# 3.4 ORDER CARNIVORA Bowdich, 1821

## 3.4.1 Family Ursidae Fischer, 1817

There are eight species of bears in the world:

- American Black Bear *Ursus americanus*
- Brown Bear *Ursus arctos*
- Polar Bear *Ursus maritimus*
- Sloth Bear *Melursus ursinus*
- Spectacled Bear *Tremarctos ornatus*
- Giant Panda *Ailuropoda melanoleuca*
- Asiatic Black Bear *Ursus thibetanus*
- Malayan Sun Bear *Helarctos malayanus*

The last two species are the only members of the family Ursidae known in Southeast Asia. They differ from each other by their furs and body sizes and both are threatened with extinction (Nowak, 1991; Corbet & Hill 1992).

Bears have relatively undeveloped carnassial teeth; narrow premolars, crushing molars with flat crowns and large robust canines.

### 3.4.1.1 Subfamily Ursinae Fischer, 1817, Plate 3(A1 to B3)

As mentioned above, two genera and two species represent the subfamily Ursinae in Southeast Asia, namely:

- Malayan Sun Bear (Figure 3.8, A), *Ursus*/*Helarctos malayanus* (Raffles, 1821) with the scientific name *Ursu* and synonym *Helarctos* is distributed in the south west of China, Assam, Myanmar, Vietnam, Peninsular Malaysia, to the islands of Sumatra and Borneo. It is the smallest of all bears found in the tropical rainforests of Southeast Asia.
- Asiatic Black Bear (Figure 3.8, B), *Ursus thibetanus* Cuvier, 1823 is mainly localized in the Himalayas, Afghanistan to southern China, Myanmar, northern Thailand and Indochina. It has several alternative names including Asiatic Black Bear, Himalayan Black Bear, Moon Bear and inhabits mountain forests.

Figure 3.8 Malayan Sun Bear (A) and Asiatic Black Bear (B) in Zoo Negara, Malaysia National Zoological Park.

The historic range of these species covered most of continental mainland Southeast Asia and known as fossils in Quaternary deposits, as in Tham Khuyen, Lang Trang, and Duoi U'Oi, in Vietnam (Olsen & Ciochon, 1990; de Vos & Long, 1993; Bacon *et al*., 2008b), Tam Hang in

Laos (Bacon *et al*., 2008a). Fossils remains of the Malayan Sun Bear have been recorded from different sites: Niah in Borneo (Medway, 1964; Harrison, 1996); Padang Highland Caves in Sumatra as *Helarctos malayanus* (Raffles) subsp. by Hooijer (1948), while Erdbrink (1953) did not think that these fossils show enough morphological differences to warrant a subspecific separation; Punung in Java (Badoux,1959), and from China under names *Ursus* cf. *boeckhi* and *Ursus praemalayanus* by Zdansky (1927) and Von Koenigswald (1935) respectively. Horsfield (1825) described two species, namely, *Helarctos malayanus* in Sumata and *H. euryspilus* in Borneo. Meijaard (2004a & b) suggested two subspecies; *Ursus malayanus malayanus* for Sumatra, the Malay Peninsula, and the Asian mainland, and the smaller sized *Ursus malayanus euryspilus* from Borneo.

Asiatic Black Bear fossils were reported from Thum Wiman Nakin in Thailand by Tougard (1998) and from Annam under name *Ursus annamiticus* by Erdbrink (1953). A subspecies of Asiatic Black Bear recorded as *U. thibetanus kokeni* (Matthew & Granger, 1923) were discovered from deposits in South China (Kahlke, 1961) and Vietnam (Olsen & Ciochon, 1990). It is quite large and much larger than the modern Asiatic Black Bear *Euarctos thibetanus* (*Euarctos torquatus* of some authors) according to Colbert and Hooijer (1953). *Ursus angustidens* Zdansky 1928 was found in most sites of northern China (Pei, 1936) and also in south China (Kahlke, 1961) and Laos (Fromaget, 1936).

The Ursinae found in the current study are *Helarctos malayanus* and *Ursus thibetanus* as in (Table 3.7).

Table 3.7 Dimensions of the upper and lower teeth attributed to bear in this study.

| | Tooth Type | No. | L | W |
|---|---|---|---|---|
| *Helarctos malayanus* | Upper C (sin.) | BDC 5-5 | 21.9 | 17.5 |
| | $M_2$ (sin.)* | SC 4-2 | 17.7 | 10.0 |
| | $M_2$ (dex.) | VC 4-25 | 15.4 | 8.8 |
| *Ursus thibetanus* | $M^2$ (sin.) | CC 4-2 | 24.0 | 14.4 |
| | $M^2$ (dex.) | CC 5-9 | 23.0 | 13.0 |
| | $M^2$ (dex.)* | BDC 1-3U | 23.0 | 12.2 |

No.=specimens field number; L= mesio-distal length; W= bucco-lingual width. All measurements in mm.*Incomplete sample.

## 3.4.1.1.1 Teeth description (Figure 3. 9)

### A. *Helarctos malayanus* in Batu Caves

Two samples identified as lower molars of *Helarctos malayanus* recovered from Batu Caves

Lower molars

$M_2$: SC 4-2 (sin.)

This is a much worn specimen, broken obliquely from the posterior part of the trigonid at the buccal side to anterior margin of the talonid at the lingual side.

No detailed observation can be made on the crown surface owing to the advanced stage of wear as the whole enamel layer on crown has been removed revealing the underlying white dentine. Only a very low enamel border is preserved along the margins. No traces of cingulid or notch separating trigonid and talonid are seen. The semi-circular posterior end of the talonid is completely closed by the enamel ridge.

$M_2$: VC 4-25 (dex.), Plate 3 (A1)

The crown has an oval shape and the tooth is well-preserved with roots. Four major cusps are located on the border of the crown surface, the largest of which is the hypoconid but the metaconid is the highest of all four. A transverse ridge connecting protoconid and metaconid runs through the occusal surface and is only interupted by a notch in the deepest part of the crown. There are two sub- equal accessory cusps (dual paraconid?) on the semi-circular anterior marginal ridge. The occlusal basin enclosed by this anterior marginal ridge and the proto-metaconid ridge has a transverse groove along its base. The separating depression between trigonid and talonid is only weakly developed on the buccal side; below it traces of a short buccal cingulid between protoconid and hypoconid can be seen. Apart from these structures, the enamel surface on the buccal side is rather smooth without any wrinkles. The base of hypoconid is large and with an accessory cusp on its lingual side. A crescent-shaped low ridge is discernible from the posterior ridge of the protoconid, running inwardly towards the base of the hypoconid. Presence of a hypoconulid is indicated by a minor accessory cusp behind the hypoconid. The entoconid is split into two adjacent small cusps located slightly posterior to the opposing hypoconid. The enclosing posterior marginal ridge of the talonid is low in the middle. The basin of the talonid appears smooth without any rugosities or wrinkles. There are two complete roots, one under the trigonid and the other under the talonid that is much larger and compressed medio-laterally.

A small contact facet is observable both in the mesial and distal interproximal surfaces.

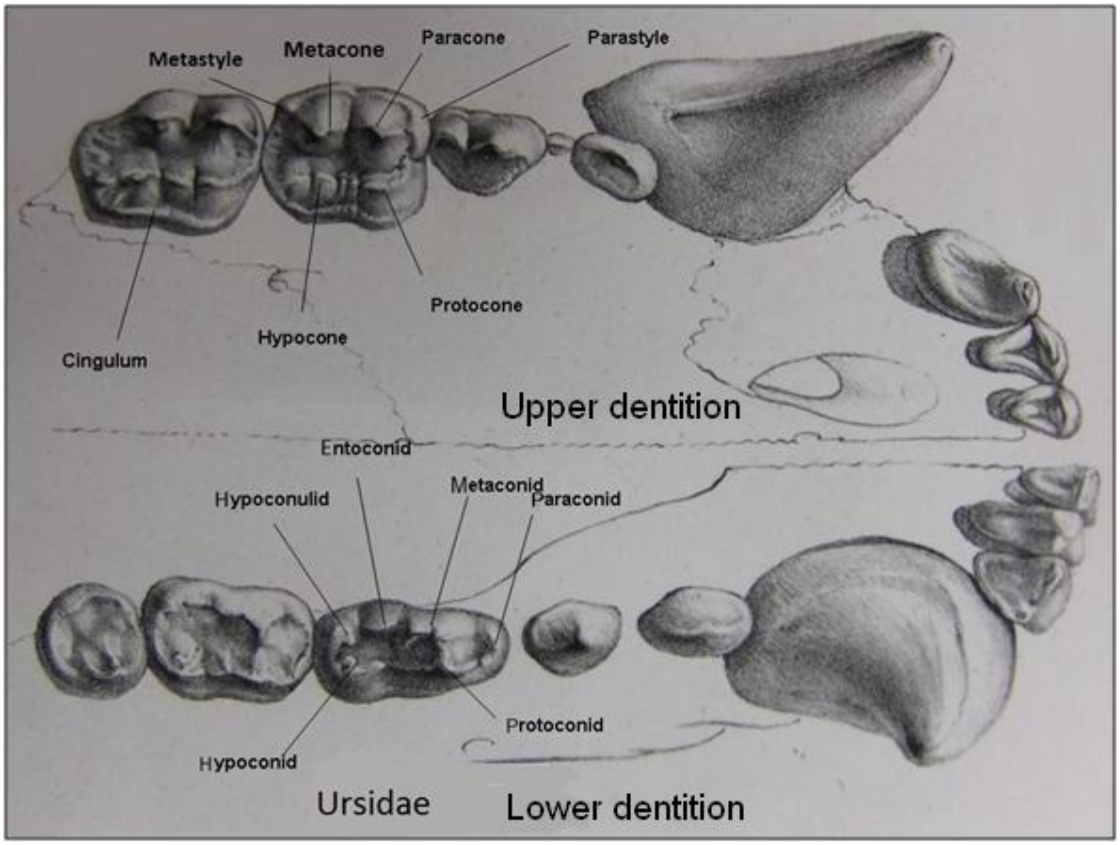

Figure 3.9 Nomenclature to describe cheek teeth structures of Ursidae modified from de Blainville (1839 – 1864).

### B. *Helarctos malayanus* in Lenggong Valley

One sample identified as upper canine of *Helarctos malayanus* collected from Badak Cave C in Lenggong Valley site

Upper canine

BDC 5-5 (sin.), Plate 3 (A2)

The heavily enamelled crown is used for catching and holding prey and covered by a great number of horizontal and parallel dark lines clearly seen especially on the lateral surface.

This specimen has no root left with gnaw marks by rodents at the base of the crown. The posterior edge is concave while the anterior edge is only slightly concave.

There is a strong enamel ridge (front half of which has broken off) at the posterior edge running from the tip towards the base of the crown. Less distinct is another ridge in the antero-internal surface that starts from the tip but its trajectory cannot be trace further down the crown as almost half of enamel layer of the internal surface from the base of the crown has fallen off. There is no indication of the presence of another ridge on the lateral external surface which is rather smooth. Its basal surface is without a cingulum. A depression is present on the inner basal part of the crown where the enamel had worn out. The horizontal cross-section at the base has an oval shape with the antero-posterior diameter larger than medio-lateral width. The tip of the crown is truncated and flattened into a smooth horizontal surface.

### C. *Ursus thibetanus* in Batu Caves

Two upper molars of *Ursus thibetanus* recovered from Cistern Cave in Batu Caves site

<u>Upper molars</u>

$M^2$: CC 4-2 (sin.), Plate 3 (B1)

It is a slightly worn complete tooth with a relatively low crown and four roots with missing tips. It has an oblong occlusal outline ending with a relatively large and broad talon. The plane of the mastication occlusal surface of the obliquely truncated talon slopes backward and exteriorly, totally opening up (without a bordering margin) onto the postero-extenal corner of the crown. There are two sharp major cusps of subequal size on the buccal side with the paracone anteriorly and the metacone behind it. Both are separated by a distinct groove on the buccal surface but it does not extend further onto the occlusal surface.

The anterior ridge of the paracone is sharp and ends with a parastyle in the antero-external angle of the crown.

The ridge running posterior to the metacone is trenchant but does not end with a metastyle. The metacone, unlike paracone sends out a transverse ridge onto the occlusal surface. This ridge, however, does not continue onto the lingual marginal ridge but ends in the middle section of the occlusal surface. The buccal surface is smooth without traces of cingulum or enamel wrinkles. The protocone and hypocone on the lingual side are long and low, both are blunted, more so for the protocone. The protocone is split into two cusplets of equal size, and though the hypocone is also has two cusplets, the anterior cusplet is decidedly larger than the posterior one. A small notch on the crown surface can be seen between these two lingual cusps. Traces of the small and not very distinct basal cingulum can be found running from the base of the hypocone and terminates at the protocone on the lingual surface. It, however, does not extend further onto the mesial surface. Both the anterior and posterior marginal ridges are semi-circular in shape and a number of irregularly arranged cusplets are found on them. Numerous wartlike rugosities are seen on the occlusal surface, especially on the side closer to the lingual marginal ridge. There is only one small contact facet observable on the mesial surface. The paracone, metacone and protocone each has a single root, while the hypocone shares a large medio-laterally compressed root with the talon.

$M^2$: CC 5-9 (dex.), Plate 3 (B2)

This tooth is very similar to CC 4-2 but smaller in size, with a slightly unworn, much lower crown. The talon is very distinct and obliquely truncated at the postero- external corner without a bordering margin. Two buccal cusps are present with the : anterior (paracone with the parastyle) a little bit higher than the posterior (metacone with a not very clear metastyle) these are all connected by an anterior-posterior marginal ridge.

These two cusps are separated from each other by a notch with a vertical groove starting from the base of the buccal side but not extending to the occlusal surface. The tops of the border buccal cusps represent the maximum heights of the crown. Two tiny transverse ridges that start from the tip of the buccal cusps are more distinguished at the posterior end (metacone) than before the middle section (central mid line) of the occlusal surface. No buccal cingulum is observed. The lingual cusps: protocone and hypocone with small cusplets are very low and compressed down along the parallel system of the anterior posterior ridge that runs along the lingual side of the crown. A small inner cingulum runs anteriorly and ends at the base of the hypocone. Anterior contact facets are present. Only one incomplete lingual root is preserved with clear traces of gnaw marks at the base of the postero-extenal end which include the metacone and the talon.

### D. *Ursus thibetanus* in Lenggong Valley

One sample of *Ursus thibetanus* collected from Badak Cave C in Lenggong Valley site.

Upper molar

$M^2$: BDC 1-3U (dex.), Plate 3 (B3)

It is a damaged tooth where the buccal side with anterior part of the crown and root are missing. The plane of the mastication occlusal surface is flat. The lingual cusps are very low and hard to recognize. They are connected by a flat and smooth lingual marginal ridge which surrounds the incomplete internal crown edge. Two root fragments are present below the base of the lingual marginal ridge. Although the crown was not complete the size of the specimen and the anterior posterior length falls within the range for *Ursus thibetanus.*

### 3.4.1.1.2 Remarks

Scientists had debated whether the panda was more like the raccoon family or the bear family for many years. It should be noted that Giant Panda, *Ailuropoda melanoleuca*, belongs to the subfamily Ailuropodinae that differentiates itself from the subfamily Ursinae by the following criteria: its enamel is not wrinkled, the canine is reduced in size, it has complex premolars that molars share many tubercular accessories with broad occlusal surfaces (Colbert & Hooijer, 1953; Tougard, 1998). These are not present in the current specimens.

DNA analyses suggest that the Giant Panda has a much closer relationship to other bears and should be considered a member of the family Ursidae. The Ursidae are represented in this study by *Helarctos malayanus* with its upper canine and two lower molars and *Ursus thibetanus* by three upper molars.

Morphological and dimensional comparisons are needed to differentiate and correctly identify the member species of a highly variable genus like *Ursus*. In order to do this comparisons with recent skulls housed in the Zoological Museum (University of Malaya), Natural History Museum (London), and National Museum of Natural History (Leiden) have been used. Ranges of size measurements from these collections with additional dimensions derived from publications available are presented in (Table 3.8).

One upper canine, BDC 5-5 (from Badak Cave C) is included in my bear collections. The crown of the canine does not show many differences in character between the Malayan Sun Bear and the Asiatic Black Bear. The enamel ridges that Erdbrink (1953) mentioned were not always observable.

The posterior ridge can be present while another ridge like the antero-internal ridge can be present or both are absent in some of the *malayanus* and *thibetanus* skulls examined so it this character is not useful to distinguish between the two species. A characteristic that might be more useful in determining isolated canine teeth is the occurrence of the horizontal, parallel, dark lines in the enamel of the upper and the lower canines. These lines are very clearly observable in great numbers on the enamel surfaces of the *malayanus* canines as in BDC 5-5, and also on the enamel surfaces of the incisor and the premolars (Erdbrink, 1953). They are very few and far apart from each other, compared to those when occurring in *malayanus* where present in *U. thibetanus.* Absolute measurements cannot be relied on to distinguish between the teeth, especially the canines, of different species. In my personal belief that the way to take measurements varies from person to person for example, there is a significant difference between the anterior- posterior length measured along the horizontal bottom section at the base of the crown or through the middle crown between the front and the back of the specimen in the case of canines.

Generally, the upper and lower Asiatic Black Bear canine is not very big compared with those of the Malayan Sun Bear. Tougard (1998) reported that the upper canine of *thibetanus* is low and robust. Erdbrink (1953) calculated the size range of the upper canines of modern Malayan Sun Bear and Asiatic Black Bear collected from different sites and conclude that the ranges for *Helarctos malayanus* is:- height (=25.5 mm – 40.0 mm), length (=13.5 mm – 26.0 mm), and width (=8.0 mm – 18.5 mm), and for Ursus thibetanus is:- height (=21.0 mm – 32.0 mm), length (=13.0 mm – 19.0 mm), and width (=8.0 mm – 14.0 mm). BDC 5-5 with height (=31.1 mm), length (=21.9 mm) and width (=17.5 mm) is thus within the range of *Helarctos malayanus*.

The upper molar teeth is represented in this study by three samples, two (CC 4-2 and CC 5-9) from Batu Caves (Cistern Cave), and one (BDC 1-3U) from Lenggong Valley (Badak Cave C).

The last upper molars of the bear are characterized by the exterior constriction behind the metacone. Tougard (1998) mentioned that the upper molars of the *U. thibetanus* from Thailand have pyramidal sharp pointed cusps with developed talon while the cusps are blunt on the $M^2$ wear specimens from Laos (Bacon *et al*., 2008a). Specimens from Duoi U'Oi Cave (Vietnam) have enlarged distally talons confined to the Asiatic Black Bear (Bacon *et al*., 2008b).

A careful comparison of the specimens from the current study with *U. thibetanus* and *H. malayanus* skulls in the Natural History Museum (London) and National Museum of Natural History (Leiden) and personal discussion with Dr. J. de Vos from the latter museum, lead to the conclusion that these isolated fossil teeth of $M^2$ belongs to the Asiatic Black Bear as the lingual basal cingulum is very clear and runs from the protocone to end at the hypocone. The posterior edge of the talon is in pointed in shape which is characteristic for the $M^2$ of *malayanus* whereas it is more rounded in *thibetanus*. The cingulum is not very distinct along the inner side making the inner part of the dentine broad and raised up inwardly ending in a distinct ridge. The larger dimensions of length and width of the Asiatic Black Bear allows it to be distinguished from the Malayan Sun Bear (Table 3.8).

The Malayan Sun Bear cheek teeth was only found in Batu Caves (Swamp Cave and Villa Cave) represented by two isolated second lower molar teeth, SC 4-2 and VC 4-25 respectively. It has an oval outline, wider posteriorly than anteriorly in both the samples from Batu Caves.

These teeth appear narrower in *H. malayanus* and the $M_1$ and $M_2$ is approximately the same size. However, in *Ursus thibetanus*, the $M_2$ is larger than $M_1$ (Tougard, 1998).

The separation area between trigonid and talonid is weakly developed in *H. malayanus* but not as in *U. thibetanus*. Bacon *et al*. (2008a) noted some characters of $M_1$ and $M_2$ specimens from Tam Hang (Laos) like a marked space between the mesial and distal cusps (hypoconid and hypoconulid) and the metaconid facing the protoconid. Both these characteristics were observed clearly in *U. thibetanus* teeth in my collections fossils. Table (3.8) show the measurements of the length and width of recent and fossil materials of *Helarctos malayanus*, *U. thibetanus* and *E. kokeni* .The dental remains of this study fall within the range of tooth size for *Helarctos malayanus* and *U. thibetanus* and below that of *E. kokeni* (Matthew &Granger, 1923) which it is quite large, much larger than the American Black Bear, *Euarctos americanus*, and considerably larger than the Asiatic Black Bear, *Euarctos thibetanus*. In all the structural features of *Euarctos kokeni* is closely comparable to *Eucarctos thibetanus*, differing from this latter form mainly in having a more robust build, the molar broad in comparison not only with its own length but also with the width (Colbert & Hooijer, 1953).

Two modern Malayan Sun Bear specimens reportedly collected from Java, marked as * in (Table 3.8), one in collection of London Museum with the original label named (? Java), and the other in Erdbrink's collection (table II, 1953) were studied. Although Erdbrink marked “Java” on the specimen that he measured, he thought that these specimens came from different localities because that bear did not live there in recent times and Java must be omitted from the distribution area of the Malayan Sun Bear. These two records appear to be erroneous because of that.

Fossil remains of the Asiatic Black Bear have been limited to Asia in historic times. This species occurs from southeastern Iran eastward through Afghanistan and Pakistan, across the foothills of the Himalayas, to Myanmar (Figure 3.10, top).

It is present in all countries in mainland Southeast Asia except Malaysia. In Malaysia it is replaced by the Malayan Sun Bear (*Helarctos malayanus*) (Figure 3.10, bottom) and in north and west of the Russian far East by the brown bear (*Ursus arctos*). However, the range of the Asiatic Black Bear overlaps the ranges of each of these species; especially the Malayan Sun Bear in a large portion of Southeast Asia. This study shows that the range of the Asiatic Black Bear can be extended into Peninsular Malaysia where it occurs together with the Malayan Sun Bear.

However, it is difficult to assess the true extent of this animal by only the small number of fossils found but these provide important clues to the presence of this animal and open the way for more detailed studies in the future.

Table 3.8 Comparative measurements of well-preserved bear teeth in this study with other modern and prehistoric material.

| ***Helarctos malayanus*** | **Upper C** | **$M^2$** | **$M_2$** |
|---|---|---|---|
| **Modern** | | | |
| Zoological Museum (University of Malaya) | | | |
| N | 3 | 3 | 3 |
| L | 18.1 - 20.5 | 17.0 - 21.7 | 14.8 - 17.0 |
| W | 13.7 - 14.0 | 11.9 - 14.2 | 9.4 - 10.6 |
| Institute of Biodiversity,Wildlife & National Parks Department (Malaysia)[1] | | | |
| N | | 3 | |
| L | | 20.6 - 21.0 | |
| W | | 12.6 - 13.3 | |
| Museum of National Zoo (Malaysia)[1] | | | |
| N | 4 | 3 | 5 |
| L | 21.8 - 25.0 | 18.2 - 19.1 | 15.2 - 16.9 |
| W | 12.4 - 18.4 | 12.5 - 13.4 | 9.4 - 10.9 |
| Natural History Museum (London) | | | |
| Borneo | | | |
| N | | 1 | |
| L | | 19.7 | |
| W | | 11.2 | |
| Sumatra | | | |
| N | | 4 | |
| L | | 19.7 - 21.2 | |
| W | | 5.7 - 14.3 | |
| Java* | | | |
| N | | 1 | |
| L | | 21.9 | |
| W | | 12.4 | |
| Burma | | | |
| N | | 1 | |
| L | | 21.6 | |
| W | | 13.3 | |
| Unknown place | | | |
| N | | 3 | |
| L | | 20.8 - 21.8 | |
| W | | 12.2 - 13.7 | |

Table 3.8, continued

| Collections taken from different sites[2] | **Upper C** | **$M^2$** | **$M_2$** |
|---|---|---|---|
| Borneo | | | |
| N | 3 | 5 | 4 |
| L | 18.0 - 22.0 | 18.0 - 21.0 | 14.0 - 16.5 |
| W | 13.0 - 18.0 | 12.0 - 14.0 | 9.0 - 10.5 |
| Sumatra | | | |
| N | 8 | 10 | 10 |
| L | 13.5 - 25.0 | 18.5 - 23.0 | 15.5 - 18.0 |
| W | 15.0 - 18.5 | 12.0 - 15.0 | 10.0 - 12.5 |
| Bangka | | | |
| N | | 1 | 1 |
| L | | 18.5 | 14.0 |
| W | | 12.5 | 10.0 |
| Netherlands East Indies | | | |
| N | 1 | 1 | 1 |
| L | 21.0 | 17.5 | 15.0 |
| W | 16.0 | 12.0 | 10.0 |
| Mal. Peninsula | | | |
| N | | 2 | |
| L | | 18.0 -21.0 | |
| W | | 12.0 -13.0 | |
| Java* | | | |
| N | | 1 | 1 |
| L | | 22.5 | 17 |
| W | | 14.0 | 11 |
| S.W. Siam | | | |
| N | | 1 | 1 |
| L | | 22.0 | 16.0 |
| W | | 13.0 | 11.0 |
| Annam | | | |
| N | | 1 | 1 |
| L | | 20.0 | 16.0 |
| W | | 14.0 | 11.0 |
| Burma | | | |
| N | | 1 | 1 |
| L | | 22.0 | 17.0 |
| W | | 14.0 | 11.0 |
| Tibet | | | |
| N | | 1 | 1 |
| L | | 21.0 | 17.0 |
| W | | 14.0 | 11.0 |

Table 3.8, continued

| American Mus. | **Upper C** | **$M^2$** | **$M_2$** |
|---|---|---|---|
| N | | 2 | 2 |
| L | | 19.0 - 20.5 | 14.5 -16.0 |
| W | | 12.0 - 13.6 | 8.5 - 10.5 |
| Zool. Mus. Amsterdam | | | |
| N | | 3 | 3 |
| L | | 19.5 - 20.0 | 16.0 - 16.5 |
| W | | 14.0 - 12.5 | 10.0 - 11.5 |
| R. M. Leiden | | | |
| N | | 4 | 4 |
| L | | 18.0 - 19.5 | 15.0 - 16.5 |
| W | | 12.0 - 13.0 | 9.0 - 11.0 |
| **Prehistoric** | | | |
| Punung (Java)[3] | | | |
| N | | 3 | 4 |
| L | | 17.0 (N=2) | 20.0 - 24.0 |
| W | | 10 .0 - 11.0 | 12.0 - 15.0 |
| Lang Trang Caves (Vietnam)[4] | | | |
| N | | | 1 |
| L | | | 18.1 |
| W | | | 11.6 |
| Collection of Von Koenigswald (Chinese drugstores)[2] | | | |
| N | | 19 | 12 |
| L | | 17.0 - 25.0 | 16.0 - 18.5 |
| W | | 13.5 - 17.5 | 9.5 - 12.5 |
| **In this study** | | | |
| Batu Caves^ | | | |
| N | | | 2 |
| L | | | 15.4 - 17.7 |
| W | | | 8.8 - 10.0 |
| Lenggong Valley^ | | | |
| N | 1 | | |
| L | 21.9 | | |
| W | 17.5 | | |

Table 3.8, continued

| ***Ursus thibetanus***<br>**Modern** | **Upper C** | **$M^2$** | **$M_2$** |
|---|---|---|---|
| Natural History Museum (London) | | | |
| Burma | | | |
| N | | 5 | |
| L | | 24.6 - 26.6 | |
| W | | 12.9 - 15.0 | |
| Vietnam | | | |
| N | | 1 | |
| L | | 27.5 | |
| W | | 15.2 | |
| Assam, India | | | |
| N | | 6 | |
| L | | 22.2 - 27.6 | |
| W | | 10.6 - 16.1 | |
| Taiwan | | | |
| N | | 6 | |
| L | | 24.5 - 27.9 | |
| W | | 12.8 - 14.8 | |
| Japan | | | |
| N | | 3 | |
| L | | 23.3 - 26.1 | |
| W | | 12.5 - 13.3 | |
| Collections taken from different sites[2] | | | |
| India | | | |
| N | | 6 | 1 |
| L | | 24.0 - 33.0 | 20.0 |
| W | | 14.5 - 15.0(N=2) | 11.0 |
| Nepal | | | |
| N | 1 | 4 | 4 |
| L | 17.5 | 24.0 - 30.0 | 17.0 - 22.0 |
| W | 12.0 | 14.0 - 17.0 | 10.0 - 14.0 |
| Assam | | | |
| N | | 6 | 6 |
| L | | 23.0 - 31.0 | 18.0 - 22.0 |
| W | | 13.0 - 17.0 | 10.0 - 13.0 |
| Burma | | | |
| N | | 1 | 1 |
| L | | 25.0 | 18.0 |
| W | | 15.0 | 11.0 |

Table 3.8, continued

| | **Upper C** | **$M^2$** | **$M_2$** |
|---|---|---|---|
| Kashmir | | | |
| N | | 7 | 6 |
| L | | 26.0 - 30.0 | 19.0 - 22.0 |
| W | | 15.0 - 17.0 | 11.0 - 13.0 |
| Siam | | | |
| N | | 1 | 1 |
| L | | 28.0 | 20.0 |
| W | | 15.0 | 12.0 |
| Dehra, Sikkim | | | |
| N | | 2 | 2 |
| L | | 25.0 - 27.0 | 17.7 - 19.0 |
| W | | 14.0 - 16.0 | 12.0 - 11.0 |
| Moupin | | | |
| N | | 1 | 1 |
| L | | 28.0 | 21.0 |
| W | | 15.5 | 13.0 |
| S.W. Shensi | | | |
| N | | 1 | 1 |
| L | | 26.0 | 20.0 |
| W | | 15.0 | 11.0 |
| Formosa | | | |
| N | | 4 | 4 |
| L | | 25.0 - 28.0 | 18.0 - 20.0 |
| W | | 14.0 - 15.0 | 10 0 - 12.0 |
| Nippon | | | |
| N | | 1 | 1 |
| L | | 24.0 | 19.0 |
| W | | 14.0 | 11.0 |
| Brit. Mus. Yamato | | | |
| N | | 2 | 1 |
| L | | 24.0 | 19.0 |
| W | | 13.0 | 11.0 |
| Nat. Hist., Leiden, Japan | | | |
| N | 5 | 5 | 5 |
| L | 13.0 – 18.5 | 22.0 - 25.0 | 17.0 - 19.0 |
| W | 8.0 – 10.5 | 13.5 - 18.0 | 10.0 - 12.0 |
| Manchuria | | | |
| N | | 8 | 5 |
| L | | 25.0 - 31.0 | 91.0 - 21.5 |
| W | | 14.0 - 16.0 | 11.0 - 14.0 |

Table 3.8, continued

| | **Upper C** | **$M^2$** | **$M_2$** |
|---|---|---|---|
| Baluchistan | | | |
| N | | 3 | 3 |
| L | | 25.0 - 29.0 | 19.0 - 22.0 |
| W | | 14.0 - 16.0 | 11.0 - 13.0 |
| Stuttgart collect. | | | |
| N | | 2 | 2 |
| L | | 25.0 - 25.2 | 19.2 - 19.8 |
| W | | 14.0 - 15.2 | 10.6 - 11.2 |
| Nat. Hist., Leiden | | | |
| N | 1 | 2 | 2 |
| L | 19.0 | 24.0 - 30.5 | 18.5 - 20.0 |
| W | 14.0 | 14.0 - 15.5 | 10.0 - 12.0 |
| Zool. Mus. Amsterdam | | | |
| N | 1 | 1 | 1 |
| L | 17.0 | 27.0 | 20.0 |
| W | 12.5 | 16.0 | 12.0 |
| *U. torquatus*, unknown loc.? | | | |
| N | | 1 | 1 |
| L | | 30.0 | 22.5 |
| W | | 17.5 | 13.5 |
| Unknown loc.? | | | |
| N | | 1 | 1 |
| L | | 27.5 | 20.0 |
| W | | 15.0 | 12.5 |
| A.M.N.H. (C.A.) No.1981, *E. thibetanus* [5] | | | |
| N | 1 | 1 | 1 |
| L | 20.0 | 27.4 | 20.2 |
| W | 13.0 | 13.9 | 10.9 |
| **Prehistoric** | | | |
| Lang Trang Caves (Vietnam)[4] | | | |
| N | 2 | 8 | 9 |
| L | 15.0 - 15.2 | 26.0 - 29.4 | 17.7 - 23.5 |
| W | 10.7 - 10.8 | 14.2 - 16.4 | 11.4 - 13.2 |
| Duoi U'Oi Cave (Vietnam)[6] | | | |
| N | | 3 | 1 |
| L | | 26.9 - 31.0 | 20.5 |
| W | | 15.4 - 17.2 | 12.0 |

| Table 3.8, continued | | | |
|---|---|---|---|
| | **Upper C** | **$M^2$** | **$M_2$** |
| Thum Wiman Nakin (Thailand)[7] | | | |
| N | 2 | 1 | 2 |
| L | 11.6 - 14.0 | 20.0 | 18.4 - 21.1 |
| W | 10.8 - 11.9 | 12.0 | 11.7 - 12.4 |
| Collection of Von Koenigswald (Chinese drugstores)[2] | | | |
| N | | | 63 |
| L | | 22.5-33.0 (N=109) | 17.5 - 23.0 |
| W | | 13.5- 17.0 (N=110) | 10.0 - 14.0 |
| A.M.N.H. No. 18735, *E. kokeni* [5] | | | |
| N | 1 | 1 | 2 |
| L | 22.3 | 30.7 | 20.7 – 21.2 |
| W | 14.5 | 16.5 | 13.1 – 13.7 |
| **In this study** | | | |
| Batu Caves^ | | | |
| N | | 2 | |
| L | | 23.0 - 24.0 | |
| W | | 13.0 - 14.0 | |
| Lenggong Valley^ | | | |
| N | | 1 | |
| L | | 23.0 | |
| W | | 12.2 | |

N= number of samples, L= mesio-distal length; W= bucco-lingual width.

All measurements in mm after:

[1] Measurements sending by Lim, 2011(unpublished data)

[2] Erdbrink (1953)

[3] Badoux (1959)

[4] De Vos & Long (1993)

[5] Colbert & Hooijer (1953)

[6] Bacon *et al*. (2008b)

[7] Tougard (1998)

* Erroneous records

^ Refer to (Table 3.7) for more details

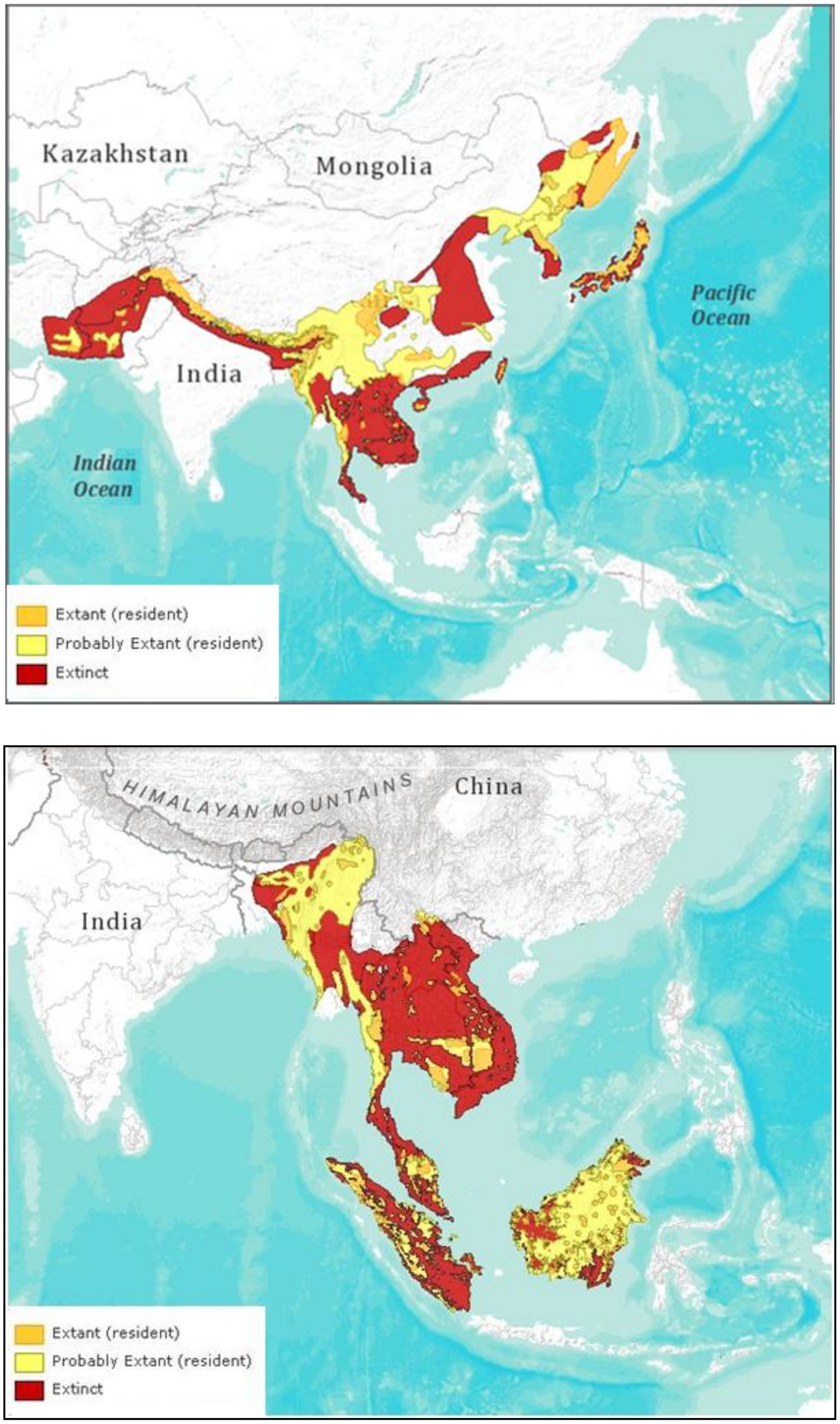

Figure 3.10 Range map of *Ursus thibetanus* (top) and *Helarctos malayanus* (bottom)**,** modified from Wildlife Conservation Society 2008. In: IUCN 2011.

### 3.4.2 Family Viverridae Gray, 1821

This is a large family commonly known as civet cats with several species similar in many ways to ancient small carnivores but very little is known about most of the viverrids. Many species look cat-like or even fox-like by having a long sinuous body with short legs and a long tail with long, low, narrow skull and pointed muzzle (Lekagul & McNeely, 1977).

This family is divided into the subfamilies: Cryptoproctinae, Euplerinae, Nandiniinae, Paradoxurinae, Hemigalinae, Viverrinae, and Prionodontinae The first three groups are relegated to Africa. Recent research with DNA analysis suggest that the Asiatic lineage, *Prionodon,* which belongs to the last group Prionodontinae is more closely related to the Felidae by the molecular studies of Gaubert &Veron (2003). They were therefore removed from the Viverridae and placed in their own family Prionodontidae with some debate.

On the dentition, they have long canine teeth, multi-cusped complex molar teeth, more rounded cheek teeth of omnivores like in the subfamily Paradoxurinae and sharper teeth for the carnivores like in the subfamily Viverrinae. This is the case with the isolated sharp tooth recovered in this study.

#### 3.4.2.1 Subfamily Viverrinae Gray, 1821, Plate 3 (C)

The subfamily Viverrinae is the largest subfamily within the family Viverridae, it consists of a mixture of small and medium-sized carnivores from the Asian and African civets. In Southeast Asia, this subfamily includes:

- Large Spotted Civet *Viverra megaspila* Blyth, 1862 in Peninsular Malaysia, Thailand, Cambodia, Vietnam, Laos, Myanmar, southern China.

- Malayan Civet (Figure 3.11) *Viverra tangalunga* Gray, 1832 in Peninsular Malaysia, the islands of Sumatra, Bintan, Kundur, Bangka, Lingga, Belitung, Karimata, Laut, Palawan and on most of other Philippine islands of Bohol, Busuanga, Culion, Leyte, Luzon, Mindanao, Mindoro, Negros, Samar and Sibuyan, and also recently confirmed in Singapore by Lim & Xiuling Yang (2012).
- Large Indian Civet *Viverra zibetha* Linnaeus, 1758, in the Malaya Peninsula, Singapore, Thailand, Vietnam, Cambodia, Laos, Myanmar, and to the south of Indochina, Bhutan, south China, Nepal, and east India.

- *Viverra tainguensis* in Vietnam, a new species described by Sokolov *et al.* (1997) (in Gaubert *et al*., 2002).

- Little Civet *Viverricula indica* Desmarest, 1804 southern and central China in the east through Indochina and India, the Indonesian islands of Sumatra, Java, Peninsular Malaysia, Singapore, and Bali. This species has been introduced to Zanzibar, Madagascar, Comoros, and Socotra (islands of the East coast of Africa) as well as several islands in the Philippines.

The fauna recorded in the present study is classified under this subfamily by one tooth of *Viverra tangalunga.*

This Malayan Civet has wide distribution cross Southeast Asia, however, there are only a few studies on its natural history and ecology. This living species is recorded in Peninsular Malaysia as confirmed by different researchers (Kawanishi & Sunquist, 2004; Jennings *et al*., 2010).

The difference in body size between the Malayan Civet from Peninsular Malaysia and those in Borneo and Sulawesi as demonstrated by their being significantly larger and heavier for both sexes supports the 'island rule' hypothesis by its positive relationship between body size and home range (Jennings *et al*., 2010).

Figure 3.11 Malayan Civet *Viverra tangalunga,* source: http:/i612.photobucket.com/itech.pensacolastate.edu

Although the Malayan Civet is a widespread species, little is known about its historical record and very few literatures listed *Viverra tangalunga* fossils compared with fossils of other *Viverra* species. The Malayan Civet was found in Niah Cave in Borneo by Harrison (1996) and Madai Caves by Harrison (1998). *Viverra zibetha* and *Viverridae* indet. recorded from Tam Hang in southern Laos (Bacon *et al*., 2008a & 2011). *Viverra zibetha, Viverra* cf. *megaspila* and Viverridae indet. from Duoi U'Oi cave, Vietnam (Bacon *et al*., 2008b). In South China, new species and subspecies have been discovered: *Viverra zibetha expectata* discovered by Colbert and Hooijer (1953) and *Viverra* sp. (Kahlke, 1961).

Diagnostic features such as the large size, accesory tubercles in premolars and in $M^2$, the large strong talon/ talonid in $P^3$ and $M_1$ distinguished the new species *Viverra peii* from Zhoukoudien (Qiu, 1980).

### 3.4.2.1.1 Tooth description (Figure 3.12)

In the current study, one isolated upper premolar tooth was extracted from Cistern Cave, Batu Caves and identified as the Malayan Civet *Viverra tangalunga* with the morphological characters as in below:

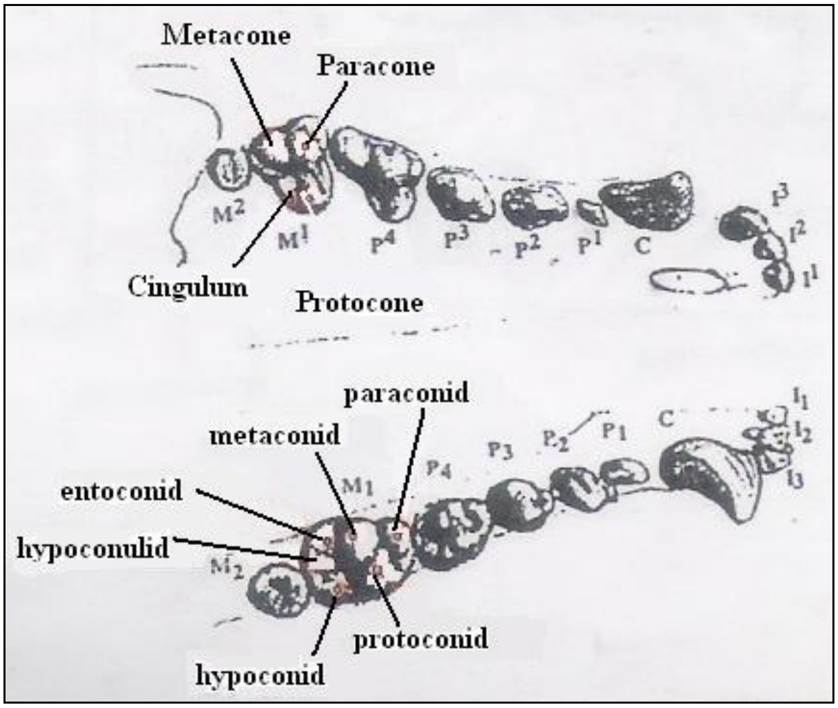

Figure 3.12 Nomenclature to describe cheek teeth structures of Viverridae modified from de Blainville (1839 – 1864).

Upper premolar

$P^4$: CC 9-1 (dex.), Plate 3 (C)

It is a small tooth with a sub- triangular elongated crown. The longitudinal diameter is larger than the transverse one with large anterior cusps. The cusps have sharp peaks. The paracone is conical in shape and considered as the largest cusp with small parastyle. The protocone extends anteriolingually out to the anterior margin of the tooth crown. Well developed cingulum extends lingually along the base of the crown.  The trigon is more distinct and deeper than the talon. Only remnant roots are present.

### 3.4.2.1.2 Remarks

With only one premolar civet tooth in my collection and only a few comparative materials available, it is not possible to determine the species of *Viverra* with confidence.

Most of the previous publications had listed the Large Indian Civet, *Viverra zibetha* among the Pleistocene collection in Southeast Asia against the little documented Malayan Civet, *Viverra tangalunga*. However, a few morphological characters for the $P^4$ of *Viverra tangalunga* with the size measurements allow for the presence of this species among the collection of fossils from Cistern Cave. These characters include:

Small sharp cusps, small and not developed parastyle with no anterior cingulum, and small in general size dimensions. Generally, the upper fourth premolar is easily determined among the other check teeth by its elongated general shape. The characters listed above may be able to be use to compare with $P^4$ of *Viverra zibetha* which it is much more developed in parastyle and larger in size.

In table (3.9) the measurements of the isolated $P^4$ Batu Caves tooth is compared with other *Viverra* teeth recorded in Southeast Asia. It can be clearly seen that the Batu Caves tooth is smaller in size than the Large Indian Civet and closer to the modern *Viverra tangalunga*.

Table 3.9 Comparative measurements of well-preserved civet tooth in this study with other modern and prehistoric material.

| ***Viverra tangalunga***<br>**Modern** | $P^4$ |
|---|---|
| Zoological Museum<br>(University of Malaya) | |
| N | 1 |
| L | 11.3 |
| W | 7.8 |
| ***Viverra zibetha*** | |
| N | 1 |
| L | 13.9 |
| W | 8.3 |
| ***Viverra zibetha ashtoni***<br>American Museum of Natural History (A.M.N.H.)[1] | |
| N | 20 |
| L | 21.1 - 14.5 |
| W | 6.9 - 8.3 |
| ***Viverra zibetha expectata***<br>**Prehistoric**<br>American Museum of Natural History (A.M.N.H.)[1]<br>(Yenchingkou, Szechwan, China) | |
| N | 2 |
| L | 13.4 - 14.3 |
| W | 8.0 – 8.3 |
| ***Viverra peii***<br>**(**Zhoukoudien, China)[2] | |
| N | 1 |
| L | 18.9 |
| W | 11.8 |
| ***Viverra zibetha***[2] | |
| N | 1 |
| L | 13.5 |
| W | 10.5 |
| ***Viverra* cf. *zibetha***<br>Duoi U'Oi Cave<br>(Vietnam)[3] | |
| N | 1 |
| L | 13.0 |

Table 3.9, continued

| | |
|---|---|
| W | 6.7 |
| **In this study** | |
| Batu Caves | |
| N | 1 |
| L | 10.3 |
| W | 5.4 |

N= number of samples, L= mesio-distal length; W= bucco-lingual width.
All measurements in mm.

[1] Colbert & Hooijer (1953)

[2] Qiu (1980); *Viverra zibetha* measured from Lydeykker, 1884, fig 12

[3] Bacon *et al*. (2008b)

## 3.4.3 Family Canidae G. Fischer de Waldheim, 1817

The dog family Canidae is found in all areas of the world except for Antarctica. Most species are omnivorous, but meat is an important part of their diet. Dogs have social behavior and high intelligence in many species. Some of the larger canids live in big groups others live in small family groups and some individuals live on their own. Most canids are hunters and have relatively long legs and large ears with a sturdy skull. The dentition is similar with that of the Viverridae, with additional lower molars and better developed upper fourth premolar and lower first molar as carnassial teeth for slicing flesh and large and strong canines (Lekagul & McNeely, 1977). In the past this family had been divided into various groups under different names and each of these groups showed an increase in body mass with time (Hone & Benton, 2005).

Only one subfamily known as Caninae is commonly referred to the present day canids.

#### 3.4.3.1 Subfamily Caninae G. Fischer de Waldheim, 1817, Plate 3(D1-D3)

It is subdivided into *Canini* (True Dogs**)** and *Vulpin*i (True Foxes).

These two groups are represented in the Asia region by the following members:

The True Dog *Canini* including ***Canis*** Linnaeus, 1758, is a large group containing extant and extinct species:

- Grey Wolf or Common Wolf *Canis lupus* Linnaeus, 1758 is the largest extant member of the dog family found north of the Sahara in Africa, north of Himalayas in Asia, India, Pakistan, throughout most of the China, Eurasia, and North America.

- Golden Jackal *Canis aureus* Linnaeus, 1758, in Thailand, Myanmar, India, Pakistan, Sri Lanka, and west through southwest Asia, and Africa.

- Domestic Dog (Figure 3.13), *Canis familiaris* Linnaeus, 1758, are the feral dogs present in Sunda, Philippine, and Molucca islands (Indonesia) (Corbet & Hill, 1992). This species is listed by some scientists as *Canis familiaris* and others as a subspecies of the wolf (i.e., *Canis lupus familiaris*).

***Cuon*** Hodgson, 1838, includes one extant species named Dhole or Wild Dog (*Cuon alpinus*) (Pallas, 1811), native to South and Southeast Asia including Thailand, Sumatra, Java, Nepal, and India. This genus differs from *Canis* by the absence of $M_3$ and some other characters like the muzzle shape and by having longer hair between the footpads (Lekagul & McNeely, 1977).

The True Foxes *Vulpin*i includes:

***Vulpes*** Frisch, 1775 that are smaller in size containing:

- The Red Fox *Vulpes vulpes* (Linnaeus, 1758) which is the largest of the True Foxes with wide spread distribution in North Vietnam, through part of China to the Himalayas and Pakistan.

- The Sand Fox *Vulpes rueppellii* (Schinz, 1825) from West Pakistan, to the Middle East, and the region of Afghanistan to most of North Africa.

- The Corsac Fox *Vulpes corsac* Linnaeus, 1768, is found throughout the central and northeast Asia. It is sometimes referred to as the Sand Fox as well.

- The Tibetan Sand Fox *Vulpes ferrilata* Hodgson, 1842, is endemic to the high Tibetan Plateau in Nepal, China to Southeast Asia, sometimes also known as Sand Fox.

As we can see between the last three species, there is some confusion in terminology because these three species are all sometimes known by this name of "Sand Fox".

- The Bengal Fox *Vulpes bengalensis* (Shaw,1800) in northeast India to west Bengal, and from the Himalayas to Nepal and from southern and eastern Pakistan and southeastern Bangladesh.

- Blanford's Fox *Vulpes cana* (Blanford, 1877) is a small fox found in west Pakistan, northwest India and throughout Afghanistan.

***Nyctereutes*** Temminck, 1839 consists of one living species, the Raccoon Dog *Nyctereutes procyonoides* (Gray, 1834) in North Vietnam, and most of China.

Figure 3.13 Domestic Dog *Canis familiaris*; source http://fineartamerica.com/art/all/dog/all

The origins of the domestic dog together with its historical record are unclear and doubtful. The earliest fossil dogs, dated ≈17–12,000 before present by radiocarbon ($^{14}C$), were found in Europe and in the Middle East (Verginelli *et al*., 2005).

Domesticated dog remains of *Canis familiaris* were found among the Neolithic deposits and archeological remains in the Niah Cave in Sarawak by Clutton-Brock (1959) & Medway (1977c). The remains of a canid attributed either to Dhole *Cuon alpines* or an early Domesticated Dog without specific identification (Cranbrook 1988b & 2010) was found in the Madai Caves in Sabah, and also from Gua Gunung Runtuh in Perak in Peninsular Malaysia by Davison (1994). There is no archaeological evidence to indicate the presence of dogs in Borneo and in Peninsular Malaysia before the Neolithic period (Medway 1977c).

In Vietnam, fossil teeth attributed to *Cuon alpines* were found in Lang Trang and in Duoi U’Oi, by de Vos & Long (1993) and Bacon *et al*. (2008b), while Ciochon & Olsen (1990) recorded *Cuon* sp. and *Nyctereutes* sp. beside the *Cuon javanicus antiques* (*Cuon alpinus*) from different localities (Tham Khuyen, Tham Om, and Hang Hum I &II). The Dhole was also recorded from Phum Snay in Cambodia by Voeun (2007) associated with *Canis lupus.*

Other teeth attributed to *Cuon alpinus* cf. *antiques* and *Cuon javanicus* cf. *antiques* were discovered from Tam Hang south in Laos (Bacon *et al*., 2008a & 2011). Fossils of dog species and subspecies like *Cuon javanicus antiques* and *Canis lupus* were reported from different sites in China such as in Szechwan, Kwangsi, Kwangtung and Lungtung Cave (Colbert, 1940; Colbert & Hooijer, 1953; Kahlke, 1961). In 1961, Takai identified a subfossil of a Wild Dog's jaw from Thailand as *Cuon alpine infuscus*.

Canids are represented in this study by three specimens consisting of two canines, and one molar. All are *ex situ* from Batu Caves with the following dimensions (Table 3.10):

Table 3.10 Dimensions of the upper and lower teeth attributed to Canids in this study.

| **Tooth Type** | **No.** | **L** | **W** |
|---|---|---|---|
| Upper C (sin.) | CC EX6 | 9.0 | 4.9 |
| $M^1$ (dex.) | VC EX5 | 13.3 | 16.0 |
| Lower C (sin.) | CC EX9 | 8.8 | 6.1 |

No. = specimens field number; L= mesio-distal length; W= bucco-lingual width. All measurements are in mm.

## 3.4.3.1.1 Teeth description

### A. Canids in Batu Caves

Upper Canine

CC EX6 (sin.), Plate 3 (D1)

It is a complete pointed tooth with one root. It is slightly concave at lingual edge and convex buccally. A longitudinal depression near the buccal edge runs through the anterior surface until the end of the root but not found on the posterior side.

Upper molar

$M^1$: VC EX5 (dex.) (Figure 3.14), Plate 3 (D3)

It is a big well preserved tooth. The buccal side has larger and higher sharp cusps (paracone and metacone) than the lingual side (protocone and hypocone) giving the crown a sub-triangular shape. The large well-developed paracone is higher than the small metacone. The protocone is smaller than the paracone and metacone. A very small forth cusp (hypocone) is present. The parastyle and metastyle are vey marked and surround the deep lingual basin. Three opened incomplete roots are preserved. No contact facet was observed.

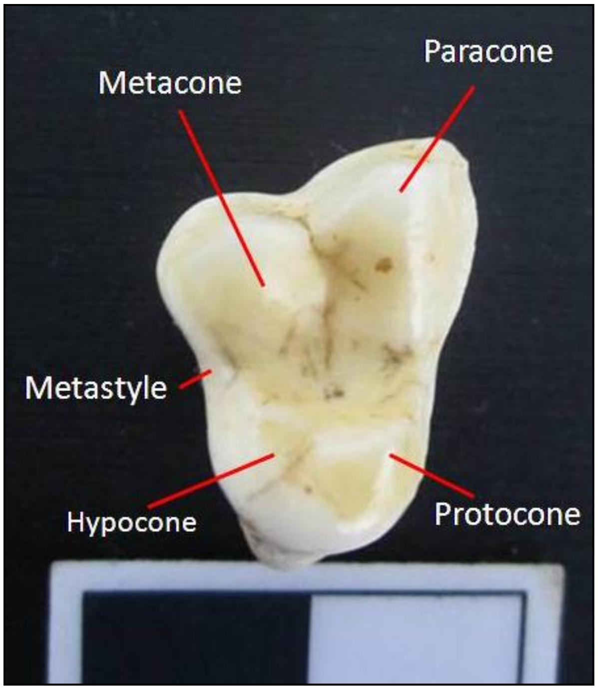

Figure 3.14 Nomenclature to describe the upper molar tooth structures of Canidae.

Lower Canine

CC EX9 (sin.), Plate 3 (D2)

It is a complete tooth with a unique robust curved root. The median line for this sample is somewhat curved. The general shape for this canine looks similar to CC EX6 with the longitudinal groove also appearing here at the same position but is less distinct and does not run downward.

### 3.4.3.1.2 Remarks

The Canids in my collection are represented by three samples: upper and lower canines, and the first upper molar, all from the Cistern and Villa Caves (Batu Caves).

The limited number and kind of these teeth that I have (especially the canines) is insufficient for specific identification. Moreover, all these specimens were recovered from loose surface material (*ex situ*).

Matthew and Granger (1923) used the metaconid character on the first lower molar to separate between the fossil and the recent dholes, because modern dholes from various places all show this well developed feature according to Colbert & Hooijer (1953).

Bacon *et al*. (2008b) consider the morphological features of $P_4$ are characteristic of *C. alpinus*.

De Vos & Long (1993) placed $M_1$ with one cusp in *Cuon* and two in *Canis*.

The criteria the others used to distinguish between the different species is not applicable in my collection beside there being no comparative specimens available for study.

Regarding to the size measurements in (Table 3.11) I can conclude that:

- Most of the previous literature did not include measurements for canine fossil teeth.
- From the canine measurements available to me, we can see that the upper canine is less wide compared with the lower canine. Generally the upper and lower canines are similar in shape except that the median line for the lower canine is more curved than the upper one.
- The fossils dimensions are mainly bigger compared with those of recent animals.

- The dimensions of my samples, except for M$^1$, fit in with the recent measurements from different localities. M$^1$ stands out by its large size, closer to the *Cuon* fossils from Szechwan and Laos and within the range of modern *Canis familiaris* specimens, For all these points mentioned above there is the possibility that my *ex situ* samples may not be part of the older cave deposits. They should just be identified as Canidae gen. et. sp. indet.

Table 3.11 Comparative measurements of well-preserved Canidae teeth in this study with other modern and prehistoric material.

| | **Upper C** | **M$^1$** | **Lower C** |
|---|---|---|---|
| **Domestic Dog *Canis familiaris* Modern** | | | |
| Zoological Museum (University of Malaya) | | | |
| N | 35 | 35 | 35 |
| L | 7.1 - 12.1 | 9.8 - 14.0 | 6.2 - 11.3 |
| W | 4.2 - 8.4 | 12.5 - 17.6 | 5.2 - 9.7 |
| Natural History Museum (London) | | | |
| ***Cuon javanicus sumatrensis*** (Malacca &Perak) | | | |
| N | 4 | | 4 |
| L | 8.7 - 9.4 | | 8.2 - 8.9 |
| W | 5.3 - 5.8 | | 5.5 - 6.4 |
| ***Cuon alpinus javanicus*** (Java) | | | |
| N | 1 | | 1 |
| L | 10.1 | | 9.3 |
| W | 6.0 | | 6.9 |
| American Museum of Natural History (A.M.N.H.)[1] | | | |
| ***Cuon javanicus dukhunensis*** (India) | | | |
| N | 1 | 1 | 1 |
| L | 9.2 | 11.8 | 9.6 |
| W | 6.0 | 13.8 | 6.6 |
| ***Cuon javanicus rutilans*** (Yunnan) | | | |
| N | 1 | 1 | 1 |
| L | 9.0 | 11.5 | 8.5 |
| W | 5.2 | 14.5 | 6.1 |

Table 3.11, continued

| ***C. j. javanicus***<br>(zoo) | **Upper C** | **M$^1$** | **Lower C** |
|---|---|---|---|
| N | 1 | 1 | 1 |
| L | 8.1 | 12.0 | 8.1 |
| W | 5.1 | 14.1 | 5.4 |
| **Prehistoric** | | | |
| ***C. j. anliquus***<br>(Szechwan) | | | |
| N | | 2 | 1 |
| L | | 11.1 - 13.2 | 10.5 |
| W | | 2.8 - 16.9 | 7.8 |
| ***Cuon alpinus***<br>(Duoi U'Oi Cave, Vietnam)[2] | | | |
| N | | 1 | |
| L | | 11.8 | |
| W | | 14.3 | |
| ***Cuon alpinus* cf. *antiquus***<br>(Tam Hang South, Laos)[3] | | | |
| N | | 2 | |
| L | | 11.7 - 14.1 | |
| W | | 16.0 - 16.6 | |
| **In this study** | | | |
| Batu Caves^ | | | |
| N | 1 | 1 | 1 |
| L | 9.0 | 13.3 | 8.8 |
| W | 4.9 | 16.0 | 6.1 |

N= number of samples; L= mesio-distal length; W= bucco-lingual width. All measurements are in mm.

[1] Colbert & Hooijer (1953)

[2] Bacon *et al*. (2008b)

[3] Bacon *et al.* (2008a & 2011)

^ Refer to (Table 3.10) for more details

### 3.4.4 Family Felidae G. Fischer de Waldheim, 1817

The wild cat family, the largest and most important group of the Carnivora, is spread over a wide range of country except for the Australasian region, Madagascar, and the West Indies. The various species of felids vary in size between the smallest cats like the Black-footed Cat *Felis nigripes* to the largest cat in the wild the Tiger *Panthera tigris*.

Most felids have general dentition characters like reduced number in premolars and molars teeth, the last upper premolar consider as the upper carnassials while the first lower molar is the lower carnassials, small conical incisor, with large and strong canine (Lekagul & McNeely, 1977).

The classification for this family is mostly unstable because most of these classifications are related to detailed characters and small differences between species, therefore, the naming and the number of the genera and species may vary depending on the system used. The felids are represented in Asia by the following groups or subfamilies: Pantherinae including *Panthera*, *Neofelis*, *Uncia*, Felinae including *Felis*, *Prionailurus*, *Catopuma*, *Pardofelis*, and Acinonychinae with its sole member, the cheetah *Acinonyx jubatus*. Some recent phylogenic classifications place the last subfamily Acinonychinae close to the Felinae group (Collier & O'Brien, 1985; Herrington, 1986, in: Corbet & Hill, 1992). Another subfamily, the Machairodontinae, known as the sabertooth cats, were endemic to Asia, Africa, North and South America, and Europe had became extinct in the Late Pleistocene. It includes the genera *Smilodon*, *Machairodus*, *Dinofelis*, and *Homotherium*.

A solitary robust canine collected in the current study is attributed to the Pantherinae.

### 3.4.4.1 Subfamily Pantherinae Pocock, 1917, Plate 3 (E)

Basically, this subfamily contains three genera:

***Panthera*** informally named the Big Cats which include the larger felid species:

- The Tiger (Figure 3.15), *Panthera tigris* (Linnaeus, 1758) is the largest cat species, had widely ranged across Asia in historical time and on the islands of Sumatra, Java and probably Borneo. It is limited today to parts of Myanmar, Thailand, Vietnam, Laos, Cambodia, Peninsular Malaysia, Sumatra, and Southeast China.

- The Lion *Panthera leo* (Linnaeus, 1758) it is the second-largest living cat after the tiger and currently exists in Africa, south of the Sahara, and in some limited populations in northwest India having disappeared from southwest Asia in historic times.

- The Leopard *Panthera pardus* (Linnaeus, 1758) it is the smallest member in the genus *Panthera*. It ranged in historical time across eastern and southern Asia and Africa and is presently found in fragmented populations in the Indian subcontinent, Java, Peninsular Malaysia and China.

The other two genera are *Uncia* and *Neofelis* :

***Uncia***, with only one species, is the Snow Leopard *Uncia uncia* (Schreber, 1775) currently restricted to Asia in China, India and Nepal. This genus more closely to the Tiger *Panthera tigris* and renamed to *Panthera uncia* (Johnson *et al.* 2006) more recently based on genetic analysis.

***Neofelis*** contains two felid species from Southeast Asia:

- The Clouded Leopard *Neofelis nebulosa* (Griffith, 1821) from mainland Southeast Asia into China, Peninsular Malaysia, Myanmar, India, and Nepal.

- The Sunda Clouded Leopard *Neofelis diardi* (G. Cuvier, 1823) in Sumatra and Borneo is genetically distinct and considered a separate species by Buckley-Beason *et al*. (2006).

A different hypothesis has been put forward to explain the current absence of tigers and leopards in Borneo. Seidensticker (1986) proposed that this absence was due to a lack of large ungulate prey, and leopards from Sumatra by an abundance of other felids, Payne (1990) suggested this was caused by lower soil fertility in Borneo.

The tiger is represented during the Late Pleistocene by canine teeth and proximal end of the metacarpal fragment bone in the Niah Cave in Borneo (Hooijer, 1963b; Medway, 1977a; Harrison, 1996; Piper *et al*., 2007), and a singular navicular from the Madai Caves in Sabah, north Borneo (Harrison, 1998), conforming that the tiger was present on the island and only become extinct during the Holocene.

Figure 3.15 Tiger individual from camera traps in Jerangau Forest Reserve, Ulu Terengganu, Peninsular Malaysia, after; Mohd. Azlan & Sharma (2003).

*Panthera tigris* remains have also been described from different sites in Southeast Asia; Punung (Java), Phnom Loang (Cambodia), and Gua Gunung Runtuh (Peninsular Malaysia) by Badoux, (1959), Beden & Guerin (1973), and Davison (1994) respectively. Tiger fossils were discovered from different caves in Vietnam with other felid species and subspecies like *Panthera pardus*, *Panthera* sp., *Neofelis* cf. *nebulosa*, *Neofelis nebulosa* cf. *primigenia*, *Neofelis nebulosa* ssp., *Felis* sp. by Ciochon & Olsen (1990), de Vos & Long (1993), Bacon *et al*. (2008b).

Tiger remains associated with a large assemblage of animal bones and a variety of smaller mammals have been reported from the island of Palawan, Philippines (Piper *et al.*, 2008), and from Laos *Panthera tigris* ssp. and *Prionailurus* cf. *bengalensis* have been reported by Bacon *et al*. (2008a & 2011).

Several papers were published describing tigers in collections from southern Chinese caves (Hooijer, 1947b; Colbert & Hooijer, 1953; Kahlke, 1961).

### 3.4.4.1.1 Tooth description

One large size canine attributed to the *Panthera* has been discovered from the Cistern Cave, Batu Caves site with the characters mentioned below:

Lower canine

CC EX 8 (dex.), Plate 3 (E)

It is a robust and strong tooth without root. A distinct posterior longitudinal ridge runs from the top until the base of the crown. Two vertical grooves are present on the outer surface near the tip but do not extend downward unlike the posterior ridge. The anterior groove is slightly deeper than the posterior. The specimen is heavily worn at the apex of the crown and downwards along the anterior surface.

### 3.4.4.1.2 Remarks

Comparative measurements demonstrate that the isolated Cistern Cave canine falls within the range of the largest felid in Southeast Asia, “the tiger”. It is very difficult to determine if it is the upper or lower canine for the isolated tooth. The upper and lower canine cannot be differentiated by size alone, as can be seen from Table (3.12) the ranges in variation overlap between the upper and the lower canines in both extant and fossil samples although the upper canine is somewhat larger than the lower in general. More materials of upper and lower canines are needed to distinguish between the two forms.

Pleistocene tigers from China, Wanhsien (Yenchingkou) like that, Chou Kou Tien, and Java, are the largest *Panthera tigris* in Table (3.12). The measurements for CC EX8 fall within the range of the recent materials from the different sites (Table 3.12). The tooth from Cistern Cave, Batu Caves most probably belongs to *Panthera tigris* based on the large size together with the morphological characters mentioned previously.

The tiger is the dominant mammalian predator in most Asian regions. Peninsular Malaysia is the southern limit of the distribution of mainland tiger populations. Increasing development with climatic change has resulted in forests becoming fragmented, isolated and reduced in size, and this fragmentation has isolated small sub-populations of tigers and reduced the populations and habitats of many other large mammals.

The Javan Rhinoceros *Rhinoceros sondaicus* and Banteng *Bos javanicus* have become extinct in Malaysia recently and the Sumatran Rhinoceros *Dicerorhinus sumatrensis* is critically endangered (Aiken & Leigh, 1992). Most of these large mammals are now classified as endangered and “Near Threatened" by the International Union for Conservation of Nature (IUCN).

This has led to more research in protected areas in Peninsular Malaysia to ensure that long-term conservation effort is concentrated on factors such as prey biomass and ungulate density based on their tracks and sightings recorded or camera-trapping (Mohd. Azlan & Sharma, 2003; Kawanishi & Sunquist, 2004).

Table 3.12 Comparative measurements of well-preserved tiger tooth in this study with other modern and prehistoric material.

| ***Panthera tigris***<br>**Modern**<br>Zoological Museum<br>(University of Malaya) | **Upper C** | **Lower C** |
|---|---|---|
| N | 2 | 2 |
| L | 16.2 - 24.6 | 16.2 - 20.2 |
| W | 12.0 - 18.0 | 12.1 - 14.3 |
| Institute of Biodiversity,Wildlife & National Parks Department (Malaysia)[1] | | |
| N | 1 | |
| L | 23.2 | |
| W | | |
| ***Felis tigris tigris*** | 16.2 | |
| American Museum of Natural History (A.M.N.H.) (India & Indo-China)[2] | | |
| N | 5 | 6 |
| L | 20.9 - 27.1 | 18.6 - 24.1 |
| W | 15.2 - 20.0 | 14.2 - 17.2 |
| Java[3] | | |
| L | 20.5 - 25.0 | 18.2 - 23.0 |
| W | 15.0 - 18.2 | 13.1 - 15.8 |
| Sumatra[3] | | |
| L | 20.0 - 28.0 | 18.8 - 25.0 |
| W | 15.0 - 19.7 | 13.0 - 17.0 |
| ***Panthera tigris altaica***<br>Vladivostok tiger (Siberia)[3] | | |
| L | 25.4 | 25.0 |
| W | 18.4 | 15.7 |
| **Prehistoric** | | |
| Lang Trang Caves (Vietnam)[4] | | |

Table 3.12, continued

| | **Upper C** | **Lower C** |
|---|---|---|
| N | 1 | 1 |
| L | 28.7 | 25.4 |
| W | 21.0 | 19.5 |
| Java[4] | | |
| L | 25.1 - 31.6 | |
| W | 23.2 | |
| American Museum of Natural History (A.M.N.H.) | | |
| Yenchingkou (China)[2] | | |
| N | 5 | 5 |
| L | 28.4 - 32.7 | 23.4 - 31.5 |
| W | 21.1 - 23.7 | 16.8 - 22.9 |
| Wanhsien (China)[3] | | |
| L | 23.5 - 31.0 | |
| W | 22.0 - 23.5 | |
| Chou Kou Tien (China)[3] | | |
| L | 27.0 | 24.4 |
| W | 19.0 | 17.3 |
| **In this study** | | |
| Batu Caves | | |
| N | | 1 |
| L | | 20.5 |
| W | | 15.4 |

N= number of samples, L= mesio-distal length; W= bucco-lingual width. All measurements are in mm:

[1] Measurements sending by Lim, 2011(unpublished data)

[2] Colbert & Hooijer (1953)

[3] Hooijer (1947b)

[4] De Vos & Long (1993)

# 3.5 ORDER PERISSODACTYLA Owen, 1848

This order is represented in the Middle Pleistocene of Asia by the families Rhinocerotidae, Tapiridae, Equidae and perhaps, Chalicotheriidae. The last two are not present in the material studied in this research.

## 3.5.1 Family Tapiridae Gary, 1821, Plate 4(A)

This family comprises a single genus and four species with three inhabiting Central and South America:

*Tapirus pinchaque* (Mountain Tapir)

*Tapirus bairdii* (Baird's Tapir)

*Tapirus terrestris* (Brazilian Tapir / Lowland Tapir)

One species, *Tapirus indicus* (Figure 3.16), (The Asian Tapir or Malayan Tapir) is native to Asia.

The Malayan Tapir *Tapirus indicus* Desmarest 1819, synonym *Acrocodia indica* formerly used to range across southern Myanmar through Thailand, Peninsular Malaysia, and the island of Sumatra (Cranbrook, 1991; Corbet & Hill, 1992) with a wider earlier range extending to China. The tapir still exists in Java (van den Brink, 1982) and western and northern Borneo up to the historic period probably until the 1930s (Cranbrook & Piper, 2009).

*Tapirus indicus* is the largest and most evolutionarily distinct of the living species of tapir.

It inhabits dense primary rainforests. Evidence of their remains suggests that tapirs have been occupying a forested palaeo-environment spread throughout the Indochinese region (Cranbrook & Piper, 2011).

They exist today as a series of isolated populations, the largest of which are in Malaysia. Habitat destruction is largely responsible for historical declines of this species, and continues to be the main threat today.

Figure 3.16 Adult female Malayan Tapir *Tapirus indicus,* source**:** www.ultimateungulate.com

Fossil evidence indicates that the tapirs are most closely related to rhinos. The genus *Tapirus* can be traced back to the early Miocene at least 8 million years ago.

Pre-historic remains of the species were found in areas as far apart as south China (Kahlke, 1961), Sumatra, Java (de Vos, 1983) and Borneo (Medway, 1961; Harrison, 1996). Based on measurements, Hooijer (1947a) described the tapir represented in Sumatran caves as an extinct large new subspecies *Tapirius indicus intermedius* when he proposed: “the Malay tapir was larger in prehistoric times in Sumatra than it is at the present day.

The fact that it was smaller again, of its recent dimensions, in the lower and middle Pleistocene of Java, and in the Pleistocene of southern China strongly suggests that the Chinese and the Javan forms represent different subspecies." Specimens discovered in Cambodia (Beden &Guerin, 1973) and Sumatra (Hooijer, 1947a) were identified under the same subspecies. Badoux (1959) rejected the sub specific nomenclature as 'quite premature'.

Other tapir fossils found in China have been identified under different species as *Tapirus sinensis* Owen 1870, is a subjective synonym of *Tapirus indicus* (Colbert & Hooijer, 1953) and *Tapirus sanyuanensis* (Huang, 1991). Both tentatively appeared in Early Pleistocene while the extinct giant tapir *Megatapirus augustus* Matthew & Granger 1923 appeared after Early Pleistocene or from the Middle Pleistocene of the Indochinese Province and lasted until the Holocene (Hooijer, 1947a; Colbert & Hooijer, 1953; Tougard, 2001; Tong *et al*., 2002). The species *Tapirus peii* was named by Li Youheng in 1979 but has not been formally published yet and only parts of the fossil materials are available today (Tong, 2005). During the Middle Pleistocene *Megatapirus augustus* was also found in Vietnam (Olsen & Ciochon, 1990) and Laos (Fromaget, 1936). *Tapirus pandanicus* Dubois 1908 from Java (Wajak), according to Hooijer (1947a), should be reduced to *T. indicus pandanicus.*

### 3.5.1.1 Tooth description

Only one specimen CC 6-1 from Batu Caves (Cistern Cave) attributed to *Tapirus indicus* has been recovered in this study with the morphological description as in below:

Lower incisor

$I_{2:}$ CC 6-1 (sin.), Plate 4 (A)

This is a second lower left incisor. The tapir has well developed incisor teeth like a horse. The incisive surface is much worn and flat in this sample. It is slightly compressed, conical in shape and nearly circular in cross section. The isolated root is much more robust and compressed longitudinally with two vertical grooves running through the anterior and posterior ends. The lingual surface is more oblique than the labial surface and both are swollen and extend along the thick root. Two contact facets are present on both sides with another occlusal contact facet extending lingualy near the incisive edge.

### 3.5.1.2 Remarks

The features mentioned above are similar in the recent *Tapirus indicus* reference specimens available for comparison.

Although, the tapir has well-developed incisor teeth like a horse most research on tapir dentition has been focussed on isolated cheek teeth, premolars and molars in order to extract systematic and evolutionary information from them. Unfortunately, not much data is available on the incisive teeth. The rare data available are focused on the upper incisor only using the dimensions of $I^3$ to calculate the $C/I^3$ ratio as an index to estimate the evolutionary levels of the fossil tapirs (Tong, 2005).

Recent skulls with complete lower incisor available to me for comparative studies are very few, both because the teeth are un-erupted and remain deep in the alveoli or because they have broken off. Of the four tapir skulls available in the Institute of Biodiversity,Wildlife & National Parks Department (Malaysia), only one has complete incisor teeth.

It is the same with the fossil data: no fossil data was available for comparison of the lower incisor teeth. Table (3.13) shows the measurements of CC 6-1 (sin.) compared with other recent materials. CC 6-1 is assigned to the Malayan Tapir *Tapirus indicus* based on its general shape and morphological characters mentioned previously.

Table 3.13 Comparative measurements of well-preserved tapir tooth in this study with other modern material.

| ***Tapirus indicus*** | **$I_2$** |
|---|---|
| **Modern** | |
| Zoological Museum | |
| (University of Malaya) | |
| N | 1 |
| L | 10.9 |
| W | 9.9 |
| Institute of Biodiversity,Wildlife & National Parks Department | |
| (Malaysia)[1] | |
| N | 1 |
| L | 10.1 |
| W | 9.4 |
| **In this study** | |
| Batu Caves | |
| N | 1 |
| L | 10.4 |

| | |
|---|---|
| W | 9.5 |

N= number of samples, L= mesio-distal length; W= bucco-lingual width.

All measurements in mm. [1]Measurements by Lim, 2011(unpublished data).

### 3.5.2 Family Rhinocerotidae Gray, 1821, Plate 4 (B1-B4)

Currently, this family includes the following species: *Dicerorhinus sumatrensis* and *Rhinoceros sondaicus* (the only rhinoceros species found in Southeast Asia) and the Indian Rhinoceros *Rhinoceros unicornis* (restricated to parts of South Asia). All will be presented in this study for comparison purposes and because of their proximity to the specimens described in this study. All of them are endangered and highly threatened.

The Sumatran Rhinoceros (Figure 3.17, A), *Dicerorhinus sumatrensis* (Fischer, 1814) is still present nowadays in small numbers in Peninsular Malaysia, Sumatra, Borneo, and perhaps also in some parts of Assam, Thailand, Myanmar and Indochina.

The Javan Rhinoceros (Figure 3.17, B), *Rhinoceros sondaicus* Desmarest, 1822 was present in Bhutan and West Bengal, Myanmar, Laos, Vietnam to the islands of Sumatra and Java. Today, this species is only recorded in Java with no recent confirmed records in Laos and Myanmar and has been declared extinct in Vietnam.

The Indian Rhinoceros *Rhinoceros unicornis* Linnaeus, 1758 was previously identified across northern India, Nepal, Bengal and Assam but now its range is currently restricted to Northeast India.

These species have ecological similarities and are found in a wide range of habitats, including swamps and low-lying forests.

Figure 3.17 *Dicerorhinus sumatrensis* (A) and *Rhinoceros sondaicus* (B), source: www. arkive.org and jumbhoanimal.blogspot.com

The earliest fossil records of *Dicerorhinus* have been documented from the Late Oligocene or the Early Miocene of Western Europe, East Africa and South Asia which included at least 14 extinct species (Hooijer 1966; Groves & Kurt 1972). Fossil remains of these three species were found in various sites of Quaternary Southeast Asia. *Rhinoceros sondaicus* still occupied Borneo at least in the period between 8000 -10000 years before present (Cranbrook, 1986). It is also noted that three extinct subspecies have been proposed: one in Vietnam, *R. s. annamiticus* Heude, 1892 of Holocene age, and the second in Cambodia, *R. s. guthi* Beden and Guerin, 1973 of Pleistocene age, and finally *R. s. sivasondaicus* Dubois, 1908, Java of Lower Pleistocene age.

Recently, Middle and Late sils of *Rhinoceros unicornis* had been recorded respectively from Thailand (Tougard, 1998) and in northern Vietnam (Bacon *et al*., 2004, 2008b), while the remains of a subspecies of *R. u. kedengindicus* Dubois, 1908, from the Late Pleistocene, were discovered in Java (Hooijer, 1946b).

The review of these materials concluded that the *R. sivasondaicus* is synonymous with the fossil subspecies *R. sondaicus sivasondaicus* and *R. kendengindicus* is a synonym of the fossil subspecies *R. unicornis kendengindicus* (Guérin, 1980; Guérin & Faure, 2002). Generally the rhinoceros fossil remains are mainly from Sumatra and Java (de Vos, 1983) and Borneo (Harrison, 1996).

We can add to this family, two more extinct species of Early to Late Pleistocene age: *Rhinoceros sinensis* Owen, 1870, recorded in South China (Kahlke, 1961) and Vietnam (Ciochon & Olsen, 1990) and *R. sivalensis* Falconer and Cautley, 1847, in Myanmar (Colbert, 1943) and Laos (Fromaget, 1936). For *Dicerorhinus*, a new species, *Dicerorhinus gwebinensis* (Zin-Maung-Maung-Thein *et al*., 2008) was recorded in Myanmar. In contrast at least one extinct species may be added: *D. mercki* (Jäger, 1839) from Chinese Pleistocene sites. The molecular analysis suggests a split at 25.9 ± 1.9 Ma between *Dicerorhinus* and *Rhinoceros*, and this is generally concordant with the palaeontological evidences (Tougard *et al*. 2001).

Another two Africa species are represented by *Ceratotherium simum* (Burchell, 1817), and *Diceros bicornis* (Linnaeus, 1758).

The Rhinocerotidae represented in the current study by six specimens with the dimensions as in (Table 3. 14).

Table 3.14 Dimensions of the upper and lower teeth attributed to rhinoceros in this study.

| | **Tooth Type** | **No.** | **L** | **AW** | **PW** |
|---|---|---|---|---|---|
| *Dicerorhinus sumatrensis* | $dP^4$ (sin.) | CC EX5 | 45.5 | 48.4 | 43.6 |
| *Rhinoceros* sp. | $M_1$ (sin.) | BDC 7-1 | 50.6 | 30.9 | 29.4 |
| *Rhinoceros* / *Dicerorhinus* sp. indet. | $dP^1/dP^2$ (dex.)* | BDC 3-1a | - | 32.8 | - |
| | $dP_3$ (dex.) | SC 2-1 | 39.3 | 18.8 | 18.3 |
| | $dP_4$ (sin.)* | BDC 1-11U | 23.9 | 18.2 | - |
| | $dP_4$ (dex.)* | VC 3-4 | 26.2 | 20.1 | - |

No. = specimens field number; L= mesio-distal length; AW= anterior bucco-lingual width, PW= posterior bucco-lingual width, All measurements in mm.
* Incomplete sample, the dimensions for the anterior half part (see the description below).

### 3.5.2.1 Teeth description (Figure 3.18)

Although the numbers of rhinoceros teeth recovered in this study are few, the degree of morphological variation appears to indicate the presence of a taxonomically diverse Rhinocerotidae community characterized as follows:

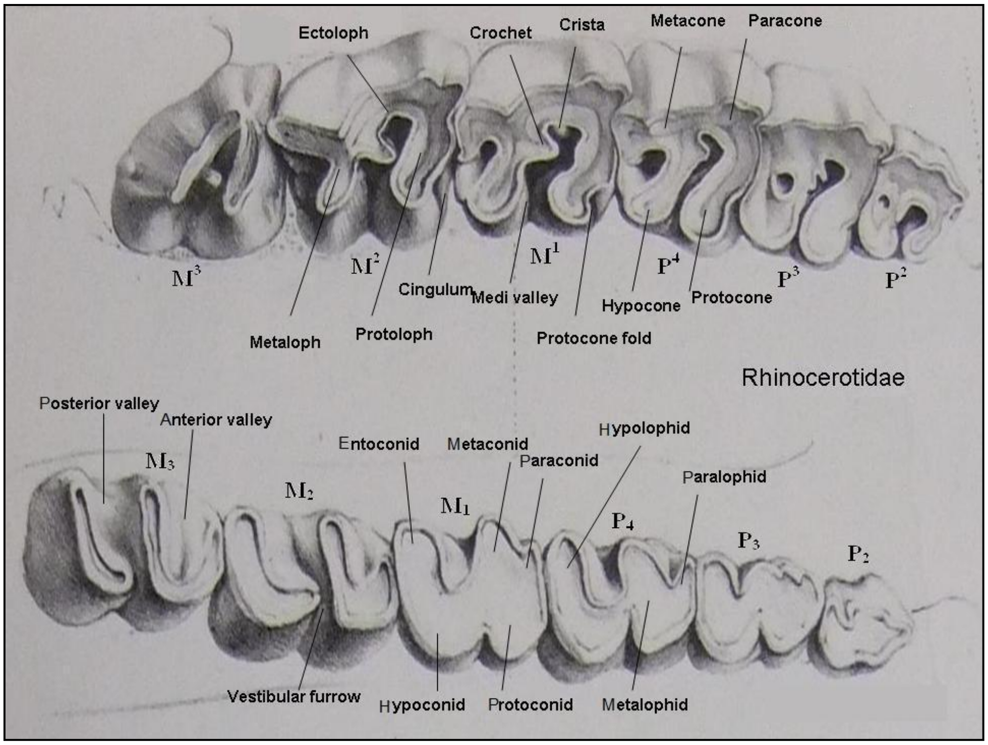

Figure 3.18 Nomenclature to describe cheek teeth structures of Rhinocerotidae modified from de Blainville (1839 – 1864).

### A. *Dicerorhinus sumatrensis* in Batu Caves

Upper premolar

dP$^4$: CC EX5 (sin.), Plate 4 (B1)

Generally, the specimen is well preserved with a partially unworn crown without roots. The shape of the crown is approximately quadrangular. A strongly developed cingulum extends along the anterior face of the protoloph on the anterior side. It does not continue along the inner surface of the tooth but terminates at the antero-external angle distinct protocone fold (vertical depression on the anterior aspect of the protoloph). These anterior features marked the *Dicerorhinus sumatrensis.* On the posterior side, the cingulum is present as a two shallow inclined grooves, the posterior half with distinctive metastyle more inclined inward than the anterior half. The buccal surface has two developed vertical ridges: the para and metastyle. The metaloph has a large and pointed crochet with a tendency to become bifid. Intersect with the crista is represented by small tubercles both forming the narrow medisinus entrance. The postsinus is sub-rounded in shape and larger than the medifossette and much deeper than the medisinus. A small tubercle occurs lingually at the entrance to the medisinus and a lingual depression is present on the hypocone fold.

### B. *Rhinoceros* / *Dicerorhinus* sp. indet. in Batu Caves

Lower premolars

dP$_{3:}$ SC 2-1 (dex.), Plate 4 (B2)

The slightly worn anterior and posterior lobes separated by a shallow depression at the buccal surface are well preserved. Five main cusps surround these lobes: paraconid, metaconid, and entoconid lingually and protoconid, and hypoconid buccally. The anterior lobe with paralophid and metalophid is wider and higher than the posterior lobe with hypolophid. The posterior valley is wider than the anterior valley and has deeper lingual entrance. A short and slightly developed cingulid runs along both the anterior and posterior sides constituting traces of transverse basal ridges. No roots are preserved and a few traces of gnaw marks are present at the buccal base of the anterior lobe. Contact facets are only preserved on the anterior side.

dP$_{4:}$ VC 3-4 (dex.), Plate 4 (B3)

This is an incomplete specimen with only the anterior half of the tooth preserved. The specimen is unworn and has a high crown at the buccal surface that aids in the identification of dP$_4$. The distinguishing features in the anterior part are: inward projection of the paralophid, high apex of the protoconid, and straight projection of the metalophid, all surrounding a wide anterior valley with deep lingual entrance. Clear gnaw marks at the buccal base of the crown extend into the crown cavity.

### C. *Rhinoceros* / *Dicerorhinus* sp. indet. in Lenggong Valley

Upper premolar

$dP^1/dP^2$: BDC 3-1a (dex.)

It consists of the anterior half of the tooth embedded in hard sediments in cave wall. Three unworn cusps are preserved: protocone and hypocone lingually and paracone buccally; the latter cusp is more distinct and prominent than the others. One vertical ridge (parastyle) is developed on the buccal surface. The anterior cingulum is slightly developed and does not continue along the protocone. The medifossette is present with no traces of crochet and crista.

Lower premolar

$dP_4$: BDC 1-11U (sin.)

This is an incomplete unworn specimen with only the anterior half preserved. The anterior valley forms an isolated pit just like in VC 3-4 but smaller. The anterior portion of the paralophid extends inward ending at the base of the deep lingual entrance while the anterior portion of the metalophid is more or less vertical. The upper lingual margin of the paralophid has fine crenulations with the highest point in the protoconid. No trace of the anterior cingulid was observed. Gnaw marks are present around the base of the crown. No roots are preserved.

**D. *Rhinoceros* sp. in Lenggong Valley**

<u>Lower molar</u>

$M_{1:}$ BDC 7-1 (sin.), Plate 4 (B4)

This sample is not well preserved. The large tooth has thick enamel different from that of other rhinoceros samples collected. Two moderately worn lobes are preserved. The anterior and posterior lobes are separated by a distinct vertical depression on the buccal surface between the metalophid and hypolophid. The anterior lobe is deeper than the posterior lobe which is more extended at the posterior internal angle to form the entoconid. The posterior lobe has its lingual entrance blocked by a thick curved wall dented on the inside. Hard matrix is still attached to anterior side therefore no anterior cingulid can distinguish. A contact facet is located at the posterior side.

## 3.5.2.2 Remarks

Most of the rhinoceros teeth collected from the cave deposits in this study are not complete and consisted of deciduous teeth with the crown portions only. No roots were observed and they might have been gnawed off by porcupines or other rodents.

My samples were compared with the Dubois Collection in National Museum of Natural History (Leiden).

The final identification depended on the available morphological features for comparison with other recent and fossil specimens from different sites (Table 3.15). The following conclusions were made based on these comparisons:

- Specimen CC EX5, a upper deciduous premolar, conforms to the distinctive characters of *Dicerorhinus sumatrensis* as observed by Hooijer, 1946b and Bacon *et al*., 2008b with a developed anterior cingulum extending along the anterior face of the protoloph, distinct protocone fold, vertical depression on the anterior aspect of the protoloph and the postsinus deeper than the medisinus.

De Vos & Long (1993) added that the teeth of *Dicerorhinus sumatrensis* are not so hypsodont than *Rhinoceros sondaicus* which are more hypsodont and they used this feature to attribute the materials from Lang Trang Caves (Vietnam) to *Dicerorhinus sumatrensis.* For measurements, CC EX5 is larger than the recent dP$^4$ example of *Dicerorhinus sumatrensis* and *Rhinoceros sondaicus* available to me but fall within the range of the fourth upper deciduous premolar of *D. sumatrensis* from the Padang Highlands Caves (Sumatra) (Table 3.15).

- Sample BDC 7-1, a lower molar is identified at the genus level *Rhinoceros* sp. This sample has different morphological characters than others. It is wider and larger in size with thick enamel. These characters (size and enamel) are used to distinguish between the lower molars of the *Dicerorhinus* and *Rhinoceros* which is large and thick in *Rhinoceros sondaicus* and in *R. unicornis* and small and narrow in *Dicerorhinus sumatrensis* (Bacon *et al*., 2008b). The ectolophid groove, another character used by Bacon *et al*. (2004) is deep and acute down to the lower molars of *R. sondaicus.*

The entrance to the posterior lobe is blocked by a thick curved wall in *R. sondaicus* or to *R. unicornis* (Hooijer, 1946b). From (Table 3.15), it can be seen that the Lenggong Valley lower molar sample BDC 7-1 is larger than the recent and fossil first lower molar of *Dicerorhinus sumatrensis* and *Rhinoceros sondaicus* available to me and intermediate in size between the length in recent *Rhinoceros unicornis* listed by Hooijer (1946b) and the posterior width in fossil specimens from Duoi U'Oi Cave (Vietnam) (Bacon *et al*., 2008b). The larger dimensions for this sample are very near to the range of the lower molars identified as *Rhinoceros* sp. in the Dubois Collection in the National Museum of Natural

History (Leiden) (Hooijer, 1946b) (Table 3.15).

Although the dimensions of this sample exceed the maximum values: mesio-distal length (= 50.6 mm), anterior bucco-lingual width (=30.9 mm), and posterior bucco - lingual width (= 29.4 mm), these measurements are not very certain because of the state of preservation and the hard matrix still attached to the anterior side. Hence, I prefer to keep the identification at the genus level as *Rhinoceros* sp.

- Sample SC 2-1, a lower deciduous premolar was compared with the pictures sent to me from the Natural History Museum (London) by Lord Cranbrook of *Rhinoceros sondaicus* (registration no. 1951.11.30.3 and 1951.11.30.4) and materials from the Padang Highlands Cave (Sumatra) in the National Museum of Natural History (Leiden).

This tooth does not have useful specific diagnostic features and does not have specific characters to determine the serial position for premolars and molars for the lower jaw dentition.

Hooijer (1946b) remarked that the shape of the posterior valley in the lower premolars can be used generally to distinguish them as there are no passes leading to this valley in *R. sondaicus* and *R. unicornis* while in some specimens this valley forms an isolated fossette. Although these passes are present in SC 2-1, they can only be regarded as an individual peculiarity.

The tooth falls within the range of measurements for Sumatran caves specimens of the third deciduous lower premolar of *Rhinoceros* / *Dicerorhinus* sp. indet. (Table 3.15) with a similarity in general morphological shape. For all these reasons, I have identified this sample as *Rhinoceros* / *Dicerorhinus* sp. indet.

- Three deciduous incomplete samples, BDC 1-11U, BDC 3-1a, and VC 3-4, all represented by the anterior part only, are attributed to *Rhinoceros* / *Dicerorhinus* sp. indet.

These specimens cannot be identified with certainty because all of them are too fragmented and incomplete. They are enumerated under the name of *Rhinoceros* / *Dicerorhinus* sp. indet.

I was able to compare them with the dimensions and morphological shapes of the anterior part s of the Sumatran caves specimens identified as *Rhinoceros* / *Dicerorhinus* sp. indet. (Table 3.16). There is a difference in size between VC 3-4 and BDC 1-11U even though the general morphological features are very similar and the position of tooth is certain (both represented the anterior part of the lower tooth). Although the length and anterior width is different (Table 3.14) the big difference in size is recognized in the high apex of the protoconids that measure 35.8 mm in VC 3-4 and 25.8 mm in BDC 1-11U.

Table 3.15 Comparative measurements of well-preserved rhinoceros teeth in this study with other modern and prehistoric material.

| | **$dP^4$** | **$dP_3$** | **$M_1$** |
|---|---|---|---|
| ***Dicerorhinus sumatrensis*** | | | |
| **Modern** | | | |
| Institute of Biodiversity,Wildlife & National Parks Department (Malaysia)[1] | | | |
| L | | | 30.9-34.9(N=2) |
| W | | | 25.3-26.0(N=2) |
| Hooijer (1946b) | | | |
| L | 29.0-36.0(N=10) | 33.0(N=4) | 36.0-41.0(N=16) |
| AW | 38.0-44.0(N=9) | 17.0-20.0(N=5)width | 24.0-26.0(N=16)width |
| PW | 34.0-41.0(N=10) | | |

Table 3.15, continued

| **Prehistoric** | **$dP^4$** | **$dP_3$** | **$M_1$** |
|---|---|---|---|
| National Museum of Natural History (Leiden) | | | |
| Padang Caves (Sumatra) | | | |
| L | 41.9-50.4(N=13) | | |
| W | 37.8-47.1(N=13) | | |
| Everett collection collected from Sarawak[2] | | | |
| L | | | 36.4-43.2(N=2)$M_1/M_2^*$ |
| AW | | | 23.0-27.5(N=2)$M_1/M_2^*$ |
| PW | | | 24.5-26.9(N=2)$M_1/M_2^*$ |
| **In this study** | | | |
| Batu Caves^ | | | |
| L | 45.5(N=1) | | |
| AW | 48.4(N=1) | | |
| PW | 43.6(N=1) | | |
| ***Rhinoceros sondaicus*** | | | |
| **Modern** | | | |
| Zoological Museum | | | |
| (University of Malaya) | | | |
| L | | 29.9(N=1) | 40.7(N=1) |
| AW | | 14.2(N=1) | 26.4(N=1) |
| PW | | 18.3(N=1) | 28.1(N=1) |

Table 3.15, continued

| | $dP^4$ | $dP_3$ | $M_1$ |
|---|---|---|---|
| Hooijer (1946b) | | | |
| L | 34.0-39.0(N=7) | 37.0–41.0(N=14) | |
| AW | 41.0-46.0(N=11) | 20.0-22.0(N=14)width | |
| PW | 38.0-42.0(N=11) | | |
| **Prehistoric** | | | |
| National Museum of Natural History (Leiden) | | | |
| Padang Caves (Sumatra) | | | |
| L | 41.9-48.5(N=2) | | |
| W | 41.4-47.9(N=2) | | |
| Hooijer (1946b) | | | |
| L | 43.0-44.0(N=2) | | |
| AW | 50.0-51.0(N=2) | | |
| PW | 47.0-50.0(N=2) | | |
| Gua Cha(Kelantan)[3] | | | |
| AW | 46.0-47.0(N=2) | | |
| PW | 40.0-42.0(N=2) | | |
| Madai Cave (Sabah)[2] | | | |
| L | $dM^3$= 41.5(N=1) | | |
| AW | $dM^3$= 49.5(N=1) | | |
| PW | $dM^3$= 46.1(N=1) | | |
| Punung (Java)[4] | | | |
| L | | 32.0(N=1) | |
| AW | | 17.0(N=1) | |
| PW | | 19.0(N=1) | |

Table 3.15, continued

|  | **$dP^4$** | **$dP_3$** | **$M_1$** |
|---|---|---|---|
| Duoi U'Oi Cave(Vietnam)[5] |  |  |  |
| L | 48.6(N=1) | 39.7-43.2(N=5) | 42.5(N=1) |
| AW | - | 17.0-19.1(N=5) | 26.9(N=1) |
| PW | >41.0(N=1) | 20.5-22.6(N=5) | 28.6(N=1) |
| Ma U'Oi cave (Vietnam)[6] |  |  |  |
| L |  | 40.0(N=1) |  |
| AW |  | 16.0(N=1) |  |
| PW |  | 20.0(N=1) |  |
| ***Rhinoceros unicornis*** |  |  |  |
| **Modern** |  |  |  |
| Hooijer (1946b) |  |  |  |
| L | 38.0 - 45.0(N=4) |  | 47.0–51.0(N=4) |
| AW | 49.0 - 56.0(N=4) |  | 26.0-28.0(N=4) width |
| PW | 48.0 - 50.0(N=4) |  |  |

| Table 3.15, continued | **$dP^4$** | **$dP_3$** | **$M_1$** |
|---|---|---|---|
| **Prehistoric** | | | |
| Duoi U'Oi Cave (Vietnam)[5] | | | |
| L | | | 44.3-46.7(N=2) |
| AW | | | 29.9-30.7(N=2) |
| PW | | | 30.0-31.7(N=2) |
| ***Rhinoceros* sp.** | | | |
| **Prehistoric** | | | |
| Hooijer (1946b) | | | |
| L | | | 42.0-53.0(N=16) |
| W | | | 25.0-37.0(N=20) |
| **In this study** | | | |
| Lenggong Valley^ | | | |
| L | | | 50.6(N=1) |
| AW | | | 30.9(N=1) |
| PW | | | 29.4(N=1) |
| ***Rhinoceros* / *Dicerorhinus* sp. indet.** | | | |
| **Prehistoric** | | | |
| National Museum of Natural | | | |

|  |  |  |  |
|---|---|---|---|
| History (Leiden) |  |  |  |
| Padang Caves (Sumatra) |  |  |  |
| L |  | 34.6-43.2(N=31) |  |
| W |  | 13.4-21.1(N=31) |  |
| **In this study** |  |  |  |
| Batu Caves^ |  |  |  |
| L |  | 39.3(N=1) |  |
| AW |  | 18.8(N=1) |  |
| PW |  | 18.3(N=1) |  |

N= number of samples, L= mesio-distal length; AW= anterior bucco-lingual width, PW= posterior bucco-lingual width, All measurements in mm.

[1] Measurements by Lim, 2011 (unpublished data)

[2] Cranbrook (1986)

[3] Hooijer (1963a)

[4] Badoux (1959)

[5] Bacon *et al*. (2008b)

[6] Bacon *et al*. (2004)

* The measurements are for the unclassified group

^Refer to (Table 3.14) for more details

Table 3.16 Comparative measurements of incomplete teeth (anterior part only), identified as *Rhinoceros* / *Dicerorhinus* sp. indet. in this study with other prehistoric materials.

| | **dP$^1$/dP$^2$** | **dP4** |
|---|---|---|
| **Prehistoric** | | |
| National Museum of Natural History (Leiden) | | |
| Padang Caves (Sumatra)$^2$ | | |
| AL | - | 21.2-23.8(N=5) |
| AW | 22.9 - 24.0 (N=3) | 17.4-19.2(N=5) |
| **In this study** | | |
| Batu Caves^ | | |
| AL | | 26.2(N=1) |
| AW | | 20.1(N=1) |
| Lenggong Valley^ | | |
| AL | | 23.9(N=1) |
| AW | 32.8(N=1) | 18.2(N=1) |

N= number of samples, AL= anterior mesio-distal length;

AW= anterior bucco-lingual width, All measurements in mm.

^Refer to (Table 3.14) for more details