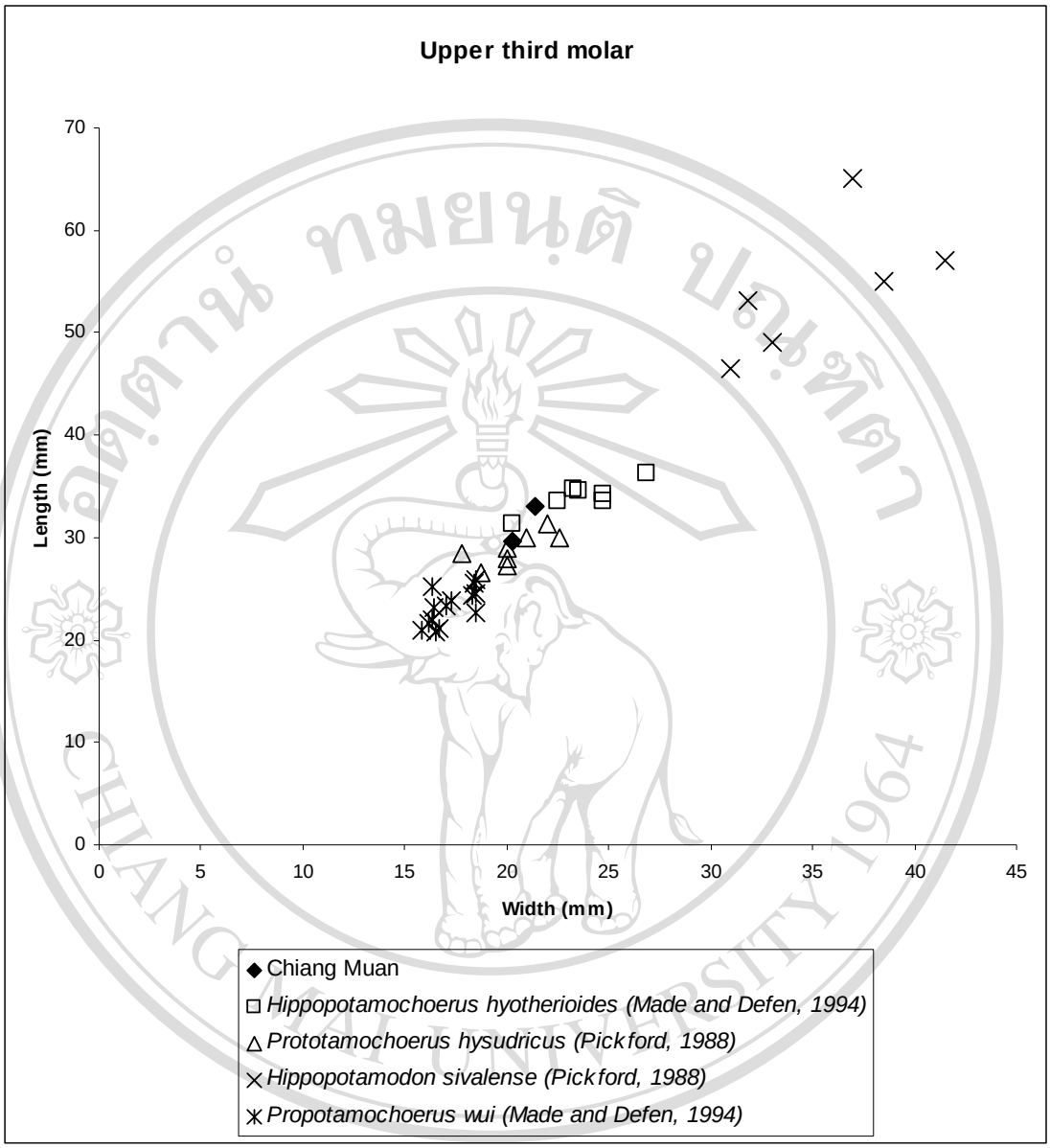

Figure 5.8 Bivariate plot of the tooth width against the length of M^3 of *Hippopotamodon* cf. *hyotherioides* in comparison with other related species.

Measurement:

Table 5.2 Dental measurement of *Hippopotamodon* cf. *hyotherioides*.

Specimen no.	Tooth	W1	W2	W3	L
CMu10-1'01	Rt P_3	11.81			20.74
	Rt P_4	14.38			19.14
	Rt M_1	15.38	14.80		20.44
	Rt M_2	18.72	17.92		25.84
	Rt M_3	-		13.25	35.59
	Rt P^3	16.53			18.59
	Rt M^2	22.14	20.56		26.11
	Rt I^1	13.45			18.40
CMu13	Rt upper C	20.51			18.94
CMu6-412'02	Lt M^2	21.84	21.04+		25.63
CMu3-12'05	Rt P_3	12.60+			18.50+
CMu6-12'01	Rt P_2	9.72			15.68
CMu050521-10	Rt I^1	10.91			17.95
CMu107	Lt I^1	9.55			16.59
SMT7-51'00	Rt P^3	16.59			17.56
	Rt M_1	14.95	14.11		20.79
	Lt M^3	21.35	19.32	11.21	32.99
SMT7-32'99	Lt M^2	21.00	20.88		23.80
SMT12-24'99	Rt M_3	18.52	17.21	11.63	34.73
SMT510507-03	Rt M_3	17.86	16.51		37.85
SMT11-4'99	Lt I^2	9.29			21.27
SMT7-49'00	Rt I^1	11.90			16.84
SMT7-1'01	Rt I^1	11.61			19.51
	Rt M^3	20.27	17.08	10.20	29.58
SMT12-36'00	Rt I^1	10.51			17.30
SMT7-10'01	Lt I_2	14.92			11.39

Remark: measured in millimeters

Locality: Chiang Muan coal mine, Chiang Muan district, Phayao province, and Sop Mae Tham village, Soem Ngam district, Lampang province.

Age: It is comparable to Xiaolongtan Formation, Yunnan Province, China, which is basal Late Miocene in age, ~10 Ma.

Subfamily Tetraconodontinae Simpson, 1945

Genus *Parachleuastochoerus* Golpe-Posse, 1972

Diagnosis: A small suid of the subfamily Tetraconodontinae, in which showing heteromorphism between P_{1-2} and P_{3-4}. However, it is not marked as it is in *Conohyus.* P_{3-4} are not as inflated as those of other Tetraconodonts. P_4 has reduced innenhugel as metaconid placed behind the main cusp. Buccal ingula are present on upper and lower molars. P^4 has two buccal cusps, which closely applied to each other, with wrinkled buccal enamel and slight buccal cingulum. There is no sagittal cusplets on P^4. P^3 is inflated with wrinkled enamel and has complete lingual cingulum. P^2 much lower crowned than P^3. Molar cusps are inflated and having enamel thick, shallow furchen. Canines show sexual dimorphism. Postcranial skeleton is generally gracile (Pickford, 1981).

Type species: *P. crusafonti* Golpe, 1972

Parachleuastochoerus sinensis (Pickford and Liu, 2001)

Figures 5.9A-5.9D

Figure 5.9A *Parachleuastochoerus sinensis*, posterior part of right mandibular with P4-M3, CMu050625-01. Scale bar = 50 mm.

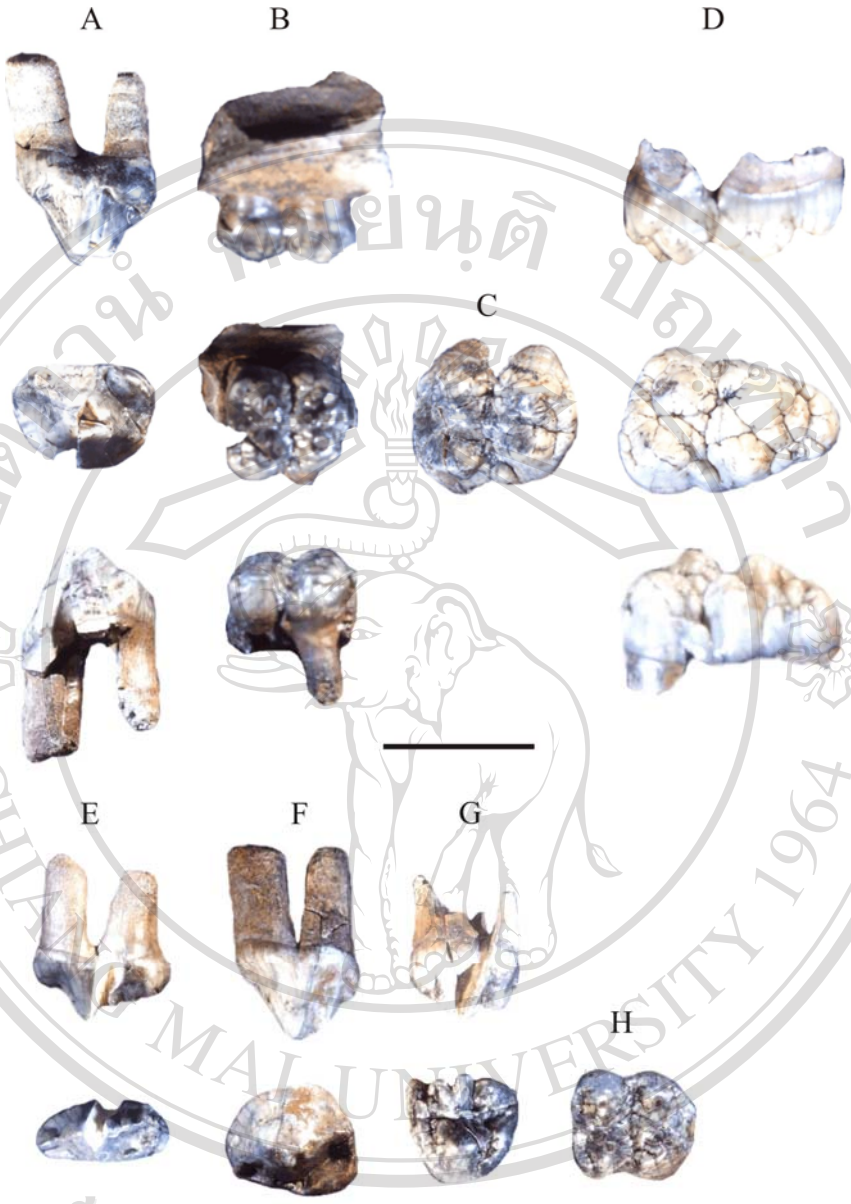

Figure 5.9B *Parachleuastochoeus sinensis*, CMu050625-01, right upper dentition A) P^3, B) M^1, C) M^2, and D) M^3; left upper dentition E) P^2, F) P^3, G) P^4, and H) M^1, scale bar = 20 mm.

Figure 5.9C *Parachleuastochoerus sinensis*, CMu050625-01, A) partial left mandible with P_3-M_3, scale bar = 50 mm, B) right I^1, C) right I_2, D) right I_3, E) left P_1, and E) left P_2, scale bar = 20 mm.

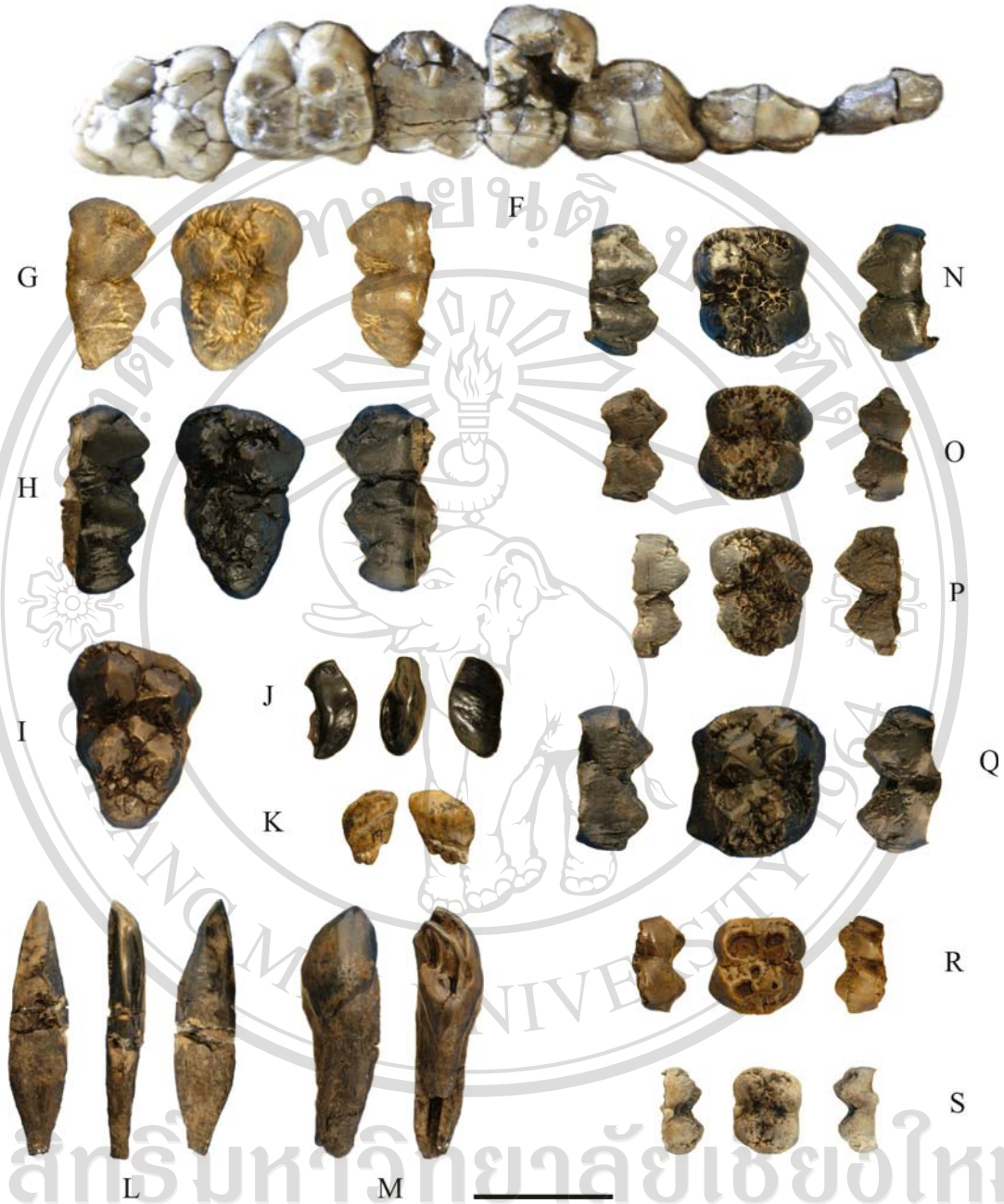

Figure 5.9D *Parachleuastochoerus sinensis*, F) CMu051129-02, G) CMu050706-03, H) CMu14, I) CMu050609-03, J) CMu060612-01, K) CMu17, L) CMu060612-04, M) CMu050707-04, N) CMu060613-03, O) CMu6-14’02, P) CMu6-4’02, Q) CMu6-401’02, R) CMu050607-03, and S) CMu6-402’02, scale bar = 20 mm.

Diagnosis: It is a large species of the genus, larger than *Parachleuastochoerus huenermanni*. It is similar in overall size to *Conohyus sindiensis*, but with slimmer, taller premolars than that of the latter species (Pickford and Liu, 2001).

Description: specimen no. CMu050625-01, It is composed of left P^2-M^1, right I^1, P^3, M^1-M^3, left P_1-M_3, and right I_2-I_3 and P_4-M_3.

I^1 is labio-lingually compressed. The slope of crown decreases distally. The tooth curved inward or toward the lingual side with prominent lingual cingulum.

P^2 is elongated mesio-distally. Though, it is partially broken at tip, anterior and posterior ridges are low very rise suggested a very low crown. Preconule is well-developed. Tooth ridge lie mesio-lingually. Lingual fossa is slightly developed.

P^3 is markedly larger and has much higher crown than P^2. It is thick and inflated. Anterior cingulum is developed and continues to lingual side, lingual wall of protocone, and posterior cingulum. Paracone is prominent and connected to smaller-size metacone.

P^4 has two labial cusps of paracone and metacone. Its size is relatively smaller than protocone. The median crest is slightly developed from paracone. Anterior cingulum is well-developed. Posterior sagittal cusplets developed on posterior cingulum.

M^1 is rectangular shape in outline. The tooth is considerably worn, showing thick enamel. Main cusps, protocone, paracone, metacone, and hypocone are of similar size. Median cusplet is well-developed than anterior and posterior cusplets. M^2 is a duplication of M^1, with larger size.

M^3 main cusps are of similar size. Protocone lie more distally than paracone. Anterior cingulum is prominent. Labial cingulum developed at median valley end. Talon is much reduced to very small pentacone and surrounded by posterior cingulum.

I_2 crown is high. Lingual rib is protruding from crown to root. It is medio-distally compressed. The labial wall curved inward.

I_3 crown height is about half of I_2. Mesial and distal edge point convergently at tip. No development of lingual rib and cingulum.

P_1 has one main cusp and placed mesially on anterior root. Posterior edge is gently sloped.

P_2 is about double size of P_1. The main cusp is place between anterior and posterior root.

P_3 is markedly larger than P_2, abrupt change in size. The main cusp is placed more distally on posterior root. Anterior edge is straight and sharp rising, whilst posterior edge is slightly convex and end at hypoconid. Metaconid is weak.

P_4 is slightly short but broader than P_3. It has two main cusps. Labial cingulum is developed at distal half of tooth length and continue to posterior cingulum with hypoconid.

M_1 to M_3 is increase in size. Crown morphology of M_1 and M_2 is obscure due to worn. M_3 is erupting showing wrinkled enamel with shallow furchen. Anterior cingulum is not prominent. Anterior, median, and posterior cusplets are well developed. Hypoconulid is marked and situated slightly toward labial side.

Specimen no. CMu051129-02, upper right cheek teeth, P^1-M^3. P^1 and P^2 are mesio-distally elongated with very low-crowned. P^2 is thicker than P^1. P^3 is

markedly larger than the two anterior premolars, P^{1-2}. Crown tip is worn strongly at posterior edge. Protocone is developed, but not protruded lingually like that of *Hippopotamodon* cf. *hyotherioides*. P^4 crown is heavily split, then crown morphology is obscure as well as that of M^1 which heavily worn to crown base. M^2 is considerably worn, showing thick enamel. M^3 has much reduced talon, strongly reduced pentacone, having only posterior cingulum.

Other isolated teeth (Figure 5.9)

I^1 (CMu050707-04) crown is much worn. The crown edge slope distally. The tooth curved lingually.

I^2 (CMu17, CMu060612-01) is low crowned and elongated mesio-distally. Tooth curve inward. Lingual cingulum developed only distal half of tooth length. P^4-M^1 (SMT9-13'99) crown split, and cannot be observed.

M^1 (CMu060613-03, CMu6-402'02, CMu4-14'02, CMu6-4'02) enamel surface is varied, highly to less wrinkled. The cusps are prominent to not well-developed which probably of an early stage of eruption.

M^2 (CMu6-401'02) labial and lingual cingulum are developed on this specimen.

M^3 (CMu203) lingual border is broad and curved buccally and relatively deep furchen.

dM^4, deciduous tooth of P^4, morphology is molar-like. It is low-crowned and thin enamel. Anterior and posterior cingulum extended labially.

I_1 is high-crown. Mesial and distal edges are straight and having prominent lingual rib. Labial wall is flat and direct toward lingual.

I_2 is tall crown. Distal edge curved toward mesial. Lingual rib curved distally at base.

I_3 has similar morphology with I_2, but lingual rib is less prominent.

Discussion: The P_{3-4} is strongly larger than P_{1-2}, suggesting a species of tetraconodonts. Based on P_3 size, Chiang Muan specimens are clearly smaller than Tetraconodon minor, a smallest species of genus Tetraconodon. Its size is close to *Conohyus sindiensis* and *Parachleuastochoerus sinensis* (Figure 5.10). But in comparison with the relative size of P_3 and M_1, *Conohyus* show broader P_3 and longer P_3 mesio-diatally length than that of Chiang Muan specimens. Their relative size is rather close to *P. sinensis*, but with slightly broader P_3 (Figure 5.11). Among *Parachleuastochoerus* species, *P. sinensis* and *P. crusafonti*, Chiang Muan specimen is largest (Figure 5.12).

Parachleuastochoerus was a tetraconodontine, third and fourth premolar enlarged relative to first molar. It was derived from *Conohyus* and had trend decrease in size in younger species. It was named to P. sinensis (Pickford and Liu, 2001) as, though falls within the range of variation of *Cononyus sindiensis*, having slimmer and taller premolars than that of *Conohyus*. The age of P. sinensis was about 10 Ma or basal Late Miocene (Pickford and Liu, 2001), as was associated with *Hippopotamodon* cf *hyotherioides*. Therefore, the age of Chiang Muan is similar to Xiaolongtan.

Materials: CMu201 (left P_2-M_3), CMu205 (right M_3), CMu301 (left P_4), CMu14 (right M^3), CMu203 (right M_3), CMu204 (left M_3), CMu17 (right I^2), CMu209 (left I_2), CMu050625-01 (right I^1, right I_2, right I_3, left P^3, left M^1-M^3, left P_1-M_3, right P^2-M^1, and right P_4-M_3), CMu051129-02 (right P^3-M^3), CMu050706-03 (left M^3),

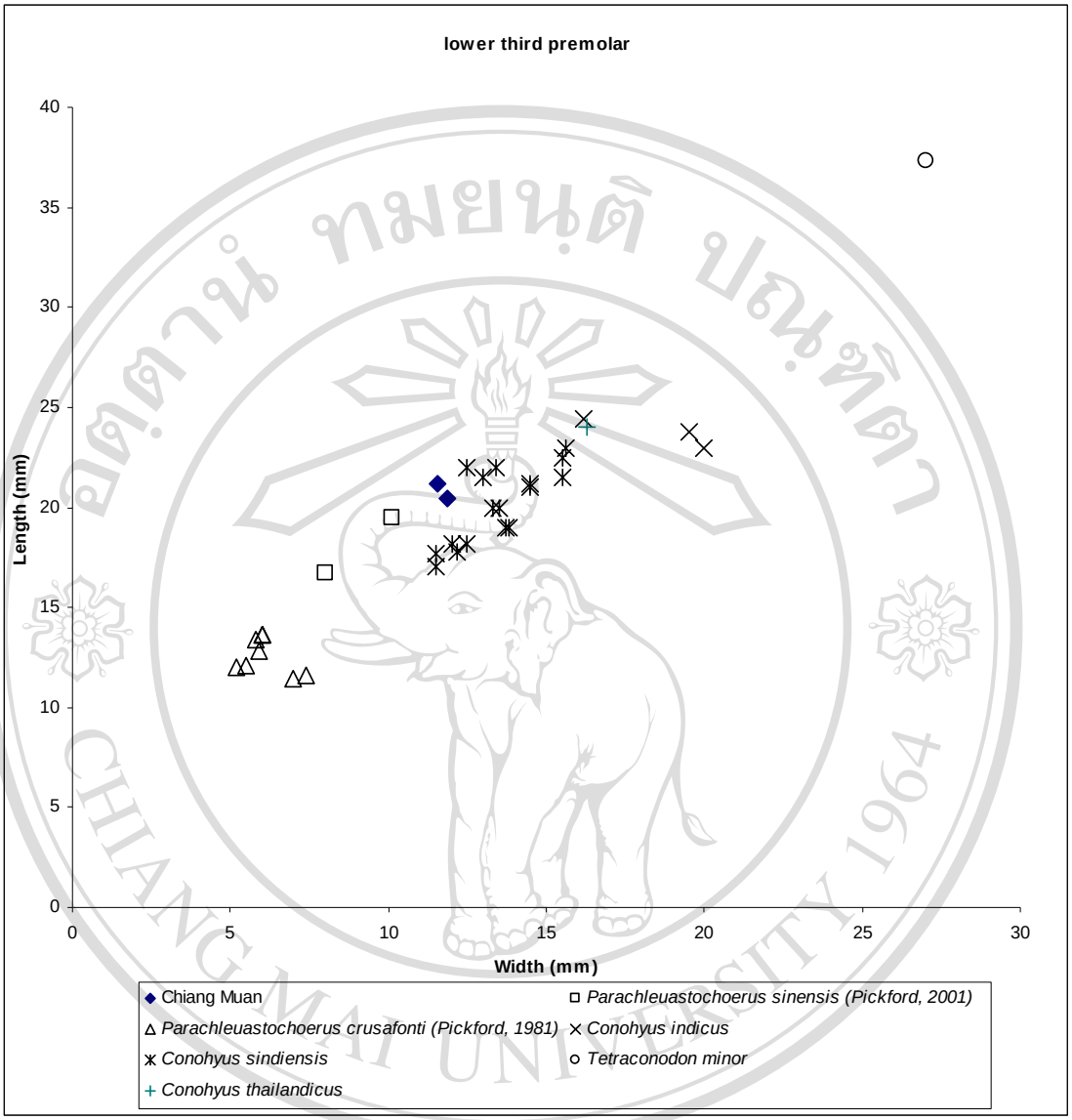

Figure 5.10 Bivariate plot of the tooth width against length of P_3 of *Parachleuastochoerus sinensis* in comparison with other related species.

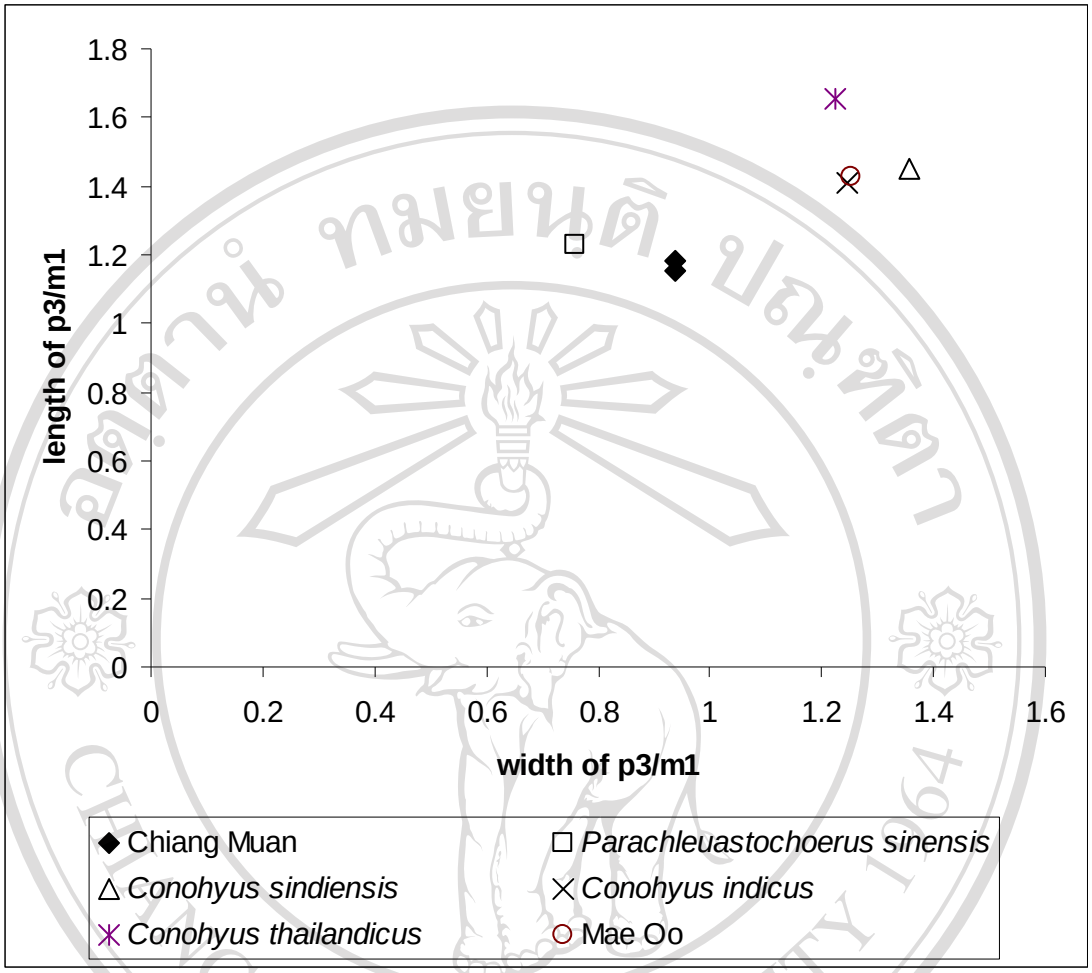

Figure 5.11 Bivariate plot of the width ratio against length ratio of P_3/M_1 of *Parachleuastochoerus sinensis* in comparison with other related species.

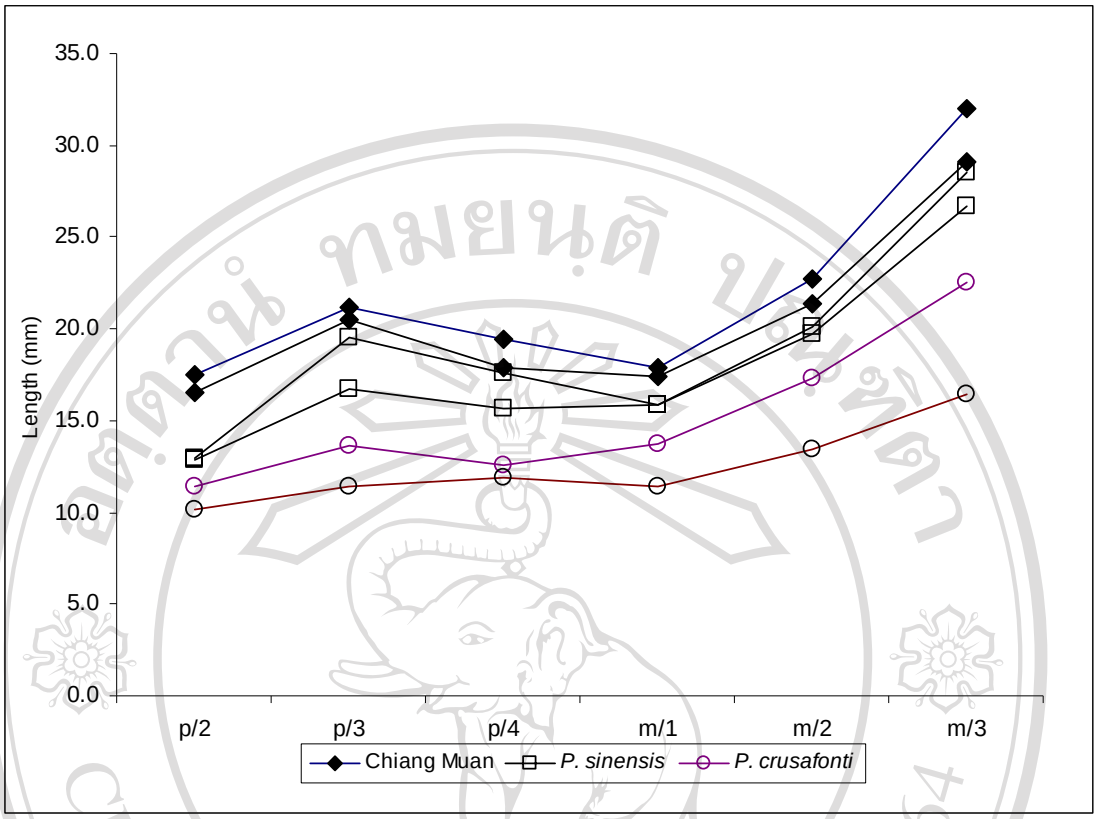

Figure 5.12 Relative tooth sizes from P_3-M_3 of *Parachleuastochoerus sinensis* from Chiang Muan in comparison with other related species.

CMu050609-03 (right M^3), CMu6-14'02 (left M^1), CMu6-402'02 (left M_1), CMu6-4'02 (right M^2), CMu060613-03 (right M^2), CMu3-13'05 (right M_3), CMu6-401'02 (left M^1), CMu050707-04 (left I^1), CMu060612-01 (left I^2), CMu050607-03 (deciduous left M^4), CMu060612-04 (right I_2), and SMT9-13'99 (right P^4-M^1).

Measurement:

Table 5.3 Dental measurement of *Parachleuastochoerus sinensis*.

Specimen no.	Tooth	W1	W2	W3	L
CMu050625-01	Rt I^1	14.96			14.36
	Rt I_2	13.11			7.36
	Rt I_3	11.04			5.99
	Lt P^2	8.40+			18.27
	Lt P^3	14.76			18.28
	Lt P^4	17.59			15.36
	Lt M^1	15.76	16.26		18.05
	Lt P_1	5.36			12.67
	Lt P_2	7.64			17.48
	Lt P_3	11.56			21.14
	Lt P_4	13.47			18.77
	Lt M_1	12.32	12.30		17.88
	Lt M_2	15.16	15.25		21.43
	Lt M_3	16.38	14.93		32.00
	Rt P^3	14.21			19.25
	Rt M^1	16.01	16.59		18.30
	Rt M^2	18.26	17.75		22.38
	Rt M^3	18.64+	16.73	10.42	28.14
	Rt P_4	13.80			19.45
	Rt M_1		13.27		17.45
	Rt M_2	15.18	15.65		21.41
	Rt M_3	16.09			30.42

Specimen no.	Tooth	W1	W2	W3	L
CMu051129-02	Rt P^3	14.43			
	Rt P^4				
	Rt M^1				
	Rt M^2	20.58	19.92		20.80
	Rt M^3	20.38	18.40	13.36	25.23
CMu050706-03	Lt M^3	20.21	15.82	11.47	24.74
CMu050609-03	Rt M^3	20.60	16.42	9.26	26.83
CMu6-14’02	Lt M^1	15.73+	15.03+		16.11
CMu6-402’02	Lt M_1	13.92+			16.84
CMu6-4’02	Rt M^2	15.42+	12.69+		19.32
CMu060613-03	Rt M^2	17.71	16.44		19.32
CMu3-13’05	Rt M_3	15.40	14.03	11.93	29.40
CMu6-401’02	Lt M^1	19.03			21.07
CMu050707-04	Lt I^1	14.98+			9.61+
CMu060612-01	Lt I^2	6.61			13.62
CMu050607-03	Lt dM^4	13.69	13.53		14.21
CMu060612-04	Rt I_2	12.08			7.09
CMu14	Rt M^3	18.91	14.83	12.00	27.12
CMu17	Rt I^2	6.00			13.41
CMu201	Lt P_2	9.42			16.53
	Lt P_3	11.86			20.46
	Lt P_4	13.92			17.85
	Lt M_1	12.67	12.53		17.75
	Lt M_2	15.98	15.63		22.72
	Lt M_3	16.45	14.84	11.70	30.77
CMu203	Rt M_3	17.91	15.71	11.76	30.85
CMu204	Lt M_3	16.21	13.95		
CMu205	Rt M_3	16.40	14.79	10.81	29.09
CMu209	Lt I_2	6.78			7.43
CMu301	Lt P_4	13.18			18.54

Specimen no.	Tooth	W1	W2	W3	L
SMT9-13'99	Rt P^4				
	Rt M^1				

Remark: measured in millimeters

Locality: Chiang Muan coal mine, Chiang Muan district, Phayao province, and Sop Mae Tham village, Soem Ngam district, Lampang province.

Age: the estimated age is basal Late Miocene, ~10 Ma.

Genus *Conohyus* Pilgrim, 1926

Diagnosis: The genus is distinguished form *Palaeochoerus* and *Hyotherium*, as well as *Sus*, by the simple cone-like structure of the main cusp in P_4. A tiny cusp is occasionally present immediately behind a summit of P_4 which is different from the marked inner cusp of P_4 in the four genera mentioned. The simple structure of P_4 was agreed with *Propotamochoerus*. It differs from these genera, except *Tetraconodon* and *Sivachoerus*, by the enlargement of the last two premolars, P_{3-4}, relative to the molars, by the vertical wrinkles on the premolars, by the hypsodonty of P^4, and by the feebleness of the cleft of P^4. All of these trace could be removed after a very small amount of wear. *Tetraconodon* is distinguished from *Conohyus* by greater enlargement of P_{3-4} and by the reduction of the inner talonal cusp and the anterior cusp in P^3 to mere cingula. *Sivachoerus* is distinguished from *Conohyus* by the less degree of wrinkling on the premolars, by the elongation and complication of M^3 and by the shape of the lower male canine, which is verrucosic instead of scrofic type.

Type species: *Hyotherium simorrense*, Lartet 1851

Conohyus indicus Lydekker, 1884

Figure 5.13

Diagnosis: The premolars do not differ in structure from those of *Conohyus chinjiensis*, but they are obviously larger than *C. chinjiensis*. Since M^3 is nearly the same size as in *C. chinjiensis*, but premolars are double of size. Other distinguishing features are a stouter mandible, more distinct wrinkles on the premolars, and stronger internal cingulum on P^4.

Description: I_2 mesial edge is straight with mesially curved dorsal edge. Lingual rib is enlarged extended to both edges. It is worn at crown and lingually toward the upper part of the rib. P_4 has one main cusp which situated mesially and placed on anterior root. Anterior edge is steep. Anterior cingulum developed as high as half of crown height. Posterior edge is gently and end at posterior cingulum which height is three fourth of crown. P_3 also has main cusp which placed between anterior and posterior roots. In P_3, Anterior edge is steep. Posterior edge is gently and convex which end at well-developed posterior cingulum, half of crown height. P^4 is large with no median crest or cusplets. The main cusps, paracone and metacone, are situated at more lingual. Labial wall is broad. M_1 crown is rectangular-shaped in outline and considerably worn showing thin enamel. M^2 anterior pair cusps are broader than posterior pair cusps. Metacone is slightly smaller than paracone. M^3 furchen is shallow. Anterior cingulum is well-developed. Talon is reduced, pentacone reduced, and only posterior cingulum remained. The talon is place lingually.

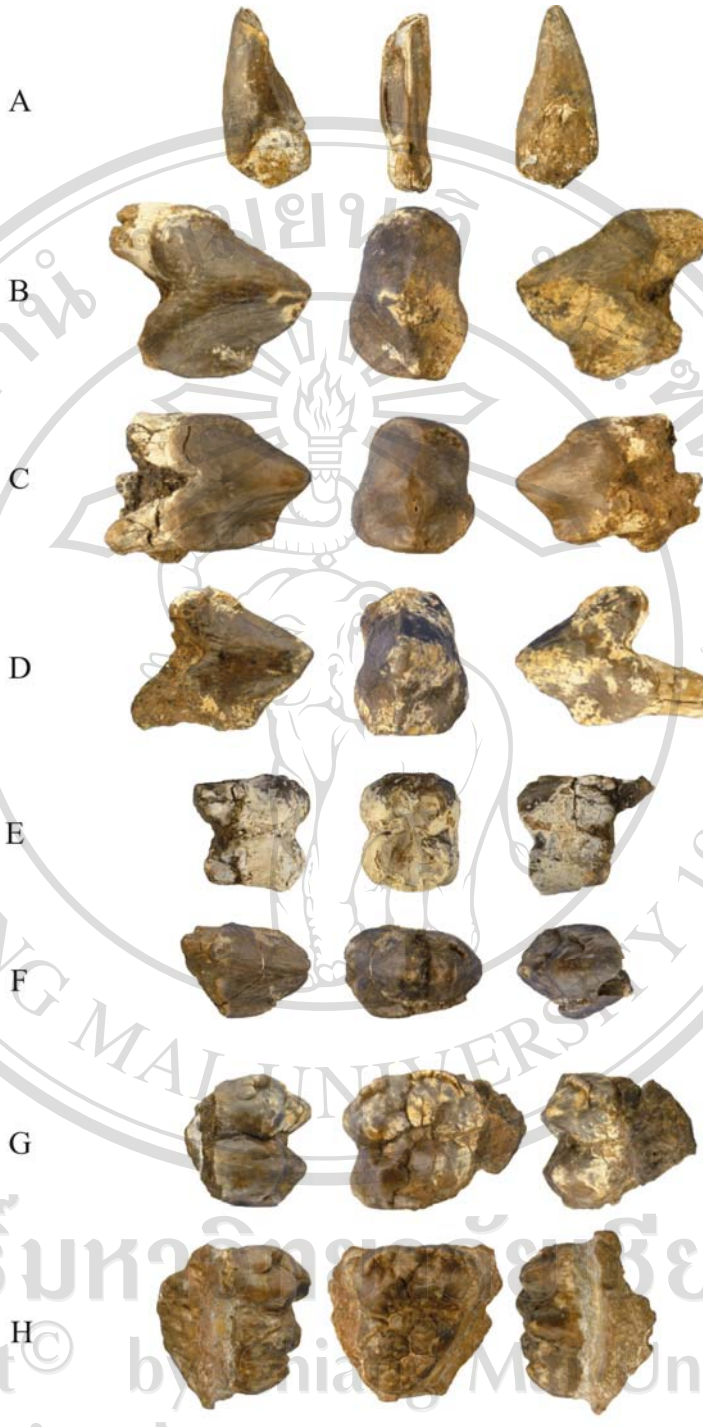

Figure 5.13 *Conohyus indicus* from Mae Oo area, MO3-1'01, A) left I_2, B) left P_3, C) left P_4, D) right P_3, E) left M_1, F) left P^4, G) left M^2, and H) left M^3, scale bar = 20 mm.

Discussion: Mae Oo specimen showing a large posterior premolar, P_{3-4}, which warrants it a tetraconodonts. Its tooth size is close to *C. thailandicus* and *C. indicus* and relatively larger than *C. sindiensis* (Figure 5.14). Its dental morphology, especially P_3, showing steep anterior edge and the posterior edge is well-developed, half of crown height. Whilst that of *C. thailandicus* has reduced anterior edge and considerably retreat slightly distally, posterior cingulum relative low height, and has cingulid around the whole crown. This morphology of P_3 of Mae Oo specimen is similar to *C. indicus* (Pickford and Gupta, 2001). *Conohyus* was evolved in Asia. *C. sindiensis* evolved in Middle Miocene in Pakistan as well as *C. indicus*, but relative larger in size (Pickford, 1988). The evolutionary trend was increase in tooth size suggesting larger bodied size (Pickford, 1988). Mae Oo *Conohyus* was very close in size to *C. thailandicus*.

Materials: MO3-1'01 (Left I_2, P_3, P_4, P^4, M_1, M^2, M^3, and right P_3)

Measurement:

Table 5.4 Dental measurement of *Conohyus indicus*.

Tooth	Breadth	Length
Left I_2	10.91	6.78
Left P_3	16.60	22.98
Left P_4	17.40	18.90
Left P^4	21.26	13.0
Left M_1	13.26	16.11
Left M^2	18.87	17.87
Left M^3	16.26	19.42
Right P_3	17.68	22.13+

Remark: measured in millimeters

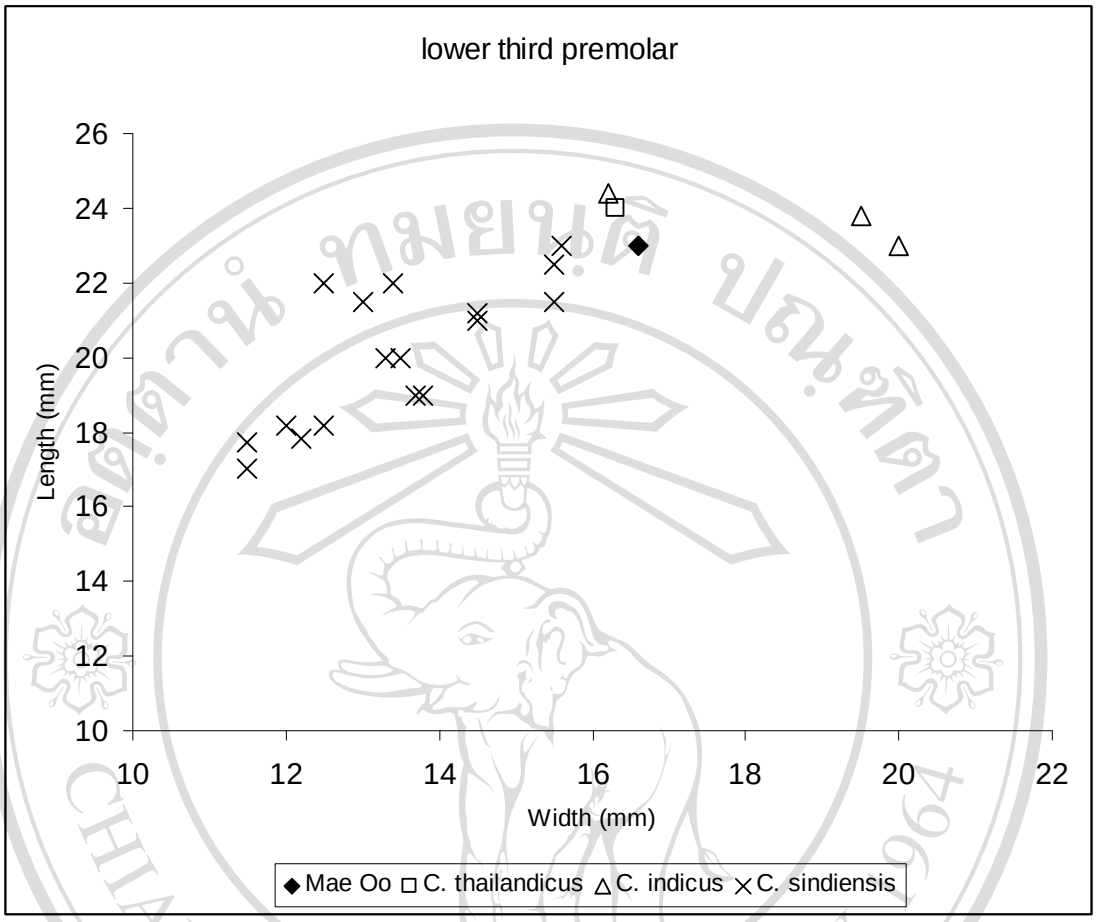

Figure 5.14 Bivariate plot of the tooth width against the length of P_3 of *Conohyus indicus* from Mae Oo in comparison with other related species.

Locality: Mae Oo village, Wang Nua district, Lampang province.

Age: *C. indicus* was found in the Chinji and Nagri Formation, then the age is between 12.5 and 9.5 Ma (Pickford, 1988) which younger than Pong basin, Phayao province.

Indeterminated genus and species

Figure 5.15

Description: specimen no. CMu051202-04 is left upper C, P^2-M^3 and right upper C, P^1-M^3. P^2 anterior and posterior crest lie mesio-lingually with shallow fossa and postero-distal cingulum. P^3 is relatively larger than P^2. It is thick, inflated, and well-developed anterior cingulum. Lingo-distal cingulum is prominent. P^4 is resembled to *P. sinensis* as median crest developed, but smaller size. M^1 crown is much worn. M^2 is considerably worn, showing thick enamel. M^3 talon is placed toward lingual. M^3 size is not distinctly larger from M^2 and P^3 and P^4 are not enlarged relative to M^1. Both characters are of tetraconodonts. This specimen could not be hyotheriine.

Discussion: These Chiang Muan specimens could not be either Listriodontinae or Tetraconodontinae, as teeth not lophodont and P_{3-4} not enlarged compare to M_1. This suid show transition between the Hyotheriinae and Suinae which based on the development of sagittal crest on P^4. It is very small or absent sagittal cusplets, in P4, in the Hyotheriinae, but it is well-developed in the Suinae. Pickford (1988) used this character in classified these two sub-families. When the cusplet is fully developed, it is reaching Suine stage, *Propotamochoerus*. This suid retains some primitive character, of Hyotheriinae, such as, a simple M^3, much reduced talon, and, especially, the labial cingulum on M^3. Though, the labial, on M^3, is variable degree of

Figure 5.15A Indeterminate g. *et* sp., CMu051202-04, upper A) right canine and B) left canine; right C) P^1, D) P^2, E) P^3, F) P^4; left G) P^2, H) P^3, I) P^4; J) right M^{1-3}, and K) left M^{1-3}, scale bar = 20 mm.

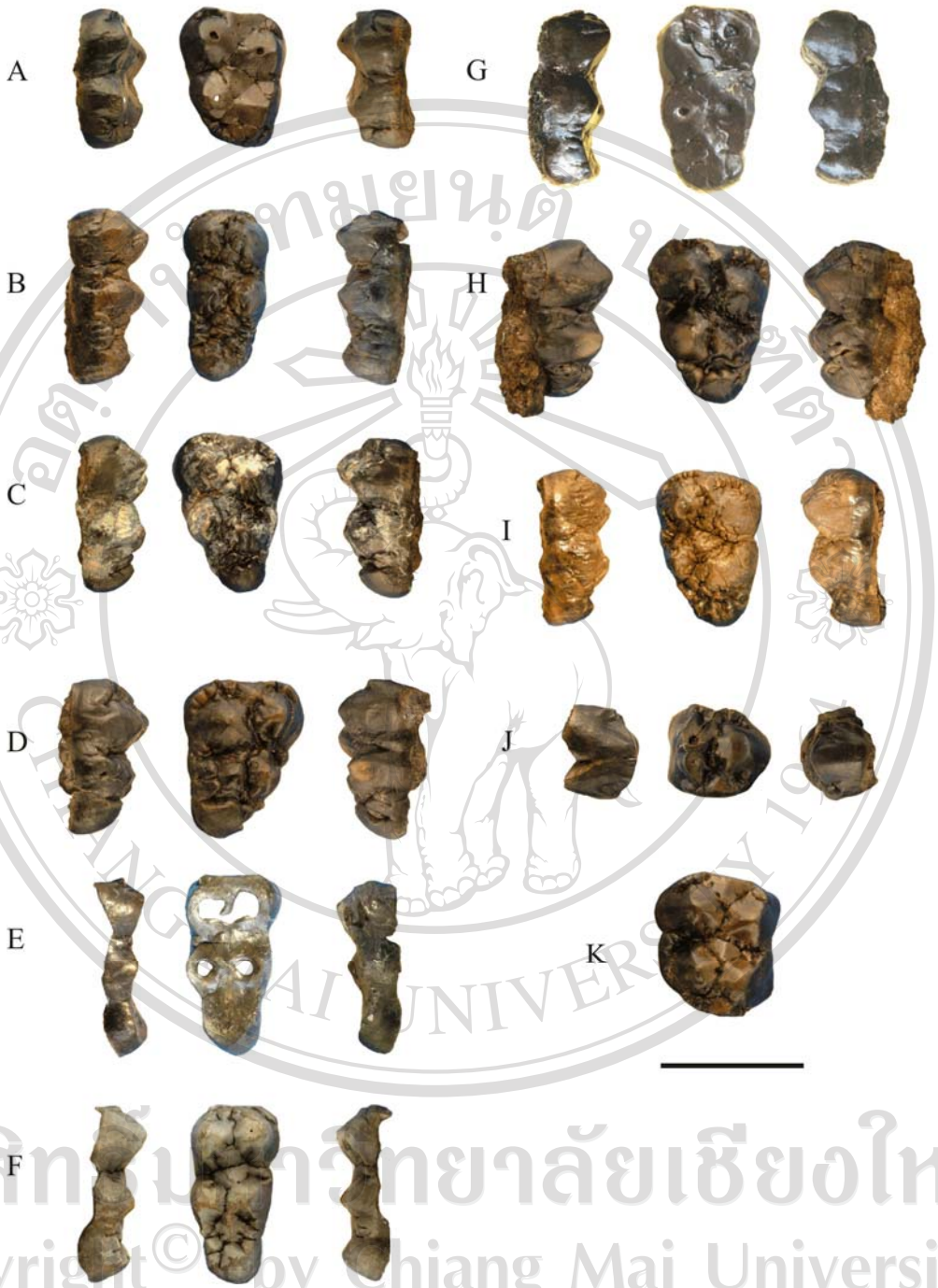

Figure 5.15B Indeterminate g. *et* sp., A) CMu3-5'05, B) CMu050515-12, C) CMu060616-05; CMu3-11'05 D) left M^3, H) right M^3, J) right P^4, K) right M^2, E) CMu060612-08, and I) CMu050607-01, scale bar = 20 mm.

development, it is apparently seen in some specimen, CMu050607-01. In comparison of the dental size of this suid with those of Suinae, *Propotamochoerus wui* (Made and Defen, 1994) (=*P. parvulus* by Pickford and Liu, 2001), and Hyotheriinae, *Chleuastochoerus*, showed that M^1 and M^2 was more stout, and M^3 clearly smaller than the latter two species. Thus, this Chiang Muan has different tooth dimension from the two species. There, it specific name will be given after further detailed study.

Materials: CMu051202-04 (left C, P^2-M^3 and right C, P^1-M^3), CMu3-11'05 (right P^3-P^4, right M^3, and left M^3), CMu3-5'05 (right M^3), CMu050515-12 (left M_3), CMu202 (right M^3), CMu060616-05 (right M^3), CMu050607-01 (right M^3), CMu060612-08 (right M_3), and CMu060612-03 (right M_3).

Measurement:

Table 5.5 Dental measurement of indeterminate genus and species specimens.

Specimen no.	Tooth	W1	W2	W3	L
CMu051202-04	Lt upper C				
(CMu3-10'05)	Lt P^2	7.44			14.24
	Lt P^3	11.99			14.66
	Lt P^4	16.27			12.59
	Lt M^1	15.32	14.79		14.86
	Lt M^2	17.66	16.36		17.80
	Lt M^3	15.89	12.86	8.21	20.92
	Rt upper C				
	Rt P^1	5.86			12.14
	Rt P^2	7.51			13.51
	Rt P^3	12.17			14.36
	Rt P^4	16.3			12.61
	Rt M^1	15.77	15.38		14.59
	Rt M^2	17.93	16.67		17.85

Specimen no.	Tooth	W1	W2	W3	L
	Rt M^3	15.82	12.69	8.36	20.80
	Lt M^2				19.13
CMu3-11'05	Lt M^3	16.66	13.07	8.73	21.21
	Rt P^2				15.03
	Rt P^3	11.24+			
	Rt P^4	14.68+			13.11
	Rt M^2	17.69	16.13		19.19
	Rt M^3	16.53	12.62	8.51	21.19
CMu3-5'05	Rt M^3	15.52	13.27	11.07	19.49
CMu050515-12	Lt M_3	12.84	11.83	9.43	25.46
CMu202	Rt M_3	13.07	11.19	7.08	24.27
CMu060616-05	Rt M^3	15.18	11.50	7.34	20.84
CMu050607-01	Rt M^3	15.79	13.50	8.88	21.86
CMu060612-08	Rt M_3	13.34	11.79	8.42	25.13
CMu060612-03	Rt M_3	12.61+	11.48+	8.16	24.96
GCMU480704-01	Rt M_3	13.40	12.03	8.77	24.12

Remark: measured in millimeters

Locality: Chiang Muan coal mine, Chiang Muan district, Phayao province.

Age: basal Late Miocene, ~10 Ma.

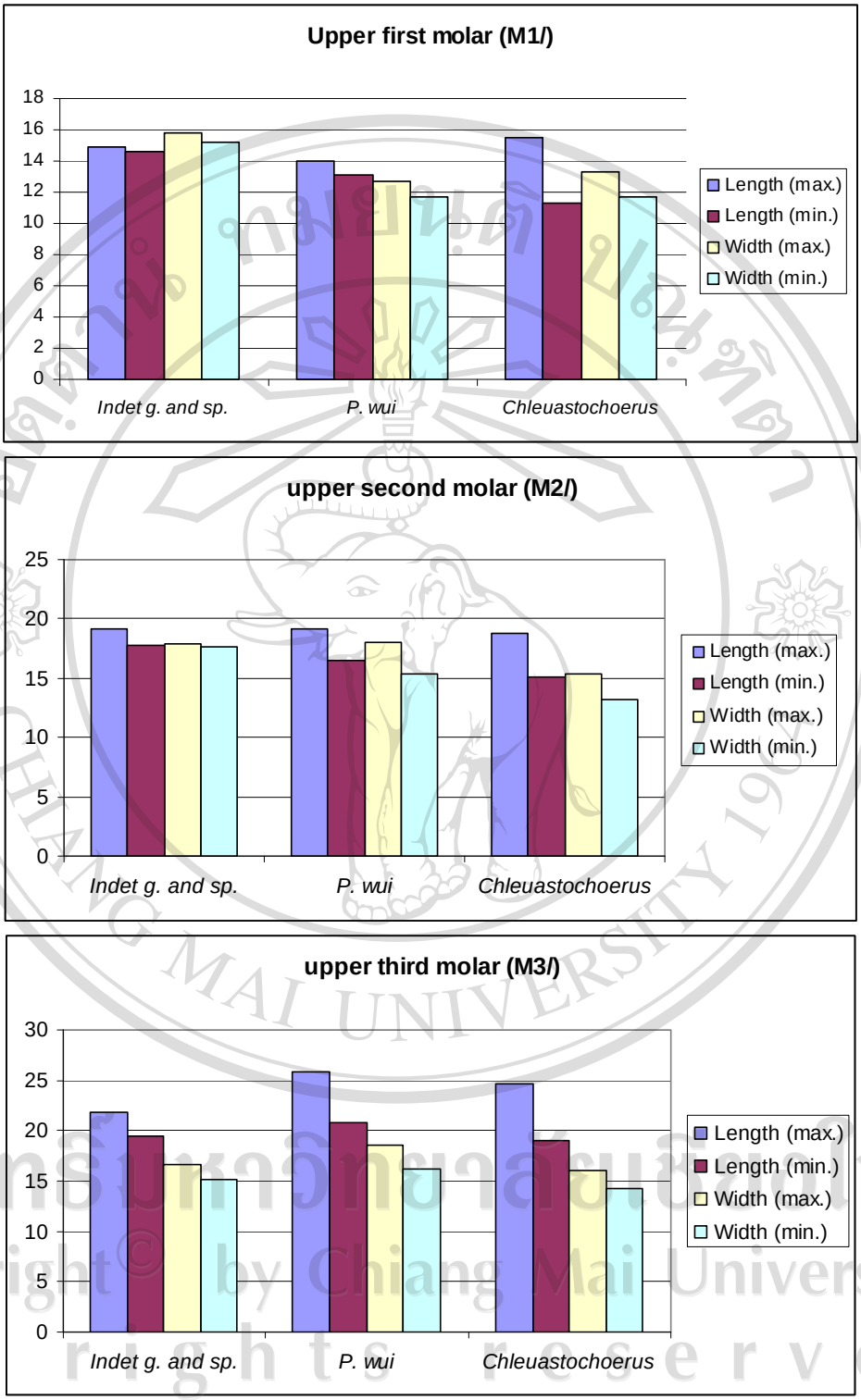

Figure 5.16 Relative tooth sizes from M^1-M^3 of indeterminate g. *et* sp. with other related species.

5.4 Tayassuidae

Tayassuidae is one of two Suoidea families, the Suidae (Old World suids or true pigs) and Tayassuidae (New World suids or peccaries). The geographical differentiation of recent representatives is not applicable to the fossil forms. The family Tayassuidae is exclusively American forms since Early Oligocene (Hünermann, 1999).

The metatarsal III and IV tend to fuse. In the hind limbs the fifth toes are reduced to a proximal rudiment and the second toes are poorly developed (Hünermann, 1999). The skull has an elevated, backward-sloping, occipital crest, along narrow palate, and small postorbital processes. The upper incisors are short and stout, with curved roots, while the lowers are long and slender with straight roots. The canines are small and lie almost vertically, with the gently curved lowers wearing against the front of the uppers to maintain sharp points. There is diastema between canine and premolar, but the premolars are contact. The molars have simple bunodont crowns with four cusps and the last premolar tends to be molariform (Pickford, 1978).

The main points of difference with the Suidae are their somewhat narrower snouts, and therefore narrower dentition. The subsidiary cusps of the molars are reduced. They have sharp canine tusks which curve in labio-lingual plane. Males and females have the same size canine and are rooted with a clearly defined crown coated with enamel (Hillson, 2005).

Fossil peccaries occur in North America from the Oligocene to the present, in Oligocene and Miocene in Europe, in Pleistocene to recent in South America, and Pliocene in Asia (Pickford, 1978).

5.4.1 Major lineages of Tayassuidae

Tayassuidae in the Old World is composed of genus *Dolichoerus* and *Pecarichoerus*. *Doliochoerus* was descended from common ancestor of Tayassuidae and Suidae and later an ancestor of *Pacarichoerus*. *Doliochoerus* appeared in Oliogocene and *Pecarichoerus* in Middle Miocene. Early in the history of the Tayassuidae, some group migrated to the New World and evolved to *Perchoerus* (Colbert, 1935).

5.4.2 Dental Terminology and Measurement

See measurement for Suidae (Figure 5.6).

5.4.3 Results

Family Tayassuidae Palmer

Genus *Pecarichoerus* Colbert, 1933

Diagnosis: Molar teeth short, brachyodont and quadricuspid. Cusps conical and separated from each other. Median valley of the third molar occupied by sharp, oblique ridges, which run between the anterior and the posterior pairs of cusps. Enamel smooth.

Type species: *Pecarichoerus orientalis* (Colbert, 1933)

***Pecarichoerus* sp.** Colbert, 1933

Figure 5.17

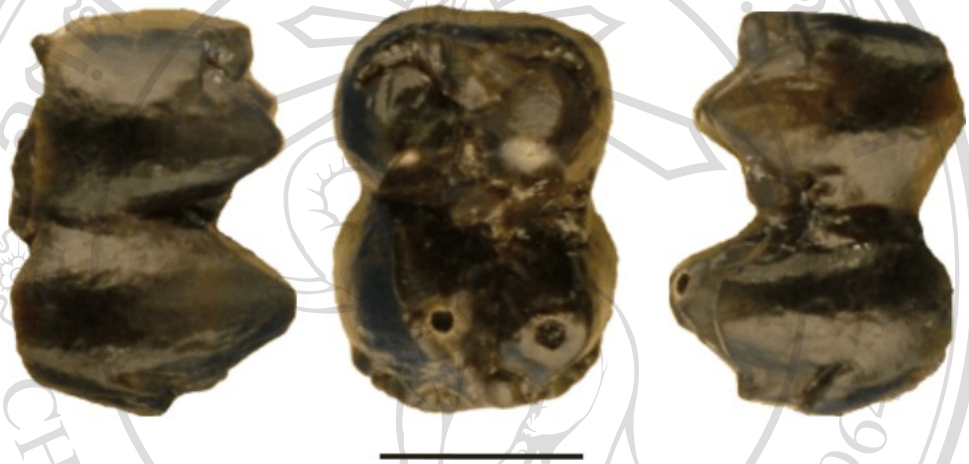

Figure 5.17 *Pecarichoerus* sp., CMu426, left M_1, scale bar = 5 mm.

Diagnosis: small-sized tayassuid, bunodont molar, gradient worn on molar, small cuspid at base of median valley end; large talonid on M_3 and well-situated on the root and inclined distally, small anterior cingulum on lower molar, groove on

Materials: CMu426 (Left M_1)

Description: lower left first or second molar, bunodont and quadricuspids, conical cusps and separated from each other, less worn, small tubercle at base of transverse valley end on labial side, anterior pair cusps worn at tips and no worn on posterior pair cusps showing gradient worn, posterior cingulum better developed than anterior cingulum.

Discussion: The *Pecarichoerus* was of Paleochoerinae, an Old World peccaries. At present the phylogeny of the old world peccaries is not well understood (Made and Defen, 1994). It is difficult to make a comparison. Those teeth found in the Siwalik were upper molars, *Pecarichoerus* (Colbert, 1935) and cannot be comparing with lower molar from Chiang Muan. However, the length of the teeth is short in Chiang Muan form.

Table 5.6 Dental measurement of *Pecarichoerus* sp.

Tooth	**Length**	**Width**
M/1 or/2	9.89	6.86

Remark: measured in millimeters

Fossil locality: Chiang Muan coal mine, Chiang Muan District, Phayao Province

Age: As it was found associated with the Chiang Muan suids, *Hippopotamodon* cf. *hyotherioides* and *Parachleuastochoerus sinensis*, suggest basal Late Miocene, ~ 10 Ma.

5.5 Ruminantia

Ruminantia are predominant large land mammals of today, composed of Tragulidae (mouse deer or chevrotain), Moschidae (musk deer), Cervidae (deer), Giraffidae (giraffe and okapi), Bovidae (cattle, sheep, goats, and antelopes) and Antilocapridae (pronghorns). Ruminantia reach it highest diversity in Late Neogene. Its originate ca. 45 million years ago in Middle Eocene. Their body sizes ranges from rabbit like forms to two meters of body height. Dietary preferences are omnivory to strictly herbivorous with adaptations to browsing and grazing (Gentry *et al*., 1999).

In limb bones, there is possible fusion between tarsals II (mesocuneiform) and III (ectocuneiform), carpals II (trapezoid), and III (magnum) as well as the third and fourth metapodials forming the so-called ‘cannon bone’. The tarsal element cubonavicular was formed by fusion of the tarsal IV or cuboid and the navicular, and distinguished the Ruminantia from other suborders of artiodactyls since the Eocene. The tooth formula is 0.1.3.3 (upper) and 3.1.3 (4).3 (lower). Extant cranial appendages are horns, antlers, and ossicones (Gentry *et al*., 1999).

5.5.1 Major lineages of Ruminantia

The subdivision of ruminant artiodactyls is further into the infraorders Tragulina and Pecora. Tragulina are composed of small hornless forms, Hypertragulidae, Leptomerycidae, Bachitheriidae, Lophiomerycidae, and Tragulidae. Pecora were defined by the possession of cranial appendages, Cervidae, Bovidae, and Giraffidae.

5.5.2 Dental Terminology and Measurement

The dental terminology is referred to Gentry *et al*., 1999 (Figure 5.18). The dental measurement are followed Driesch, 1976. A molar length is measured mesio-distally and molar width measured bucco-lingually.

5.5.3 Results

Family Tragulidae Milne-Edwards, 1864

Genus *Siamotragulus* Thomas *et al*., 1990

Diagnosis: Small tragulidae, intermediate size between *Dorcatherium minus* Lydekker and *D. minimus* West; lower premolars, especially P_3, very pointed and sharp; P_4 possess an elongate posteriorly directed metaconid but no entoconid or entostylid. P_3 long trenchant, strongly compressed, tall protoconid, minute paraconid and distinct hypoconid; no posterolingual ridge (metaconid) on P_3; upper canines of males (?) saberlike; limb bones long and slender, metapodials tend toward pecoran type. Metatarsals II and V much reduced and fused to metatarsals III to IV; metacarpals III and IV fused together; no reduction of metacarpals II and V to proximal rudiments; navicular-cuboid separated from ectomesocuneiform; convex surface of malleolar articulation of calcaneum; malleolar bone not fused with tibia.

Type species: *Siamotragulus sanyathanai* Thomas *et al*., 1990

Siamotragulus haripounchai Mein and Ginsburg, 1997

Figure 5.19

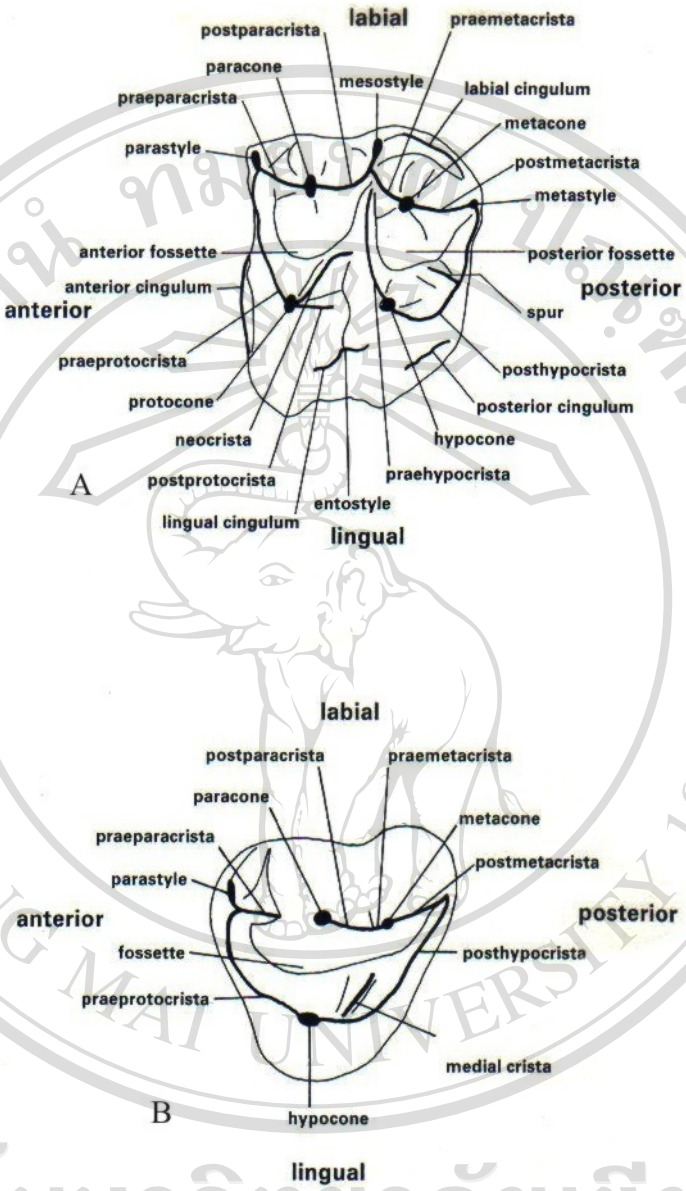

Figure 5.18 Dental terminology of ruminants, A) upper molar, B) upper fourth premolar, C) lower molar, and D) lower fourth premolar (Gentry *et al*., 1999).

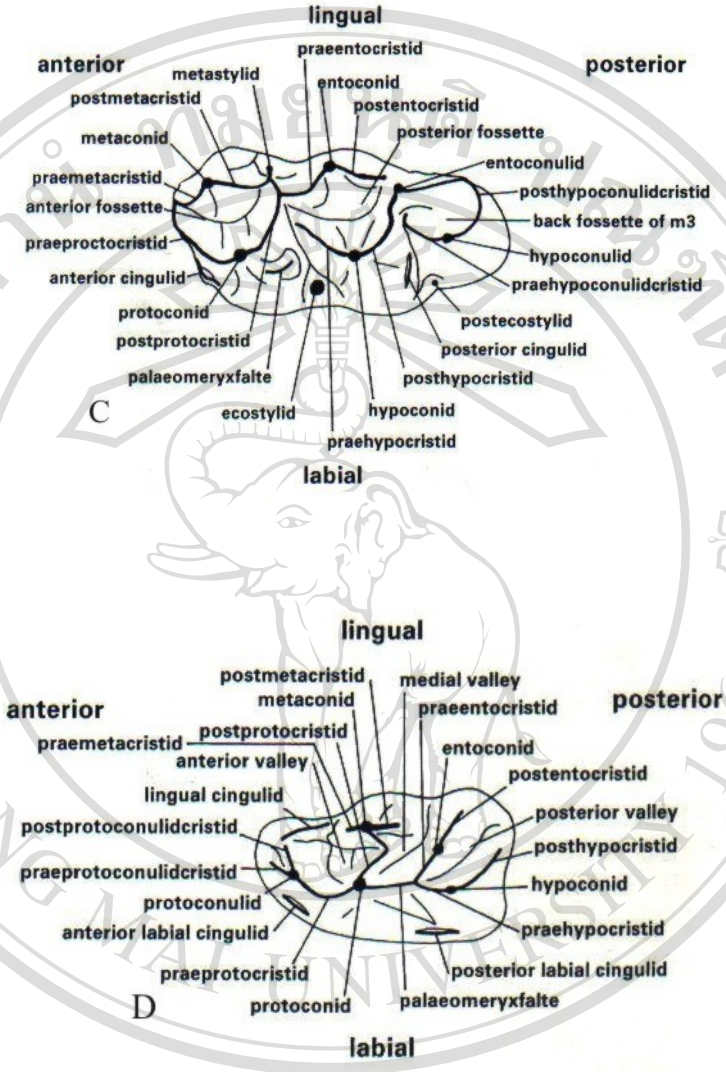

Figure 5.18 Dental terminology of ruminants, A) upper molar, B) upper fourth premolar, C) lower molar, and D) lower fourth premolar (Gentry *et al*., 1999) (cont.).

Figure 5.19 *Siamotragulus haripounchai*, A) CMU05, M^2 and B) CMU06, M^{2-3}, scale bar = 10 mm.

Diagnosis: an intermediate size between *Dorcatherium minus* and *D. minimus*; upper canines of males (?) saber-like; lower premolar, particulay P_3, very pointed and sharp; P_3 long, trenchant, and strongly compressed, tall proconid, small paraconid, distinct hypoconid, no metaconid; P_4 elongate posteriorly directed metanoid and no entoconid or entostylid.

Materials: CMU05 (right M^1 or M^2?), CMU06 (right M^{1-2} or M^{2-3}?)

Description: The tooth is selenodont type with four main cusps. The ectolophs of both paracone and metacone are strong. Paracone and metacone are of equal size. The anterior pair of cusps is wider than the distal pair. Protocone was situated more lingually than the hypocone. The cingulum is slightly developed at mesial and relatively strong at lingual of the protocone.

Discussion: The tooth size of an individual no.1, GCMU05, is relatively smaller than individual no.2, GCMU06. The individual no. 1 is smaller than that of *Siamotragulus sanyathanai*, but individual no.2 is larger. These specimens are likely to b*e S. haripounchai*, found in Mae Long valley 8 km northwest of Na Sai. Unfortunately, the M^{2-3} of *S. haripounchai* have not been found yet, then no data to be compared.

Measurement: The genus, *Siamotragulus*, was tragulid of Thailand recognized by Thomas *et al.*, 1990 with new species, *S. sanyathanai* and another species *S. haripounchai* was found from Mae Long sub-basin in Lamphun province. As Na Sasi was very close to Mae Long, therefore the tragulid found in Na Sai probably belongs to *S. haripounchai*. If so, it gives more information on upper molars.

Table 5.7 Dental measurement of *Siamotragulus haripounchai*.

Tooth	Length	Width
CMU05		
M^2	9.15	11.20
CMU06		
M^2	9.64	11.36
M^3	10.35	12.41

Remark: measured in millimeters

Fossil locality: Na Sai coal mine, Li District, Lamphun Province

Age: The age of *S. sanyathanai*, found in Pong district, Phayao province, is Middle Miocene, approximately 16-14 Ma. The age of Na Sai is relatively older than the Pong area. Then the Na Sai tragulid is relatively older than *S. sanyathanai* (Hanta *et al*., 2006). It is late Early Miocene. The relative age between Na Sai and Mae Long is controversial, however, approximately same age.

Genus *Dorcatherium* Kaup, 1833

Diagnosis: high crowned cheek teeth, upper molars bear strongly developed buccal styles, lower molars characterized either by a well-developed ectostylid (basal pillar) or by a vestigial ectostylid and presence of a *Dorcatherium* fold (Colbert, 1935).

Type species: *Dorcatherium naui* Kaup, 1833

Dorcatherium minus Lydekker, 1876

Figure 5.20

Material: CMu501 (left P_4), GCMU01 (right M_3)

Figure 5.20 *Dorcatherium minus*, A) CMu501, left P_4 and B) GCMU01, right M_3, scale bar = 10 mm.

Description and discussion: P_4 is hypsodont and narrow crowned. The parastylid is distinct and separated from the protoconid. It is small lobe and directed slightly lingually. Postprotocristid is thick and similar to prehypocristid. Enamel is thick, 0.5 mm. Hypoconid directed posteriorly and postero-lingually at the crestid end. Posterior cingulum is slight developed. M_3 are least worn, except protoconid. Principle conids are well-developed. Protoconid is crescentic. The preprotocristid (anterior wing) run anteriorly and lingually unites with the premetacristid of the metaconid. The postprotocristid is bifurcated into two thin oblique ridges running postero-labially. The postprotocristid connect to preentocristid and the paleomeryx fold to the prehycristid. The anterior cingulum is strongly developed. The metaconid is pointed. Premetacristid and postmetacristid have sharp slope. The postmetaconid is bifurcated and the labial ridge is so-called 'Dorcatherium fold'. The metaconid and entoconid are higher than protoconid and hypoconid. Entoconid is slightly lower than the metaconid and pointed. Hypoconid is slightly smaller than the protoconid. Postectostylid is well- developed. The hypoconulid is strongly crescentic in shape and the wings are close together. The presences of dorcatherium and paleomeryx folds are typical for tragulidae. Both of these teeth are slightly larger than *Dorcatherium minus* (Farooq, 2005).

Dorcatherium minus was found from Chinji and Dhok Pathan (Farooq, 2005). The tooth morphology between these two formations was similar. The species had a tendency toward decrease in prominence of cingulum, from the Chinji to the Dhok Formation. Parastyle and mesostyle were usually moderately developed and metastyle was weakly developed. No remarkable change in size among the specimens of the Lower Siwalik and Middle Siwalik (Farooq, 2005).

Measurement:

Table 5.8 Dental measurement of *Dorcatherium minus*.

Tooth	Length	Width
P_4	12.60	5.99
M_3	19.90	10.12

Remark: measured in millimeters

Locality: lower lignite layer, Chiang Muan coal mine, Chiang Maun District, Phayao Province.

Age: As it was found associated with the Chiang Muan suids, *Hippopotamodon* cf. *hyotherioides* and *Parachleuastochoerus sinensis*, suggest basal Late Miocene, ~ 10 Ma.

***Dorcatherium* sp. 1**

Figure 5.21

Material: CMu108 (right upper molar)

Description and discussion: An upper molar is selenodont with brachyodont (low-crowned). All principle tooth cones are well-developed and less worn, except the protocone which is considerably worn. Labial cones are higher than lingual cones which are V-shaped. The preprotocrista is longer than postprocrista and extended to the parastyle. The metacone is situated more lingual than paracone. Hypocone is more reduced than protocone. Prehypocrista and posthypocrista are of equal length. Entostyle is well-developed. These are common features of genus *Dorcatherium*. However, the tooth size is extremely small in comparison with other species of *Dorcatherium* (Figure 5.22)

Figure 5.21 *Dorcatherium* sp. 1, CMu108, right upper molar, scale bar = 5 mm.

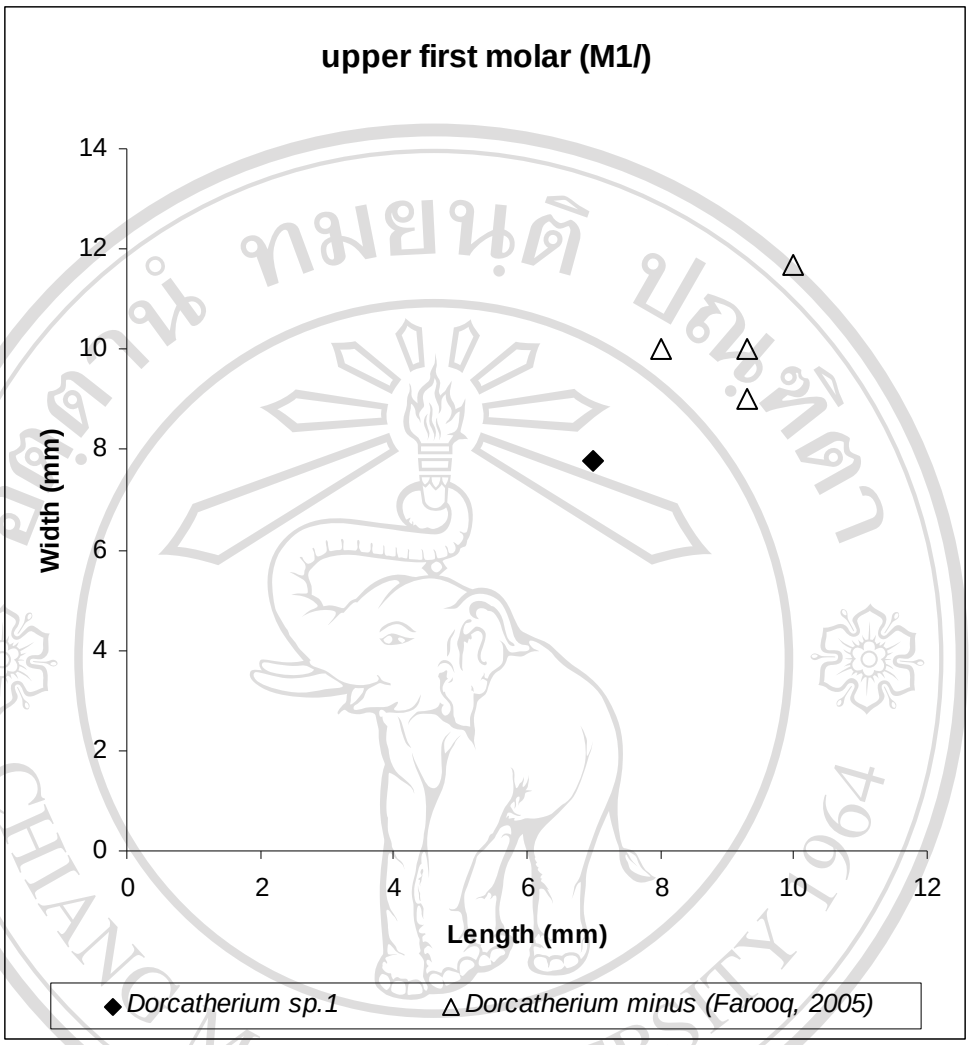

Figure 5.22 Bivariate plot of the tooth width against length of M^1 of *Dorcatherium* sp.1 in comparison with other related species.

Measurement:

Table 5.9 Dental measurement of *Dorcatherium* sp.1.

Tooth	Length	Width
right upper molar	6.99	7.79

Remark: measured in millimeters

Locality: lower lignite layer, Chiang Muan coal mine, Chiang Maun District, Phayao Province.

Age: As it was found associated with the Chiang Muan suids, *Hippopotamodon* cf. *hyotherioides* and *Parachleuastochoerus sinensis*, suggest basal Late Miocene, ~ 10 Ma.

***Dorcatherium* sp. 2**

Figure 5.23

Material: MS-6_Dch-2, left P_3 (?), left M_1 and mesial half of M_2

Description and discussion: P_3 is well preserved and less worn. The tooth is hypsodont and thin. Protoconid is more prominent than parastylid and hypoconid. Paraconid is not developed. Protoconid shows bifurcated, lingual crest directed posteriorly and labial crest is continuing to hypoconid which directed posteriorly and postero-lingually at the crestid end. Enamel is finely wrinkled at labial side and is smooth at lingual side. M_1 is considerably worn and M_2 slightly worn. The enamel of molars is finely wrinkled all around the teeth. Anterior cingulum is present. Protoconid and hypoconid are aligned postero-linguallly. Preprotocristid continue with premetacristid. Postprotocristid bifurcated into two crest, the inner is connect to

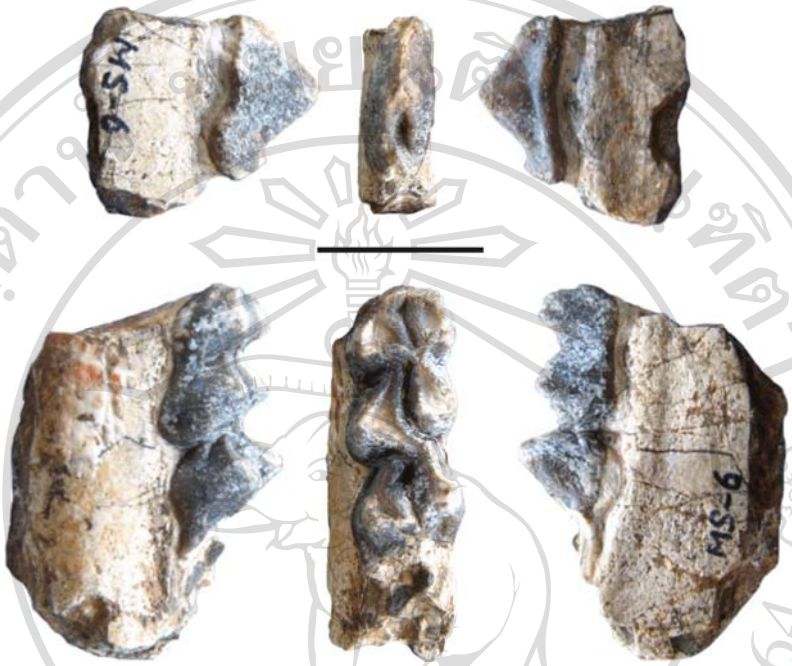

Figure 5.23 *Dorcatherium* sp.2, MS-6_Dch-2, left P_3 (?), left M_1 and mesial half of M_2. Scale bar = 10 mm.

preentocristid and the outer crest, paleomeryx fold, connect with prehypocristid. Postmetacristid is also bifurcated, the outer is dorcatherium fold and the inner crest connects with inner crest of postprotocristid and preentocristid. The hypoconid is also crescentic in shape. Posthypocristid is longer than prehypocristid. Anterior fossette is shallower and narrower than the posterior fossette.

Measurement:

Table 5.10 Dental measurement of *Dorcatherium* sp.2.

Tooth	Length	Width
P_3 (?)	9.66	4.17
M_1	10.33	6.81

Remark: measured in millimeters

Locality: Doi Chang locality of Mae Soi site, Chom Thong District, Chiang Mai Province

Age: As it was found at the site of primitive Amebelodontid, *Archaeobelodon* sp., the age of this proboscidean is 19-18 Ma (Nakaya *et al*., 2007). The age estimation of this tragulid is not distant from this age.

***Dorcatherium* sp. 3**

Figure 5.24

Material: GCMU07 (left M_1)

Description and discussion: tooth is highly worn approaching to the crown base. Enamel is very thin, 0.35 mm, in comparion with other tragulids, 0.5-0.6 mm, of the same locality. The ectostylid (basal pillar) is also worn, the remaining portion indicating a very robus pillar. Protoconid is much reduced than hypoconid. Posterior

Figure 5.24 GCMU07, left M_1. Scale bar = 5 mm.

fossette is observable, but the anterior is worn out. Its size is of *D. minus* which specimen also has basal pillar (Farooq, 2005).

The tooth size, lower first molar M_1, of *Dorcatherium* sp. 2 and *Dorcatherium* sp. 3 was the same size (Figure 5.25), though they were discovered from different age of rock. Because their sizes was not changes from older deposit to younger deposit (Farooq, 2005).

Measurement:

Table 5.11 Dental measurement of *Dorcatherium* sp.3.

Tooth	Length	Width
M_1	10.34	6.88

Remark: measured in millimeters

Locality: lower lignite layer, Chiang Muan coal mine, Chiang Maun District, Phayao Province.

Age: As it was found associated with the Chiang Muan suids, *Hippopotamodon* cf. *hyotherioides* and *Parachleuastochoerus sinensis*, suggest basal Late Miocene, ~ 10 Ma.

Family Lagomerycidae Pilgrim, 1941

Genus *Stephanocemas* Colbert, 1936

Diagnosis: Antler broadly palmate with an average of six or eight tines in adult. Antler supported on a rather long, heavy pedicle, which joins the antler in the middle of the palmate portion.

Type species: *Stephanocemas thomsoni* Colbert, 1936

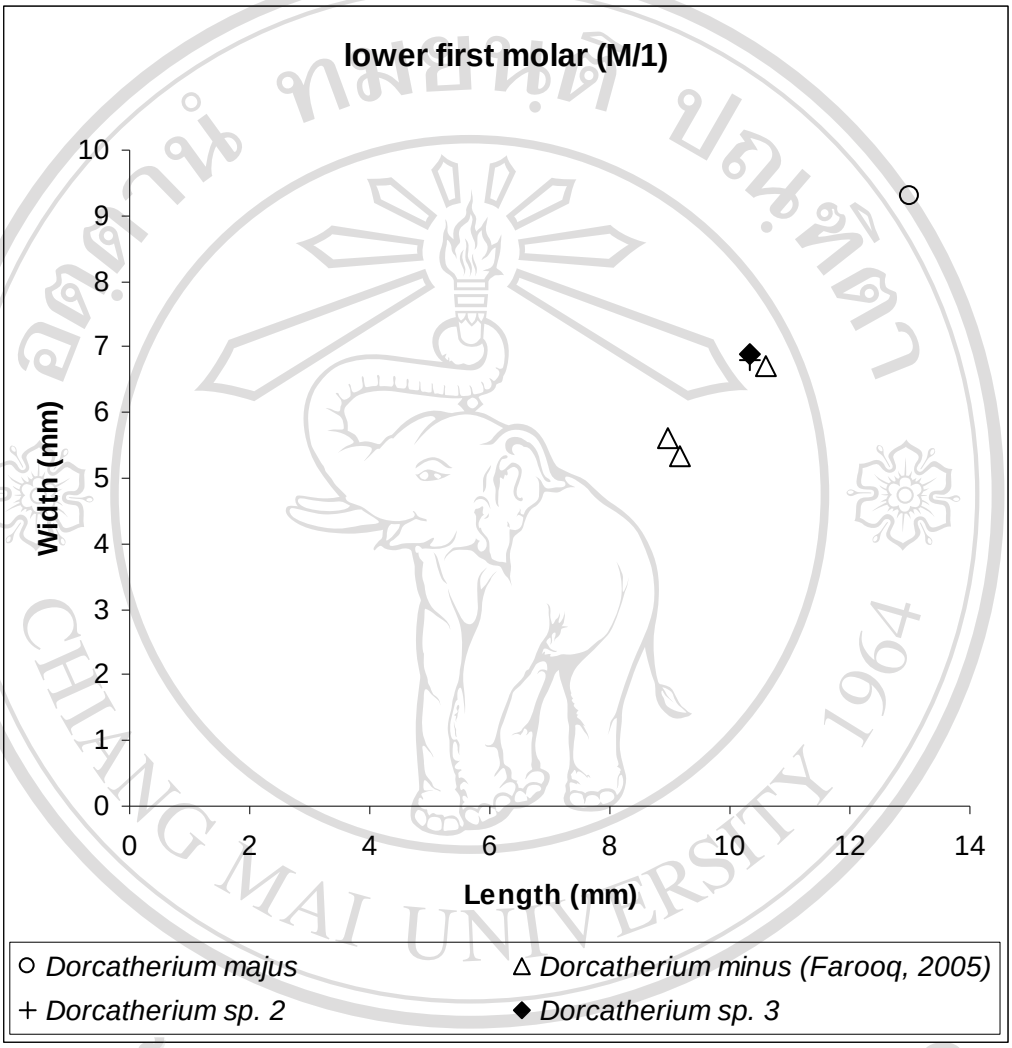

Figure 5.25 Bivariate plot of the tooth width against length of M3 of *Dorcatherium* sp. 3.

Stephanocemas rucha Ginsburg and Ukkakimapan, 1983

Figure 5.26

Diagnosis: second lower molar (M_2) quadrangular in shape, posterior wing of metaconid not end in a bulge style or no mestastylid, entoconid arranged back of, or more labially than, metaconid; postentocristid reduced or absent; on labial side, protoconid and hypoconid each has two wings which open broadly; postprotocristid not linked proentocristid; posthypocristid entended backward to disto-lingual angle; entostylid elevated and thin; palemeryx fold short and thick.

Materials: ML108 (left M_{1-2})

Description: left M_1 and M_2 attached to mandibular fragment. Teeth are selenodont, high crown, and quadrangular shape in occlusal outline. Teeth are less worn. Metaconid and entoconid are slim and aligned mesio-lingually. Entoconid is located more labially, no metastylid, anterior and posterior wings open broadly. Posthypocristid extended disto-lingually and almost reach the lingual side. Anterior cingulid is well-developed which contrary to posterior cingulid. Posterior cingulid is less developed on M_1 and much reduced on M_2. Entostyle or basal pillar is prominent, thick and flat lingo-labially. Its height is approximately half of crown height. Paleomeryx fold is marked. These features are alike to *Stephanocemas rucha*, except postentocristid is well-developed.

Figure 5.26 Stephanocemas rucha, ML108, left M_{1-2}. Scale bar = 25 mm.

Measurement:

Table 5.12 Dental measurement of *Stephanocemas rucha*.

Tooth	Length	Width
M_1	11.88	7.39
M_2	13.10	7.49
Mandibular height at M_1	15.42	-

Remark: measured in millimeters

Locality: Mae Lai village, Hod District, Chiang Mai Province

Age: Beginning of MN4 or between 18.5-17.8 Ma

***Stephanocemas* sp.**

Figure 5.27

Material: GCMU03, incomplete tooth of upper third molar (M^3)

Description and discussion: The molar width generally exceeds length. Molar crowns are brachyodont (low-crowned) and hypsodont. Tooth is moderately worn or comparable to tooth wear stage (TWS) C (Hillson, 2005). Enamel surface is crenulated. Metastyle are well developed. Protocone is well developed with a bifurcated posterior wing. The wings of protocone are of the similar length. The anterior wing of the hypocone which show bifurcated is longer than the posterior wing. Antero-lingual cingulum is well developed and basal pillar is fused to the lingual cingulum. These characters are mostly resembled to *Stephanocemas* aff. *thomsonii* (Jie Ye, 1989). The hypocone is much reduced than the protocone. Jie Ye (1989) stated that M^1 is relatively small and nearly square in outline, M^2 is slightly larger than M^1 with a breadth that exceeds its length, and M^3 is posteriorly reduced.

Then, this material is likely the upper third molar (M^3) of genus *Stephanocemas*. This *Stephanocemas* could not be *S. rucha* as having larger tooth size, but probably a younger relative of *S. rucha* which found in Li, Lamphun province.

Measurement:

Table 5.13 Dental measurement of *Stephanocemas* sp.

Tooth	Length	Width
M^3	12.61+	15.03

Remark: measured in millimeters

Locality: lower lignite layer of Chiang Muan coal mine, Chiang Muan District, Phayao Province.

Age: As it was found associated with the Chiang Muan suids, *Hippopotamodon* cf. *hyotherioides* and *Parachleuastochoerus sinensis*, suggest basal Late Miocene, ~ 10 Ma.

Figure 5.27 *Stephanocemas* sp., GCMU03, incomplete tooth of upper third molar (M^3). Scale bar = 10 mm.

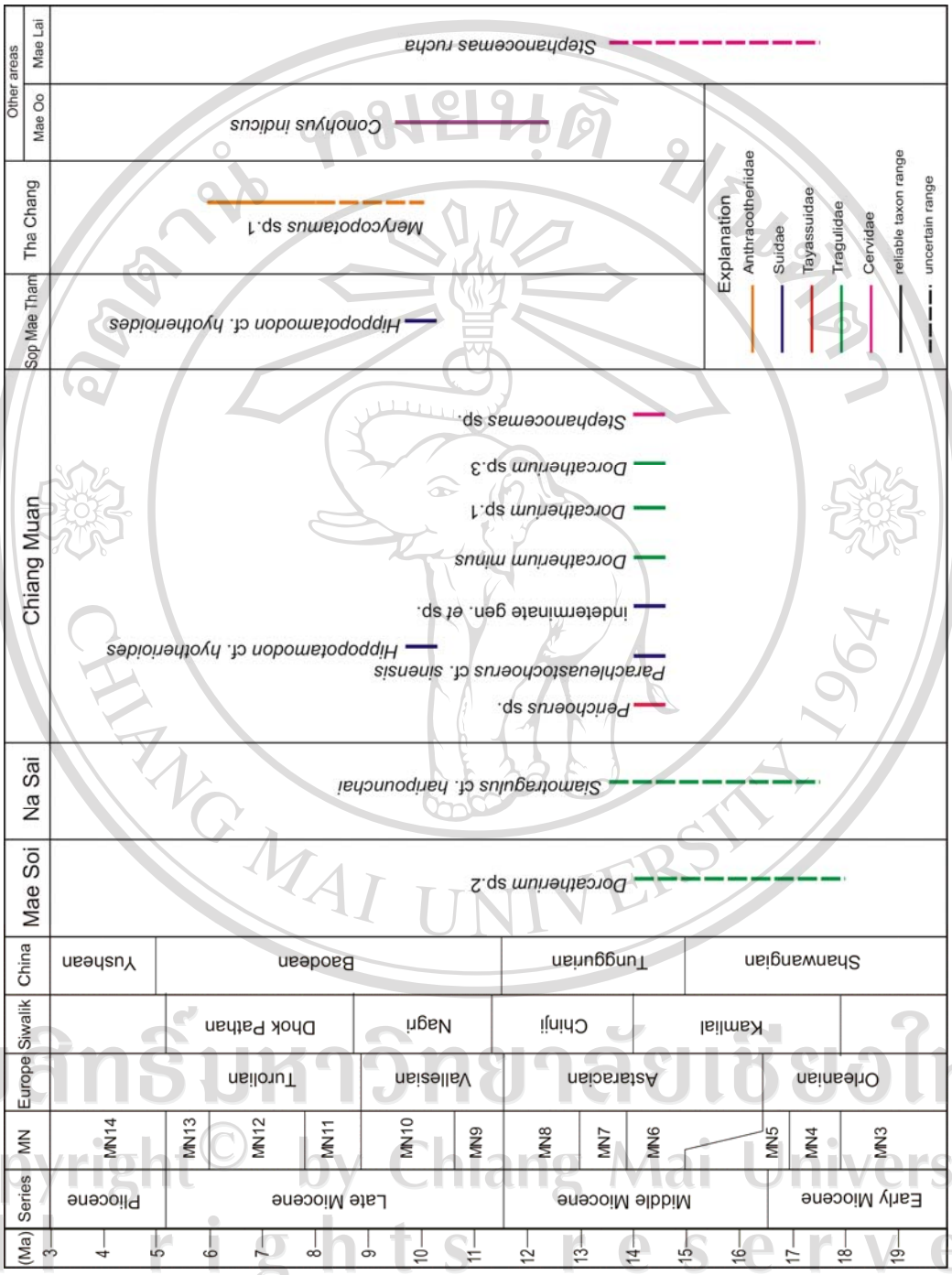

Figure 5.28 Taxon ranges of artiodactyls which present in this chapter.