3.6 ORDER ARTIODACTYLA Owen, 1848

In this study, this order is represented by the families Suidae, Cervidae, and Bovidae.

3.6.1 Family Suidae Gray, 1821, Plate 5

This family has the largest number of specimens of all the mammalian remains collected from the cave sites.

The family Suidae is represented in Southeast Asia by two genera and six species:

Babyrousa babyrussa Linnaeus, 1758, endemic to Sulawesi and its adjacent islands Malengi, Taliabu, and Buru (Groves, 1980; Corbet & Hill, 1992)

Sus barbatus Müller, 1838, Malaya, Sumatra, Borneo, and Philippines

Sus philippensis Nchring, 1886, Philippines

Sus cebifrons Heude, 1888, Philippines

Sus celebensis Müller & Schlegel, 1843, Sulawesi

Sus scrofa Linnaeus,1758, most of the Southeast Asia but not naturally in Borneo

Sus verrucosus Müller,1840, Java

Sus bucculentus Heude,1892, Laos and Vietnam

Sus ahoenobarbus Huet, 1888, endemic to the Palawan Philippines

Sus oliveri Groves, 1997, Mindoro in the Central Philippines

The high degree of morphological similarity between members of *Sus* adds a significant problem to ascertaining exactly which species of Sus is actually present within the palaeontological and archaeological record. Lucchini *et al*. (2005) discussed the evolution of Southeast Asian pig species by using morphological and genetic data to confirm the existence of a new species of wild pig on Tawi Tawi Islands (Philippines).

The most widespread species among the Suidae in Southeast Asia is *Sus scrofa*. It is a relatively recent species that probably entered Sundaland about 70,000 years ago and is found alongside *S. verrucosus* (Van den Bergh *et al*., 2001) even though these two were considered to be quite distinct by Groves (1981). It is hard to discriminate between the two species in the field. Only adult male *S. verrucosus* can be distinguished because of their large size and facial warts, whereas *S. verrucosus* females and subadults are almost indistinguishable from male and female of *S. scrofa* (Semiadi & Meijaard, 2006). They suggested that *S. verrucosusis* was rare or locally absent and have declined in many areas in Java whereas *S. scrofa* is more abundant and increased in number and has replaced *S. verrucosusis* in some places.

Pressure from overhunting and a decrease in habitat area are the main cause's suggested for the decline of *S. verrucosusis*. It appears that *S. scrofa* was able to withstand these pressures better than *S. verrucosus*, probably because of the ecological differences between the species with *S. verrucosusis* found confined in coastal forest and *S. scrofa* distributed at all altitudes in most habitats. Randi *et al*. (1996) in Lucchini *et al*. (2005) stated that *S. scrofa* diverged from *S. barbatus* between 1.3 and 6.6 Mya.

3.6.1.1 Eurasian Wild Pig *Sus scrofa* Linnaeus, 1758

Sus scrofa (Figure 3.19, A) has by far the largest range of all pigs. It is found in all forest and forest –edge situations throughout the mainland, mostly near streams, rivers or swamps in most of Southeast Asia region, in Laos, Cambodia, Vietnam, Thailand, Myanmar, and Peninsular Malaysia but not naturally in Borneo and Palawan (Kempe, 1946; Corbet & Hill, 1992).

3.6.1.2 Bearded Pig *Sus barbatus* Müller, 1838

Sus barbatus (Figure 3.19, B) found in all the natural and semi-natural environments, from the islands to the highest mountain tops and in all kinds of jungle from the beach to the river banks (Medway, 1977d).

It is more widespread in distribution occurring in Sumatra, Borneo, Philippines, and Peninsular Malaysia (Corbet & Hill 1992; Groves, 2001b), but not in Java (Van den Bergh *et al*., 2001).

Figure 3.19 *Sus scrofa* (A) and *Sus barbatus* (B), source: www.wikipedia.org.

In Peninsular Malaysia, *Sus scrofa* occur with *Sus barbatus* and was found in the Punung fissures fauna of Late Middle Pleistocene to Early Late Pleistocene in Java, presumably having migrated from or via Sumatra while it is absent in Borneo. Therefore, *Sus scrofa* might have been able to reach Borneo during the last glacial maximum (LGM) either from Malaya, Sumatra, or Java. Meijaard (2004a) explained the absence of *S. scrofa* in Borneo as they were either wiped out by disease or affected by the geology of Borneo in the low fertility of its soils or habitats.

There are more than 83 dental material (all isolated teeth) belonging to *Sus* recovered from all the cave sites in this study except for the Dark Cave at Batu Caves where most samples collected were fragmented bones of small mammals.

Both *Sus scrofa* and *Sus barbatus* have been identified. Three lower molars from the Batu Caves sites (two from Cistern Cave and one from Villa Cave) have been identified as *S. barbatus* based on mesio-distal length and other morphological characters mentioned later. Ten specimens collected from the Batu Caves site (Cistern, Swamp, and Villa Caves) have high morphological structures similar to *Sus barbatus* and are assigned to *Sus* cf. *barbatus*, five of them were identified as lower canine (not scrofic), the other five **(**P^1, P_3, P_4, M_3**)** have small areas of overlap with the upper limit of *S. scrofa* dimensions and with *S. barbatus*, therefore these specimens are tentatively assigned to *Sus* cf. *Barbatus*
(Table 3.17).

Another group of fossils collected from both the Batu Caves and Lenggong Valley sites could not be identified to species level are listed as *Sus* sp. either because they are too broken or have high morphological similarity to both species. Table (3.18) shows the dimensions of the upper and lower well-preserved pig teeth collected from the study area.

Cheek teeth of both jaws are better represented than incisor and canine, all showing varying degrees of wear surfaces indicating a natural population and dependent on the diet and feeding habits and the relationship between the surface wear and age (Morris, 1972; Grant, 1982). The illustrated guide of Wright and Albarella (2010) (Figure 3.20) was used in this study to code different degrees of wear (w) applied to the last premolar and molars for both mandibular and maxillary teeth to distinguish the pattern of the tooth wear stages on the enamel occlusal surfaces.

Table 3.17 Comparative measurements of the isolated teeth of *Sus* cf. *barbatus* in this study with other *Sus scrofa* and *Sus barbatus* materials.

Sus scrofa	$\mathbf{P^1}$	$\mathbf{P_3}$	$\mathbf{P_4}$	$\mathbf{M_3}$
Modern				
Mainland of Malay Peninsula & Sumatra[1,2]				
N	2	6	6	8
L	8.2 - 9.1	13.0 - 14.3	14.4 - 15.2	29.0 - 40.0
W	4.3 - 4.6	7.4 - 8.1	10.5 - 12.1	16.0 - 19.0
Prehistoric				
Lang Trang Caves (Vietnam)[3]				
N		40	62	42
L		12.0 - 15.4	13.3 - 18.3	35.8 - 47.7
W		6.0 - 9.4	3.4 - 12.2	11.4 - 19.7
Duoi U'Oi Cave (Vietnam)[4]				
N	7	14	12	18
L	7.3 - 9.8	11.5 - 14.4	13.6 - 16.4	30.6 - 46.8
W	3.1 - 4.2	5.5 - 8.3	9.8 - 11.7	16.4 - 20.3
Sus barbatus				
Modern				
Bornean Bearded pig[1,2]				
N	2	9	9	40
L	9.9 - 10.4	14.0 - 16.7	15.0 - 17.3	33.0 - 48.0
W	4.5	7.6 - 10.4	8.5 - 11.7	19.8 - 21.8
Prehistoric				
West mouth, Niah Cave[1]				
N	1	4	10	31
L	10.6	15.0 - 16.1	15.3 - 17.0	33.0 - 44.4
W	4.1	7.2 - 8.3	9.8 - 12.0	14.3 - 19.6
Duoi U'Oi Cave (northern Vietnam)[4]				
N				2
L				39.7 - 40.3
W				17.3 - 18.5
Sus* cf. *barbatus				
In this study				
N	2	1	1	1
L	8.5 - 9.9	16.0	18.0	35.2
W	4.6 - 6.8	11.0	12.5	16.4

N=number of samples, L=mesio-distal length; W= bucco-lingual width. All measurements in mm after: [1]Medway (1977d), [2]Cranbrook (1979), [3]de Vos & Long (1993), [4] Bacon *et al.* (2008b).

Table 3.18 Dimensions of the upper and lower teeth attributed to Suidae in this study.

	Tooth Type	**No.**	**L**	**W**
Sus scrofa	I^2 (sin.)	BDC EX1	8.0	3.7
	P^1 (dex.)	CC 4-5	8.7	4.7
	P^1 (sin.)	BDC EX2	9.0	3.8
	P^2 (dex.)	BDC EX15	11.7	6.4
	dP^2 (sin.)	BDC 4-5	11.9	7.9
	P^2 (sin.)	NC 1-4	9.5	4.8
	P^3 (sin.)	CC 4-11	14.0	10.5
	P^3 (dex.)	BDC EX10	11.7	10.3
	P^3 (sin.)	BDC EX12	11.5	10.6
	P^4 (sin.)	CC 6-2	13.8	14.0
	P^4 (dex.)	BDC 1-29U	10.2	11.5
	P^4 (sin.)	BDC 5-2	11.0	11.2
	P^4 (dex.)	BDC EX8	10.7	13.1
	P^4 (sin.)	BDC EX11	11.5	12.7
	M^1 (sin.)	CC 1-4	16.1	14.0
	M^1 (dex.)	BDC 1-5U	16.8	15.0
	M^1 (sin.)	BDC 1-16U	15.2	12.9
	M^1 (sin.)	BDC 1-27Ua	17.9	13.6
	M^1 (sin.)	BDC EX9	14.3	15.1
	M^2 (sin.)	CC 4-9	23.4	17.0
	M^2 (sin.)	VC 4-16	22.0	17.3
	M^2 (dex.)	BDC 5-8	23.0	18.2
	M^2 (sin.)	BDC 6-1	21.3	20.4
	M^2 (sin.)	NC 2-1	20.9	20.3
	M^3 (dex.)	CC 4-1	32.3	16.4
	M^3 (dex.)	CC 5-1	29.6	14.0
	M^3 (sin.)	CC EX3	32.7	19.0
	M^3 (sin.)	CC EX4	32.7	17.7
	M^3 (sin.)	SC 3-1	36.1	19.7
	M^3 (sin.)	SC 4-1	31.8	11.6
	M^3 (dex.)	VC 2-1	32.3	18.5
	M^3 (dex.)	VC 3-1a	33.5	17.7

Table 3.18, continued

	Tooth Type	**No.**	**L**	**W**
	M^3 (dex.)	VC 4-7	31.9	17.4
	M^3 (dex.)	BDC 1-2U	30.6	18.9
	M^3 (dex.)	BDC 1-30U	34.5	18.6
	M^3 (dex.)	BDC 4-12	35.2	20.3
	M^3 (dex.)	BDC EX19	24.4	14.4
	M^3 (dex.)	NC 1-5	31.7	17.3
	P_2 (dex.)	BDC 1-1U	12.2	6.0
	P_2 (sin.)	BDC 4-15	11.9	4.9
	P_3 (sin.)	SC 5-1	14.2	7.1
	M_1 (dex.)	VC 3-2	16.8	11.7
	M_1 (sin.)	VC EX1	15.0	12.3
	M_1 (sin.)	VC EX4	15.4	11.1
	M_1 (dex.)	BDC 4-9	16.2	13.1
	M_1 (sin.)	BDC 5-12	18.4	11.8
	M_1 (dex.)	NC 1-3	16.1	11.9
	M_2 (sin.)	CC 7-2	16.8	10.8
	M_2 (dex.)	VC 4-3	21.7	13.0
	M_2 (dex.)	VC 4-11	21.2	15.4
	M_2 (dex.)	VC EX2	20.6	14.3
	M_2 (dex.)	BDC 4-7	21.5	14.1
	M_3 (dex.)	CC 7-4	34.2	16.7
	M_3 (dex.)	VC 4-14	35.0	15.7
	M_3 (dex.)	VC 4-24	34.6	14.7
	M_3 (dex.)	BDC 1-23U	30.7	13.4
Sus barbatus	M_3 (sin.)	CC 4-3	40.0	17.2
	M_3 (sin.)	CC 5-3	45.1	17.7
	M_3 (dex.)	VC 4-15	43.0	16.9
Sus cf. *barbatus*	P^1 (dex.)	CC 4-10	8.5	4.6
	P^1 (dex.)	CC 7-3	9.9	6.8
	Lower C (sin.)	CC 4-8	14.8	10.0
	Lower C (dex.)	SC 1-2	23.6	14.7
	Lower C (dex.)	VC 1-1	14.2	10.1
	Lower C (sin.)	VC 4-1	10.8	8.4
	Lower C (sin.)	VC EX7	11.3	7.4

Table 3.18, continued

	Tooth Type	**No.**	**L**	**W**
Sus cf. *barbatus*	P_3 (dex.) P_4 (dex.) M_3 (sin.)	CC 5-2 CC EX10 SC 1-1	16.0 18.0 35.2	11.0 12.5 16.4
Sus sp.	I^2 (sin.)	BDC EX18	6.2	6.7
	P^1 (dex.)	BDC 5-15	5.8	4.8
	P^4 (dex.)	BDC 4-8	13.9	10.9
	M^2 (?)	BDC 5-25 BDC 4-2	16.5 24.4	19.3 /
	M^3 (sin.)	BDC 4-10	/	16.0
	Lower C (?)	CC EX12	4.8	5.3
	Lower I (?)	BDC 3-5	5.8	4.6
	P_3 (dex.)	NC 1-8	7.4	6.0
	P_4 (sin.)	BDC EX4	7.9	9.2
	M_1 (?)	BDC EX5	15.7	11.2
	M_2 (dex.)	BDC 4-13	/	18.1
	M_3 (?)	BDC 1-12U BDC 4-17	18.9 /	11.0 12.2

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

Codes

M1/M2/M3/dP4

w1	No dentine exposure - enamel wear only
w2	Dentine exposed as one or more small unconnected area(s) on the occlusal surface
w3	Dentine exposed as a single area occupying most of the occlusal surface
w4	Enamel on part or all of the pillar edge has worn away

Mandibular P4

w1	No dentine exposure - enamel wear only
w2	Dentine exposed but broken by enamel into more than one area
w3	Dentine exposed and unbroken by enamel, creating one larger area of exposure

Maxillary P4

w1	No dentine exposure - enamel wear only
w2	Dentine exposed on buccal side of tooth only
w3	Dentine exposed on both buccal and lingual sides of tooth

Examples

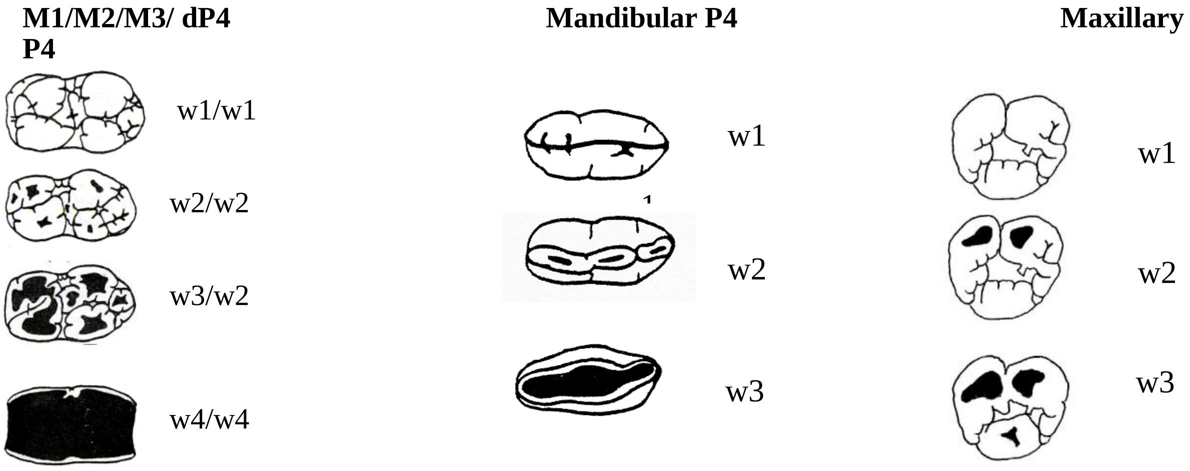

Figure 3.20 New systems of tooth wear stages for pigs applied to both the upper and lower teeth of the last premolar and molars (after Wright and Albarella, 2010).

3.6.1.3 Teeth description (Figure 3.21)

The enamel pattern of the crowns of the cheek teeth in all pigs is very complex. The following descriptions of the teeth are based on their morphological characters:

A. *Sus Scrofa* in Batu Caves

Upper premolars

P^1: CC 4-5 (dex.), Plate 5 (A1)

There is only one upper P^1. The tooth has an unworn crown with sharp triangular shape. It is unicuspid (paracone) with conical shape with no accessory cusps. The anterior edge is smooth and straight, while the posterior edge is concave with a distinct basin that runs from the apex of the cusp to the base of the crown. Parts of the confluent roots are preserved with a distinct longitudinal groove at both lingual and buccal sides.

P^3: CC 4-11 (sin.), Plate 5 (A2)

It is represented by only one worn tooth with a distinct well preserved paracone from the crown. A high anterior-posterior ridge extends from the tip of the paracone backward to reach the hypocone and forward to reach the protocone. A deep basin between the protocone and hypocone opens lingually. The developed hyopcone compared with the small protocone makes the anterior portion less wide than the posterior part. Parts of the root preserved include one large anterior root and two smaller confluent posterior roots. The contact facet is preserved on both anterior and posterior surfaces.

P^4: CC 6-2 (sin.), Plate 5 (A3)

It is square in outline with only the crown and immediate parts of the roots preserved. The crown is relatively worn with small parts of the dentine exposed on both buccal and lingual sides of tooth placing the tooth wear under (w2) of the Wright and Albarella (2010) scale. The buccal cusps are clearly divided into two parts (paracone and metacone) and the lingual cusp (protocone) which occupies most of the area with a small hypocone. All are compressed towards the wider and deeper central fossa. Contact facets are present on both anterior and posterior surfaces.

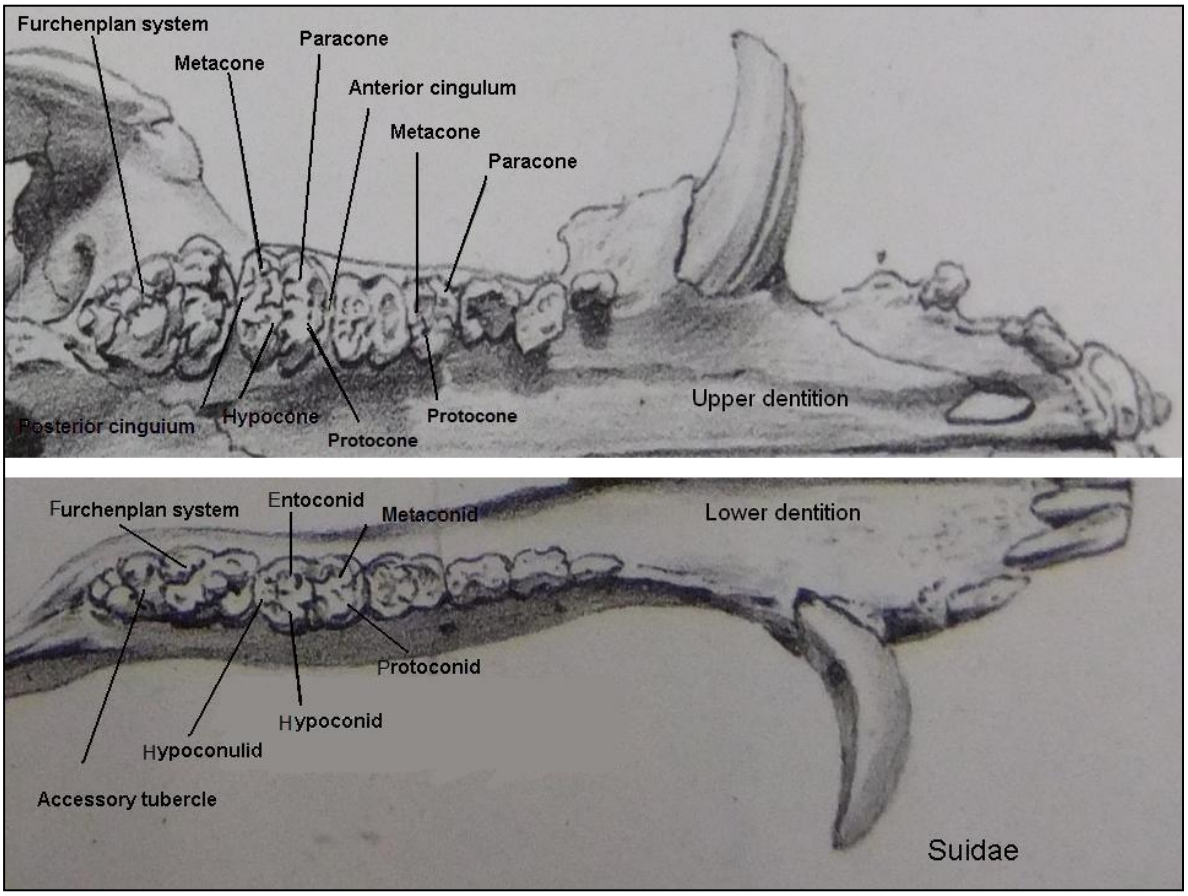

Figure 3.21 Nomenclature to describe cheek teeth structures of Suidae modified from de Blainville (1839 – 1864).

Upper molars

M^1: CC 1-4 (sin.)

The crown and remnants of roots are preserved. It is square in outline and small in size compared to M^2 and M^3. The crown is divided into an anterior and posterior part with the anterior being wider than the posterior. Occlusal enamel wear is graded as (w1) on the Wright and Albarella (2010) scale. No cusps were observed in the occlusal view while relatively borders surrounding the lingual and buccal sides can be distinguished.

M^2: CC 4-9 (sin.), VC 4-16 (sin.), Plate 5 (A4)

Only the crown is preserved. It is square in outline and relatively unworn. Both lingual and buccal sides can be divided into two parts with four major sharp cusps :(paracone and metacone) buccaly and (protocone and hypocone) lingually. Median accessory cusps preserved in both specimens in between the major cusps are sharp and pointed in VC 4-16 while relatively flat in CC 4-9. Mesial and distal cingula are preserved but weakly developed in CC 4-9 and strongly developed in VC 4-16. Contact facets are present on both the anterior and posterior surfaces of CC 4-9 and only on the anterior surface of VC 4-16.

M^3 : CC 4-1 (dex.), Plate 5 (A7), CC 5-1 (dex.), CC EX3 (sin.), CC EX4 (sin.), SC 3-1 (sin.), SC 4-1 (sin.), VC 2-1 (dex.), VC 3-1a (dex.) A6, VC 4-7 (dex.)

The nine specimens show different degrees of wear. CC 4-1 and VC 4-7 are most worn with both under (w3) while CC EX3, CC EX4, SC 3-1, VC 2-1, and VC 3-1a are not worn with complete crowns, CC 5-1 has a broken anterior part, SC 4-1 is broken on the buccal side. Generally, the outlines look triangular in shape with four major cusps: paracone, protocone, metacone, and hypocone that are arranged nearly in a straight line with short and compress talons. Median accessory cusps between the first lobe (paracone and protocone) and second lobe (metacone and hypocone) are complicated in some specimens while simple and clear in others. Some other accessory cusps occur in between the second lobe and the talon. Anterior cingula are well developed in most specimens. Gnaw-marks were observed in specimens CC 4-1, CC EX4, VC 3-1a, VC 4-7 on the lower surface of the crown and could possibly explain the absence of roots. Parts of the roots have been preserved in CC EX3, SC 3-1, and VC 2-1. Contact facets are clearly present on the anterior surfaces of CC 4-1, CC EX3, CC EX4, SC 3-1, and VC 2-1.

Lower premolar

P_3: SC 5-1 (sin.)

It has buccal and ligual faces with their cusps compressed longitudinally. A high and sharp ridge runs from the apex of the higher anterior cusp (protoconid) backwards to the distal edge. The anterior slope of the protoconid runs down until the anterior pillar. Contact facets are present on the upper part of the posterior surface. A complete posterior root and a damaged anterior root are preserved. Small dentine areas are exposed in the occlusal parts of the higher anterior cusps.

Lower molars

$M_{1\,:}$ VC 3-2 (dex.), VC EX1 (sin.), Plate 5 (A5), VC EX4 (sin.)

They have rectangular crowns with much worn occlusal part coded as (w4) for VC EX4, (w3) for VC 3-2 and (w2) in VC EX1which has a complete crown and used here for description. Five major cusps are resealed. Lingual cusps (metaconid and entoconid) are higher than the two buccal cusps (protoconid and hypoconid). The hypoconulid located in the distal side in the middle position behind the entoconid and hypoconid is the smallest. The median accessory cusp is present but relatively small. The anterior cingulid is compressed strongly against the anterior surface. Contact facets are visible on the posterior surface only in VC EX4, and in both anterior and posterior surfaces in VC 3-2 and VC

EX1. Remnants of four roots are preserved in all the samples and better preserved in VC 3-2 and VC EX 4.

$M_{2:}$ CC 7-2 (sin.), VC 4-3 (dex.), VC 4-11 (dex.), Plate 5 (A6), VC EX2 (dex.)

The crown is rectangular shape in outline. The lingual cusps are higher than the buccal cusps especially the metaconid which is more pronounced among the specimens that are not worn like CC 7-2 and VC 4-11 unlike in VC EX2 which has (w3) wear. Features are similar to M_1 but larger in size especially the anterior-posterior measurements. The area in between the four major cusps (protoconid, metaconid, hypoconid, and entoconid) is larger than in M_1. A pillar is present on the buccal surface of the median valley in between the protoconid and hypoconid. A weak ridge runs from the posterior of the protoconid buccaly towards the posterior side where wear facets are visible. Gnaw marks are present at the bases of the crown (no roots) in VC 4-3 while fragments of four open roots in VC 4-11 and CC 7-2 and closed roots in VC EX2 are present.

M_3: CC 7-4 (dex.), VC 4-14 (dex.), Plate 5 (A10), VC 4-24 (dex.)

The crown is rectangular in shape. In CC 7-4 a minor part (anterior cingulid) of the anterior surface is broken. The teeth are not worn in the occlusal side of CC 7-4 and VC 4-14 but relatively worn (w2) in VC 4-24.

The five major cusps (protoconid, metaconid, hypoconid, entoconid, and hypoconulid) are well preserved. The lingual cusps (metaconid and entoconid) are higher than the buccal cusps (protoconid and hypoconid). A median accessory cusp is present at the center of the main cusps separated between the first lobe (protoconid and metaconid) and second lobe (hypoconid and entoconid). A wide hypoconulid cusp is clearly present to separate the second and the third lobes (talonids). The talonid is subdivided by a shallow groove into two parts (posterior accessory cusps) lingually and buccally with the buccal cusps larger than the lingual cusps. Parts of damaged roots are preserved in all samples. Contact facets are well preserved on the anterior surfaces of VC 4-14 and VC 4-24.

B. *Sus barbatus* in Batu Caves

Lower molars

M_3: CC 4-3 (sin.), CC 5-3 (sin.), Plate 5(C1), VC 4-15 (dex.), Plate 5(C2)

The two specimens from Cistern Cave are relatively worn (w2) and the one from Villa Cave is not worn and larger in size and more elongated in shape. The mesial side is wider than the distal side. The three lobes are pronounced. The third lobe (talonid) is narrower than both first lobe (protoconid with metaconid) and the second lobe (hypoconid with entoconid). The hypoconulid is well preserved. An anterior accessory cusp is present but small. A median accessory cusp is present at the center of the four main cusps. The talonid is divided by the shallow grooves into three parts is lingually, buccaly, and posteriorly. All are represented as large posterior accessory cusps that are as large as the main cusps. The talonid with these cusps give *Sus barbatus* specimens a larger size compared to *Sus scrofa* specimens. Contact facets on the anterior surfaces are present in all the samples. Gnaw-marks are found shown in the Cistern Cave specimens on different places of the root fragments.

C. *Sus* cf. *barbatus* in Batu Caves

Upper premolars

P^1: CC 4-10 (dex.), CC 7-3 (dex.)

The crown is triangular to sub- rectangular in outline. The occlusal surfaces are much worn and flat leading to difficulties in identification. No cusps can be recognized. Two closed roots of unequal size and which are not fused are preserved. The anterior is larger than the posterior in CC 4-10 and smaller in CC 7-3. The samples show differences in size and may be different in sex or age.

Lower canines

CC 4-8 (sin.), Plate 5 (B1), SC 1-2 (dex.), VC 1-1 (dex.), VC 4-1 (sin.), VC EX7 (sin.), Plate 5 (B2)

The crown is crescentic in outline. Its three sides, the lingual, buccal and posterior make up the triangular cross section. The posterior surface with no enamel is "*verrucosic*" (not scrofic) and is narrower than both the lingual and buccal surfaces. There are smooth edges with a middle ridge running across only one side (the lingual) in Villa Cave samples and on both sides (lingual and buccal) on CC 4-8 while it is not clear in the damaged Swamp Cave sample. A longitudinal groove runs along the posterior side. Open roots are observed in the tooth from young males in CC 4-8 and VC 1-1 and female (?) in VC EX7 and a female in VC 4-1. The posterior tip from a young male in CC 4-8 is moderately worn.

Lower premolars

P_3: CC 5-2 (dex.)

Both buccal and ligual cusps are compressed longitudinally to display the two faces separated by a sharp and high mesiodistal crest which connects the apex (protoconid) that lacks distinct cusps and runs down to the mesial end of the crown to make the mesiolingual corner of the tooth slightly curved. The buccal side can distinguished by the occurrence of two shallow depressions near the mesial and distal ends. Remnants of some roots are preserved. Contact facets are present on the upper part of the posterior side. The tooth is not worn.

P_4: CC EX10 (dex.)

It is very similar in morphology to the lower P_3 but is bigger and wider. The lingual and buccal sides are compressed together longitudinally with signs of wear (w3) appearing as a continuous dentine exposure along the apex of the cusps. The anterior cingulid is relatively curved lingually while the distal end is pointed lingually and has a more pronounced slope than in the lower P_3. The shallow depressions on the buccal side are ‘V shaped’ and deeper than in the lower P_3 and look subdivided into fine parts at both the mesial and distal edges. Contact facets are present on both the anterior and posterior surfaces. Two roots are attached to the lingual side while they are broken in the buccal side.

Lower molar

M_3: SC 1-1 (sin.)

The four major cusps (prtoconid, metaconid, hypoconid, and entoconid) are well preserved and arranged in a straight line around the wide median accessory cusps. The hypoconulid behind the hypoconid and entoconid not well preserved enough to give a specific identification. The long and compress talonid form the posterior end. The anterior cingulid is broken. No dentine exposure is preserved and enamel wear is only (w1).

D. *Sus scrofa* in the Lenggong valley

Upper incisor

I^2: BDC EX1 (sin.)

The shape looks compressed obliquely. It is convex on the labial side and narrower towards the oblong-shaped cutting edge with a single open root. The crown enamel at the labial side extends towards the root more than on the lingual side. The gingival line is present clearly on both the labial and lingual surfaces. The tooth is slightly worn near the tip of the transverse edge.

Upper premolars

P^1: BDC EX2 (sin.)

There is one isolated P^1 tooth in the Lenggong Valley collections that belong to *Sus scrofa*. The crown consists of one main cusp (paracone) which looks more compressed and is less conical in shape. It is less abroad at the base compared with the P^1 from the Batu Cave collection. A high ridge runs from the apex of the paracone forwards and backwards with a shallow lingual fossa and traces of wear posteriorly. Its posterior root is preserved.

P^2: BDC EX15 (dex.), BDC 4-5 (sin.) (DEC), NC 1-4 (sin.)

The three specimens are different in size. BDC EX15 is relatively larger in size while NC 1-4 is smaller and less wide than the others. Lingual and buccal cusps are compressed by the anterior-posterior ridge. The anterior cingulum is weakly developed. The posterior internal fossa is very distinct in NC 1-4. The dentine is exposed as a long area occupying most of the occlusal surface of the ridge. The posterior contact facet is well preserved in BDC EX15. Two roots are attached to the anterior and posterior ends of BDC EX15 and NC 1-4. They are covered by hard sediments in BDC EX15 and broken from the posterior-buccal side in NC 1-4. BDC 4-5 is a deciduous tooth as the lingual cusps (protocone and hypocone) are smaller than the buccal cusps (paracone and metacone) while the paracone is more distinct and pointed among the four main sharp cusps. The posterior fossa is larger than the anterior fossa which is surrounded by the metacone and hypocone. No root is preserved.

P^3: BDC EX10 (dex.), BDC EX12 (sin.)

The specimens are relatively not worn and smaller in size. The anterior- posterior buccal ridge was not very well defined and the lingual basin can be divided into two parts: a smaller anterior inner basin bounded by the paracone and a larger posterior inner basin bounded by the hypocone. Parts of open roots are preserved including two fused roots at both the anterior and posterior ends with contact facets on both sides.

P^4: BDC 1-29U (dex.), BDC 5-2 (sin.), BDC EX8 (dex.), BDC EX11 (sin.)

The crown is square in outline. These are relatively smaller premolars compared to the P^4 from Batu Cave. The three cusps are well preserved in BDC EX8 and BDC EX11 and partially worn (w2). They consist of the paracone and metacone buccaly and a compressed protocone lingually with a shallow buccal groove separating the paracone and metacone. Only the outer borders with flat dentine are exposed on these cusps in the occlusal sides of BDC 1-29U and BDC 5-2 with wear (w3). These cusps are compressed transversely around the shallow central fossa. The fossa is deeper and wider in the P^4 from Batu Cave. Four broken roots are preserved in these samples; two from buccal side and two from the lingual side. All the specimens have anterior and posterior contact facets.

Upper molars

M^1: BDC 1-5U (dex.), BDC 1-16U (sin.), BDC 1-27Ua (sin.), BDC EX9 (sin.)

The crown is nearly square in occlusal view. The specimens show a different degree of wear. BDC 1-5U is relatively unworn and the anterior part is absent. The enamel in both BDC 1-16U and BDC EX9 are worn with no dentine exposure (w1) on the cusps. Four main sharp conical cusps are present in BDC 1-27Ua: paracone, protocone, metacone, and hypocone with a deep median valley occurring between the anterior cusps and the posterior cusps. Both anterior and posterior cingula are distinct in BDC 1-27Ua with the posterior being more developed. Two open incomplete buccal roots are preserved in BDC 1-27Ua, and four broken unequal roots are preserved in BDC 1-16U and BDC EX9. Anterior and posterior contact facets in BDC EX9 are preserved.

M^2: BDC 5-8 (dex.), BDC 6-1 (sin.), NC 2-1 (sin.)

They are very similar in morphology with M^2 from Batu Cave but much larger in size. The crown is nearly square in outline. The specimens show different degrees of wern: not worn in BDC 5-8, slightly worn (w2) in BDC C 6-1 at the apex of the anterior cusps and more worn (w3) on the occlusal side in NC 2-1. Four main cusps are preserved: (paracone, protocone) anteriorly and (metacone, hypocone) posteriorly. The buccal part of the paracone with part of median accessory cusps is broken and absent in BDC 5-8 and the buccal part of metacone is absent in BDC C 6-1. In all the specimens the anterior and posterior cingula are present. Contact facets are present on both ends in NC 2-1 while present only in the upper part of the anterior end in BDC 5-8. Remnant roots are preserved in all the samples.

M^3: BDC 1-2U (dex.), BDC 1-30U (dex.), Plate5 (A9), BDC 4-12 (dex.), BDC EX19 (dex.), Plate5 (A8), NC 1-5 (dex.)

All specimens are triangular in shape and not worn except for BDC EX19 which is slightly worn (w2) and NC 1-5 which is heavily worn (w3) on the occlusal surface so that not many morphological characters can distinguish from this sample. The specimens show different sizes especially BDC EX19 which looks very small compared with the others. The first lobe (paracone and protocone) is wider than the second lobe (metacone and hypocone). The talon is compressed and consists of one cusp. A series of not well-developed but distinct cusps run along the buccal side of the talon as the buccal basal accessory cusps in all the unworn specimens. This character distinguishes the 3rd upper molar samples taken from Badak Cave C. The arrangement of the buccal cusps does not correspond to the lingual cusps but deviates somewhat towards the anterior. Median accessory cusps are clearly seen in all the specimens. The cingulum is only developed anteriorly. Contact facets are clear in BDC EX19. No roots are preserved in nearly all the specimens except for NC1-5 that has broken roots.

<u>Lower premolars</u>

P_2: BDC 1-1U (dex.), BDC 4-15 (sin.),

The crown is triangular in shape. The protoconid is displayed as a main cusp. A very weak and thin ridge connects the apex of the protoconid mesialy with the slight cingulid and distally with the curved talonid. The enamel is smooth and worn in the occlusal side of the distal ridge; slightly in BDC 1-1U and much worn at the tip of the protocone in BDC 4-15.

Anterior and posterior incomplete roots are preserved in both samples. The posterior side is distinguished by the contact facet.

Lower molars

M_1: BDC 4-9 (dex.), BDC 5-12 (sin.), NC 1-3 (dex.)

It is rectangular in occlusal view. The specimens have different degrees of wear and damage on the crown. BDC 4-9 is a damaged tooth with enamel wear (w1) and no features can distinguish. NC 1-3 too worn (w3) and not clear for the description while BDC 5-12 is relatively worn (w2) with a more complete crown compared with the others. Four main cusps are arranged in two distinct lobes: the anterior lobe (protoconid and metaconid) narrower and shorter than the posterior lobe (hypoconid and entoconid) with both separated by a median valley. Shallow depressions are present in the median valley between the two lobes corresponding to the median accessory cusps. A small hypoconulid occurs at the disto-buccal side of the tooth. The lingual side is higher than the buccal side in most of the specimens. A tiny compressed and not well developed cingulid is present at the mesial edge. Contact facets are present on both sides in BDC 5-12 and NC 1-3 with four distinct but incomplete roots in BDC 5-12 while the roots are not well preserved in others.

M_2: BDC 4-7 (dex.)

It is a broken tooth. The crown area is much larger than in M_1. Its four major cusps are arranged in two distinct lobes which are separated by a clear depression in the median valley, three of the cusps: (metaconid, hypoconid and entoconid) are well preserved, while the mesio- buccal side of the protoconid is broken so that the anterior cingulid cannot be seen. The wide hypoconulid covers the posterior surface of the crown which is much pointed and very distinct compared to the same cusp in the Batu Caves collection. No roots are preserved.

M_3: BDC 1-23U (dex.)

Triangular in outline shape with much narrower at the posterior end. The wear at the occlusal surface (w3) leads to the appearance of the main cusps to be of the same height. The first anterior lobe (protoconid and metaconid) has relatively similar size to the second lobe (hypoconid and endoconid). The median accessory cusp is present in the center between the two lobes. The hypoconulid is present but not well developed like in M_2. The third lobe (talonid) is simple and not divided and is represented by the posterior accessory cusp. Contact facets are present at the anterior end. Remnant roots are preserved at the base of the crown.

E. *Sus* sp.

This group of fossils includes some isolated teeth from both sites (Batu Caves and Lenggong Valley) which cannot be identified specifically either because there are too broken or because they have mixed characters cannot be used for specific identification.

Upper incisor

$I^{2:}$ BDC EX18 (sin.)

This is a complete specimen, worn with a long open root. The tooth seems to be curved along the longitudinal axis from the apex of the crown downward to the root. A continuous ridge runs along the anterio-buccal edge. The height of the enamel on the anterior surface is equal to one-fourth (1/4) of the total height of the tooth with the root. The enamel at the anterior surface extends upward to cover the posterio- buccal edge.

Upper premolars

P^1: BDC 5-15 (dex.)

This is a small incomplete tooth broken at the anterior part. A small but clear contact facet at the posterior end provides the indication for the correct position. The posterior part of the apex (paracone) is connected distally to worn thin ridge. One incomplete root is preserved.

P^4: BDC 4-8 (dex.)

This is a broken tooth. Only the external part of the tooth is in good condition. The identification depended on the outline shape which is relatively square. No inner characters can be distinguish. No roots are preserved.

Upper molars

$M^{2:}$ BDC 5-25 (?)

This is a broken tooth. The posterior part is absent. Its anterior part, anterior cingulum, median valley and anterior contact facet are all well preserved. Two anterior broken roots are present. The enamel has moderate wear (w2).

$M^{3:}$ BDC 4-10 (sin.)

The anterior part with the first lobe (paracone and protocone) is broken. The second lobe (metacone and hypocone) is very distinct and well preserved. A compressed and simple talon confirms its identification as the last upper molar. Median accessory cusps are preserved.

Lower canine

CC EX12 (?)

A small thin fragment of a canine is preserved. It is triangular in cross section. The posterior side has no enamel and its longitudinal groove is similar in size to smooth labial and lingual sides with no recognizable ridges in both of them. It could possibly be from a small-sized female.

Lower premolars

P_3: NC 1-8 (dex.)

Only half the tooth is preserved. Its anterior part is missing. The crown is less wide than that in P_4. A worn longitudinal ridge on the occlusal side connects the preserved posterior part. A contact facet is seen at the top of the posterior end. One root is preserved.

P_4: BDC EX4 (sin.)

One isolated half tooth is preserved. The anterior part is absent while the posterior part has a contact facet on the lingual side and thus must have been placed obliquely in the mandible. The width is greatest along the base of the crown. Part of ridge that connects the lingual and buccal sides is preserved with signs of slight wear (w2) at the occlusal side. One root is preserved.

Lower molars

$M_{2:}$ BDC 4-13 (dex.)

The crown nearly rectangular and not worn on the occlusal side. The morphology is very similar with M_1 and M_2 *Sus scrofa* but much longer and wider. The anterior lobe (protoconid and metaconid) is larger than the posterior lobe (hypoconid and entoconid) and is separated by a median accessory cusp.

The hypoconulid is not distinct and broken at the posterior end. A small pillar is present at the buccal side of the median valley. The anterior cingulid is represented by a weak ridge that runs from the antero –buccal protoconid to the antero-lingual metaconid. Contact facets are present at the anterior base of the crown. No roots are preserved.

3.6.1.4 Broken teeth of Pig

Another group of isolated broken teeth that are hard to described are those that were severely broken up during their extraction because they were very fragile and friable due to the climate conditions inside the caves or because they were embedded in very hard strongly cemented sediments. The last reason was more prevalent in Badak Cave C but the fragments recovered were still sufficient to identify them as *Sus* sp.

BDC 4-2 (2nd upper molar): half tooth with broken lingual or buccal side.

BDC EX5 (1st lower molar): two lobes, the posterior lobe is not complete and a contact facet is preserved at the anterior side. It is relatively worn (w2). Two remnant roots are present.

BDC 1-9L (3rd, lower molar): incomplete, much damaged tooth with wear (w1).

BDC 1-12U (3rd lower molar): only posterior part (talonid) is well preserved with much wear (w3).

BDC 4-17 (3rd lower molar): with broken anterior part, talonid is preserved, much wear (w3)

BDC 1-32Ua (molar, lower? upper?): with flat enamel surface (w1) and is much damaged at occlusal surface.

BDC 3-5 fragment of lower incisor

NC 2-2: only one side of the enamel crown is preserved (lingual? buccal?)

3.6.1.5 Present distribution of Bearded Pig

As compared to the more common and widespread Eurasian Wild Pig (*Sus* scrofa), Bearded Pig is truly an indigenous species of the Sundaland biogeographical region of Southeast Asia (Francis, 2008).

The present distribution of the Bearded Pig extends from Peninsular Malaysia, Sumatra, Bangka, and Borneo. According to the IUCN/SSC (2006) (International Union for Conservation of Nature and Species Survival Commission) and like many other threatened species, data on the actual distribution range of the species in Peninsular Malaysia is limited. Bearded pig were found only in the North central and southern Peninsular Malaysia. These areas refer to south of Taman Negara National Park and the southern state of Johor (Kawanishi *et al*., 2006).

Bearded Pig *Sus barbatus* Müller, was originally described from Borneo and later discovered in Sumatra now to be plentiful in north-eastern parts of the country. It has been recorded from several islands in the Rhio Archipelago and described by Miller under the name *Sus oi*. There is a difficulty to distinguish between *Sus barbatus* of Borneo and *Sus oi* of Sumatra and Rhio Archipelago by the dental characters. Robinson and Moulton (1922) listed some differentiation by the morphological characters of skulls with notation that this alleged characters can be explained by the varying age of the specimens examined. Therefore they agree to retain *Sus barbatus* name to cover the Bearded Pig of Borneo, Sumatra, the Rhio Archipelago, and Pahang.

Palaeontological evidence, however, seems to suggest that it was fairly abundant and widespread in the mainland Southeast Asia.

Fossil remains of *Sus* identified as belonging to *barbatus* have been found from areas outside its current distribution range, as far north as Thailand (Tougard, 1998) and Vietnam (Bacon *et al*., 2008b), as south as Java (Badoux, 1959; de Vos & Long, 1993) and as west as Sumatra (de Vos, 1983).

In Peninsular Malaysia, the archeological evidence Showed that the Bearded Pig was fairly plentiful and widespread in about 1500 to 2000 years ago (Gibson-Hill,1950) while Meijaard (2004a) suggested a wider distribution in former times for the populations.

The first record of Bearded Pig in Peninsular Malaysia was in 1918 at Pekan in the state of Pahang on the east coast of the peninsula some 257.4 km directly north of Singapore, later on the skull was identified as that indistinguishable from the *Sus barbatus* of Borneo the home of true *Sus barbatus* or of the Riau Archipelago. The second record was from the east coast at the Kota Tinggi district of Johor near the southern tip of the peninsula. At best the differences between the Bornean and Sumatran species are slight and by only few records of shooting animals, it was suggested that small numbers might occasionally be finding their way across the water from Borneo or Sumatra. Kempe (1946) leave the impression that there may still be some doubt about the animal’s status in the peninsula.

So what actually is the status of this pig in Peninsular Malaysia? Are they truly native or merely recent migrants from nearby areas?

The answer for these questions came after a series excavations were carried out in deposits in the limestone caves where remains of the species had been noted in archaeological sites in Peninsular Malaysia (Collings, 1937; Tweedie, 1940; Kempe, 1946; Groves, 1985; Medway, 1969).

The occurrence of *Sus barbatus* bones among other mammalian remains in Neolithic cave deposits like Gua Madu in Kelantan (west of Peninsula) and in Bukit Chuping in Perlis (north of Peninsula) and in other places (Figure 3.22) prove that the Bearded Pig is truly indigenous in the Malaya Peninsula.

So the known facts are that the Bearded Pig did inhabit the Peninsular Malaysia. It’s not clear why this species become constricted distribution in range as compared with its estimated range in prehistoric times with habits do not seem different from those in Sumatra and in the islands of the Riau Archipelago? Many researchers answer this question by different views.

Figure 3.22 Map showing recent and the prehistoric records of Bearded Pig in Peninsular Malaysia.

Gibson-Hill (1950) conclude that the Bearded Pig in generally prefer a rather damper and less covered terrain than the Wild Pig. This would certainly seem to be true in Borneo. While the peninsula covered by the thick jungle clothed almost the whole of the interior parts until recently, when some areas opened up for the plantation of rubber. During the intermediate period, there must have been wide areas of open damp country. He thinks that the Bearded Pig which had found its way into southern Malaya from Sumatra plentifully and suggested that the specimens recorded at various times from Pekan and Kota Tinggi probably represent small and irregular eruptions comparable to the movements that have been recorded from Borneo arising from a pocket surviving area southern Pahang. While (Kempe, 1946) suggested that the pig arrived on the islands of Pula Tinggi (Johor) are from the nearest islands to the southern tip of Johor are those of the Riau Archipelago some ten miles to the southward. There is no recent information on the status of these animals in the northern end of the Sumatra. Recent information on their status on Bangka Island and in the Riau Archipelago (Bintang Island), where they are known to have occurred (Groves, 1981).

According to the hunters' reports, there is a seasonal pattern of pig movements which follows the monsoons and related to the seasonal variations in food available. It is commonly believed amongst the hunters that the pigs respond to the cooler and wetter months by moving down from higher altitudes and out from the deeper forest into the lowlands (Diong, 1973).

On the other hand, Caldecott *et al*. (1993) explained the annual movements of Bearded Pig populations in Malaya which appear to have been associated with the regular fruiting of camphor wood forests, where several thousands of square kilometers of this forest have been virtually destroyed and long-distance movement by forest-dwelling mammals is no longer possible in many areas.

Pfeffer and Caldecott (1986) attributed the migration of Bearded Pig to the widespread disturbance of the habitats (logging, forest fire, human agency, and shifting cultivation) lead to resettlement and transmigration schemes. Human hunting of Bearded Pigs was undertaken since before the Palaeolithic (Medway, 1977d). All these factors have excluded large wild animal's population from many areas by change the forest and destroy the key feeding. Davison (1994) suggested that the prehistoric limit of the species west of the Main Range was never any further north than it was in recently time given that no remains of it have been noted among the animal material from Gua Gunung Runtuh (Lenggong Valley). However, he may have over look to the species further north (Bukit Chuping in Perlis).

Through previous recordings and the conclusions derived from there, which interpreted the presence of Bearded Pig in both eastern and western coastal plains, as well as south of the peninsula can be explained by its presence from the nearest islands vicinity of it across the water and outside the boundaries of Peninsular Malaysia (i.e., Pahang specimen east coast of the peninsula identified as *Sus barbatus* from Borneo, Johor specimen southern tip of the peninsula are from those of the Riau Archipelago directly south of the Peninsular Malaysia, and according to Gibson-Hill (1950) the specimen from Perak west coast of Peninsular Malaysia matches with an old boar killed in Sumatra). The western Peninsular Malaysia populations (exterminated recently) roamed within only about 80 km from Batu Caves area (Kempe, 1946; Hislop, 1952). The characteristic nomadic habit of the species, as recorded by Hislop (1949) in Peninsular Malaysia, and by Caldecott (1988) in Sarawak, renders highly reasonable a range extension to this part of Peninsular Malaysia in former times.

If we are acceptable all these examples and if the *barbatus* identification of our molars samples is validated with new specimens, it may indicate a former continuous distribution for the species on the western coast of Peninsular Malaysia, which mean that the Bearded

Pig discovered so far from Batu Caves (central part of West Peninsular Malaysia) may derived from the nearest outside land like Sumatra island (Lida Ajer Cave and Sibrambang Cave placed between 60 - 80 ka almost like Batu Caves age) contains *Sus barbatus* (de Vos, 1983). In relation to this it should also be mentioned that *barbatus* is absent from northern Sumatra and the Sumatran population was restricted to the southern part and did not reinvade the northern parts after the last glacial maximum (LGM; 20.000 years ago) (Meijaard, 2004a) and therefore the current disjunct distribution may be a recent development with high significant in extending the historical range of the species.

3.6.1.6 Remarks

The remains of pig are more abundant than those of any other mammals in the sites examined. In Malaya, there are two species of wild pigs, the Eurasian Wild Pig *Sus scrofa* and the Bearded Pig *Sus barbatus.* Records of these species show some of the morphological differences, namely the great length of the skull of a Bearded Pig compared with that of a Eurasian Wild Pig.

Based on this fact, the two species (*Sus scrofa* and *Sus barbatus*) are different and separable mainly according to their size of teeth. It is hard to establish differentiation points to distinguish between them except for differences in the measured dimensions between the adult cheek teeth especially the molars (Table 3.18).

This is not entirely satisfactory as the difference in size between the two sets of teeth may be the result of sexual dimorphism (male larger than the female) or although this difference is due to the presence of two distinct species or as they elongate during the pig's life. Others such as Raia and Meiri (2006) had suggested body sizes on islands evolve according to the prevailing ecological conditions related to the presence or absence of competitors and predators.

Therefore, it is hard to maintain that the measurements alone could be sufficient for reliable comparison. The examination of morphological characters of each tooth for the different dental ranks besides the measurements of the tooth size might support the observations related to each species.

The M_3 was specifically chosen to distinguish between the two species for a few reasons:

- Among the three permanent molars of *Sus* dentition, the M_3 is the largest and most complex and exhibits more variability in its morphology – especially when examining the structure of the posterior lobe (talonid).
- The M_3 is the final permanent tooth to erupt and, therefore, retains its morphological integrity for longer; since it suffers less from inter-proximal and occlusal abrasion than other permanent molars.

Therefore, the dimensions of this molar are used in order to determine the fossil species especially the adult *Sus barbatus* which shows a marked increase in size compared to the adult lower molars of *Sus scrofa.* The maximum length of the M_3 of *Sus barbatus* is generally equal or above 40.0 mm and those less than 40.0 mm belongs to *S. scrofa.*

Table (3.19) show that although there is extensive overlap in the mesiodistal length and the labiolingual width dimensions of the third lower molar specimens of both *Sus scrofa* and *S. barbatus* teeth those belonging to *S. barbatus* are consistently longer than the dimensions for the *S. scrofa* teeth.

Table 3.19 Comparative measurements of the third lower molars of *Sus scrofa* and *Sus barbatus* in modern and prehistoric samples.

	N	**L**	**W**
Sus scrofa			
Modern			
Malaya and Sumatra[1]	6	33.3 - 37.4	-
Mainland of Malay Peninsula & Sumatra[2,3]	8	29.0 - 40.0	16.0 - 19.0
Prehistoric			
Sumatran Caves[4]	157	27.2 - 47.0	14.1 - 20.0
Lang Trang Caves (Vietnam)[4]	42	35.8 - 47.7	11.4 - 19.7
Duoi U'Oi Cave (Vietnam)[5]	18	30.6 - 46.8	16.4 - 20.3
In this study	4	30.7 - 35.0	13.4 - 16.7
Sus barbatus			
Modern			
Pekan (Pahang), Malaya Peninsula[6]	2	44.0 - 46.0	17.0 - 19.0
Indragiri River, Sumatra[6]	2	33.8 - 38.9	17.7 - 18.4
Rhio Archipelago[6]	1	41.0	18.0
Sarawak, Borneo[6]	10	37.0 - 48.0	17.0 - 20.0
Bornean Bearded Pig[2,3]	40	33.0 - 48.0	19.8 - 21.8
Specimens in Sabah Museum[7]	15	32.2 - 42.0	15.6 - 20.2
Prehistoric			
Punung (Java)[8]	10	29.5 - 35.7	14.5 - 17.5
West mouth, Niah Cave[2,3]	31	33.0 - 44.4	14.3 - 19.6
Duoi U'Oi Cave (Vietnam)[5]	2	39.7 - 40.3	17.3 - 18.5
In this study	3	40.0 - 45.1	16.9 - 17.7

N= number of sample; L= mesio-distal length; W= bucco-lingual width.
All measurements in mm after:
[1] Medway (1973)
[2] Cranbrook (1979)
[3] Medway (1977d)
[4] De Vos & Long (1993)
[5] Bacon *et al*. (2008b)
[6] Robinson & Moulton (1922)
[7] Measurements sending by Lim, 2011 (unpublished data)
[8] Badoux (1959), measurements published in de Vos & Long (1993)

A few morphological characters I found that can be useful to distinguish between the two adult species by comparing these characters in the dentition of the modern skulls in the collection of the Zoological Museum in the University of Malaya (eighteen specimens of *Sus scrofa* and four specimens of *Sus barbatus* from Sarawak and Johor) and fifteen specimens of *Sus barbatus* from collection in the Sabah Museum* (totaling eighteen specimens of *Sus scrofa* and nineteen specimens of *Sus barbatus*), are:

1- The talonid cusp (posterior lobe) on adult M_3 in "*Sus barbatus"* is more complicated and divisible into three or more posterior accessory cusps with distinct hypoconulid, while in *Sus scrofa* it is relatively more simple and less developed with single or double cusps (not more than three) with a hypoconulid between them. Seventeen specimens (five of *S. scrofa* and twelve of *S. barbatus*) fits this hypothesis, seven specimens (one of *S. scrofa* and six of *S. barbatus*) do not fit while the remaining (twelve of *S. scrofa* and one of *S. barbatus*) were either not erupted or missing.

2- In the lower jaw, a small depression runs buccaly from the apex of the cusp to the base of the crown especially in the P_3 and $P_{4.}$ This character is clearer in *Sus scrofa* while the buccaly lower premolars of Sus *barbatus* are relatively flat. Twenty-five specimens (eighteen of *S. scrofa* and seven of *S. barbatus*) shows this character and twelve specimens (of *S. barbatus*) do not.

3- The lower canine of adult males have two ridges in both the buccal and lingual sides in *Sus barbatus* that are more pronounced on the buccal side in most cases, while the lower canine of *Sus scrofa* is without ridges or only on the lingual side in most cases.

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*LIM Tze Tshen kindly checked this collection.

Nineteen specimens (fourteen of *S. scrofa* and five of *S. barbatus*) support this observation, eight specimens (two of *S. scrofa* and six of *S. barbatus*) do not, while the others (two of *S. scrofa* and eight of *S. barbatus*) are either from females or are absent.

4- Several researchers (Hooijer, 1954a; Groves, 1981; de Vos & Long, 1993) have used the character of the scrofic-type for the lower canine (males) with the triangular section to distinguish between the suidae species.

Hooijer (1954a) defined the scrofic-type: when the labial side is narrower than the posterior side as in *Sus scrofa* and *S. salvanius* which means that the section is "*scrofic*" the other type of canine is "v*errucosic.* Based on this character, de Vos and Long (1993) identified the fossils of Lang Trang Caves (Vietnam) as belonging to *Sus scrofa* and he noted the difficulties in distinguishing between the species of Sumatran pig materials by using the other dental elements. Similarly, Groves (1981) noted in the cross section of the lower canine of adult males in *Sus scrofa* and *S. salvanius* that the inferior surface is narrower than in *S. verrucosus* and *S. barbatus* with the width of the inferior surface less than the width of the posterior side. In the seventeen specimens of *S. scrofa* examined, six specimens are scrofic and those that are not are juveniles so this hypothesis could only be applied to adult males.

Lucchini *et al*. (2005) used the lower canine ratio of breadth of labial surface to breadth of distal face to distinguish the species. It is generally < 100% in the *Sus scrofa* group and usually 120 - 150% of the posterior surface in the *Sus barbatus* group for the inferior surface in males. Table (3.20) shows the values of the lower canine ratio for both *Sus scrofa* and *Sus barbatus* from the different collections compared with the lower canine ratio for the specimens identified as *Sus* cf. *barbatus* collected in this study. The table shows that the present collection has a mean value ratio above the mean for *Sus scrofa* and below the mean for *S. barbatus* and is therefore assigned to *Sus* cf. *barbatus*.

Table 3.20 Comparative values of the permanents of lower canine ratio for *Sus scrofa*, *Sus barbatus*, and *Sus* cf. *barbatus*.

	N	**Range**	**Mean**
Sus scrofa[1]	3	89.0% - 101.0%	93.0%
Sus barbatus[1]	4	140.0% - 200.0%	160.0%
Sus barbatus[2]	10	120.8% - 204.5%	150.6%
Sus cf. *barbatus*[3]	5	110.0% - 160.0%	140.0%

N=number of samples.
[1] Specimens in Zoological Museum in the University of Malaya.
[2] Specimens in Sabah Museum; Measurements by Lim, 2011 (unpublished data)
[3] Specimens in present study.

These characteristic features mentioned above show some different trends that might be useful for taxonomical purposes since there is no single reliable character useful to distinguish between *S. scrofa* and *S. barbatus*.

According to Badoux (1959) Punung (Java) has probabily three species of *Sus*: *Sus vittatus*, *S. barbatus*, and probably *S. verrucosus*, based not on canines but on small characters that are highly variable and not very diagnostic at species level.

In Niah Cave, the specimens attributed to *Sus barbatus*, canines are not present among them (Medway, 1977d). He did not observe any specific feature that could distinguish *Sus barbatus* from *Sus scrofa* in samples from Borneo and specimens from Peninsular Malaysia and Sumatra except for differences in the dimensions of several teeth (the third molars of both jaws) which show the greatest range in individual variation. Tougard (1998) gave a few differentiation characters besides the average size to distinguish the Suidae of Thailand.

Bacon *et al*. (2008b) did not notice any difference in size between *Sus scrofa* and *Sus barbatus*, and ridulated enamel is the only feature that distinguished the pig samples from Duoi U'Oi Cave (Vietnam).

In conclusion, I think I am justified in referring most of the isolated teeth collected in the present study to *Sus scrofa,* three lower molars to *Sus barbatus,* and the remaining specimens to *Sus* cf. *barbatus* and *Sus* sp.

Since the two sites studied belong the different ages (the Lenggong Valley fauna is older than the Batu Caves fauna) some differences between the pig materials collected from the two sites will be discussed:

- The isolated teeth collected *ex situ* found on surface sediments with the same matrix near to Cluster 4 in Badak Cave C could probably belong to the same individual on the basis of their similar state of preservation. It could have died in the cave or might have been dragged in there by a predator or by other transportation factors (Figure 3.23).

- The upper 3rd molar of *Sus scrofa* collected from Badak Cave C (Lenggong Valley) have distinct buccal cusps along the talon that appear like a series of not well-developed basal accessory cusps which it is not clear on the upper molars from Batu Caves sites . At the same time the buccal cusps do not correspond to the lingual cusps arrangement and often forms two cusps behind one another.

- All the isolated teeth identified as *Sus barbatus* or *Sus* cf. *barbatus* were collected from the Batu Caves site. No canine was recovered from the Lenggong Valley caves and no incisor from Batu Caves site.

Figure 3.23 Four isolated *ex situ* teeth from Badak Cave C (Lenggong Valley) identified as 3rd and 4th upper premolars of *Sus scrofa* perhaps from one individual showing similar degree of wear and morphological structures between left and right sides.

3.6.2 Family Cervidae Goldfuss, 1820

This family has wide and diverse geographical distribution (northern South America, throughout North America, Europe, northwest Africa and Asia) (Nowak, 1991), but today many of its species are threatened with extinction throughout its range, including Southeast Asia. The deer has special characteristics among the other mammals: presence of antlers in males (with few exceptions) which differs from the true horns of Bovidae composed of bone **(**Lekagul & McNeely, 1977). Deers have enlarged upper canines which are curved strongly outward, tusk-like in males and small in females. The incisors are relatively differentiated in size, and it has distinct low-crowned cheek teeth with sharp crescent shaped cusps. This family includes four living subfamilies (Lekagul & McNeely, 1977):

- Moschinae (the Asian Musk Deer)
- Muntiacinae (the Asian Barking Deer)
- Cervinae (Asian, European, and North American typical Deer)
- Odocoileinae (North and South America, European, with no representative in Southeast Asia) (Nowak, 1991).

Two sets of teeth relating to this family were found among the fossil remains from Batu Caves and Lenggong Valley, the first set is characterized by small and simple dental enamel typical of Muntiacinae while the second set can be grouped roughly as the same type but of different sizes and has more complex dental enamel typical for Cervinae.

3.6.2.1 Subfamily Muntiacinae Pocock, 1923, Plate 6

This deer is more widely distributed in Asia. The subfamily Muntiacinae includes two living genera confined to southern Asia with one genus *Elaphodus* found only in China and Myanmar. The species and their distributions are as below:

- *Muntiacus muntjak* Zimmermann, 1780, from India to China and South to Peninsular Malaysia, Sumatra, Java and Borneo.
- *Muntiacus reevesi* Ogilby, 1839, south China and Taiwan.
- *Muntiacus crinifrons* Sclater, 1885, southeast China.
- *Muntiacus feae* Thomas & Doria, 1889**,** west of Thailand, eastern Myanmar, and south-westernYunnan.
- *Muntiacus gongshanensis* Ma, 1990**,** west of Yunnan and to the east of Tibet.
- *Muntiacus atherodes* Groves & Grubb, 1982, Borneo.
- *Megamuntiacus vuquangensis* Tuoc *et al*., 1994, Laos.

- *Elaphodus cephalophus* Milne-Edwards, 1872**,** south of China and eastern Tibet and adjacent areas of Myanmar.

Several new species have been discovered recently including the Giant Muntjac (*Muntiacus vuquangensis*) which is relatively closer to *Muntiacus reevesi* than to other muntjacs (Wang & Lan 2000). Muntjac-like Deer (*Cervocerus*) first appeared in the Late Miocene fauna of China (Geist 1998).

Previous studies had placed *M. crinifrons* at the base of the phylogenetic tree.

This contrasted with the phylogenetic study of four species of mainland Asian muntjac where it was found that *M. muntjak* (the most widely spread species) was sister-species to the three others, *M. gongshanensis*, *M. crinifrons*, and *M. reeves* (Lan *et al.,* 1995). The divergence between *M. muntjak* and the other muntjacs might have occurred at approximately 2.7 Mya. The origin of *Muntiacus* is more likely to be in the Late Miocene (Wang & Xu 1986).

The Red Muntjac (Figure 3.24), *Muntiacus muntjak* is a small deer with short antlers and the most widely distributed at present but also the most frequently encountered in the Quaternary fossil sites in Southeast Asia in Vietnam (Ciochon & Olsen, 1990), Sumatra (de Vos, 1983), Java (von Koenigswald, 1939, de Vos,1983), and Borneo (Harrison,1996).

Figure 3.24 *Muntiacus muntjak*
Source: brucekekule.com

The species *Muntiacus muntjak*, is subdivided into several subspecies as: *Muntiacus muntjak muntjak* in Java, *Muntiacus muntjak grandicornis* in Myanmar, *Muntiacus muntjak curvostylis* in Thailand, *Muntiacus muntjak vaginalis* in the north India, *Muntiacus muntjak reevesi, Muntiacus muntjak feae,* and *Muntiacus muntjak crinifrons* in China (de Vos & Long,1993) and *Muntiacus muntjak margare* in Yenchingkou, southern China, (Colbert & Hooijer, 1953). The subspecific identifications of the Cervidae are mainly based on the form of the antlers and the color of the fur. Since the samples collected from all sites contains only teeth and no antlers, it is impossible to give a subspecific distinction of the materials. The premolars and molars in each jaw in this section are not differentiated enough to be used for specific identification.

The dimensions of the isolated *Muntiacus muntjak* teeth collected in this study show in (Table 3. 21).

3.6.2.1.1Teeth description (Figure 3.25)

A. *Muntiacus muntjak* in Batu Caves

Upper molars

M^1: SC EX1 (sin.), Plate 6 (A2)

M^2: CC 4-4 (dex.), VC 4-6 (dex.)

M^3: VC 4-26 (sin.), Plate 6 (A5)

There are no major morphological differences between the M^1, M^2, and M^3. All the upper molars have very similar measurements with M^2 being slightly larger than the others. Subrectangular in shape. They are worn at the occlusal side.

Table 3.21 Dimensions of the upper and lower teeth attributed to *Muntiacus muntjak* in this study.

Tooth type	**No.**	**L**	**W**
P^3 (sin.)	BDC 5-21	8.8	9.3
P^3 (sin.)	NC 1-2	9.1	10.7
M^1 (sin.)	SC EX1	11.7	13.3
M^1 (sin.)	BDC 4-21	10.0	12.2
M^1 (sin.)	BDC 5-14	11.7	13.3
M^2 (dex.)	CC 4-4	13.8	12.8
M^2 (dex.)	VC 4-6	10.6	14.8
M^2 (dex.)	BDC 5-6	13.5	15.0
M^3 (sin.)	VC 4-26	11.7	11.8
M^3 (sin.)	BDC 2-2	12.3	13.7
M^3 (dex.)	BDC 2-3	14.0	12.6
I_3 (sin.)	BDC 5-9	4.8	4.0
M_3 (dex.)	CC 3-3	20.0	10.2
M_3 (sin.)	CC EX7	20.6	8.5

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

Four main cusps are well preserved. The subtriangular anterior lobe contains a paracone buccaly and protocone lingually. It is lower and narrower than the posterior lobe which contains a semi-rectangular metacone buccally and hypocone lingually and both have a U shape fossa. The protocone and hypocone are oblique and rounded in occlusal view while the paracone and metacone look sharp. In M^1 and $M^{2:}$ parastyle, mesostyle, and metastyle are all preserved with well developed mesostyle and paracone pillar while in M^3 the metastyle is not developed and the second lobe is more oblique towards the anterior lingual direction. No interlobe column was observed. Contact facets are present on the anterior side of VC 4-26.

Three roots are preserved with one at the anterior buccal side and two fused at the lingual side in SC EX1 and VC 4-6 while more fragmented open roots are found in CC 4-4.

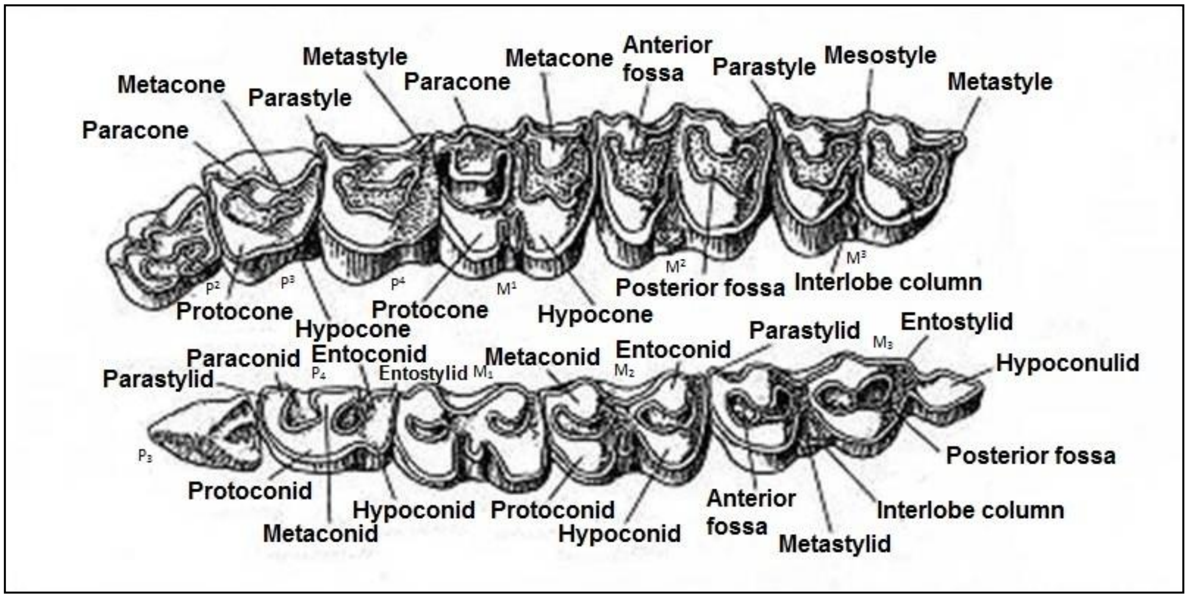

Figure 3.25 Nomenclature to describe cheek teeth structures of Cervidae and Bovidae modified from de Blainville (1839 – 1864).

Lower molars

M_3: CC 3-3 (dex.), Plate 6 (A8), CC EX7 (sin.), Plate 6 (A9)

Three lobes are well preserved in both samples. Two sharp minor interlobe columns are present immediately above the lower margin of the buccal cusps in CC 3-3. The first column between the protoconid and hypoconid is higher and less pointed than the second column between the hypoconid and hypoconulid. Only the first is present in CC EX7 and it is not much developed. The parastylid is very salient among other stylids in both specimens with two sharp unworn cusps as the metaconid and entoconid. Vertical ridges run lingualy except at the posterior side which looks less developed and is flatter.

CC 3-3 is less worn and younger than CC EX7. Contact facets are present on the anterior side for both samples. Remnants of the posterior roots are preserved in CC EX7.

B. *Muntiacus muntjak* in Lenggong Valley

Upper premolars

P^3: BDC 5-21 (sin.), NC 1-2 (sin.), Plate 6 (A1)

The upper premolar presented the same characters except for some difference in shape and size.

The crown are semi- triangular outline, relatively worn and slightly broken at the occlusal surface in NC 1-2 and more worn in BDC 5-21. The lingual side is swollen and has a shallow groove separating the protocone from the hypocone. It is very marked on P^3. The metastyle is well- developed among the other styles. Buccal styles with vertical ridges converge at the base of the crown. The central fossa is crescent shaped. Three roots, two from the buccal side and one from the lingual side are preserved in BDC 5-21. A contact facet is present on the anterior side on BDC 5-21.

Upper molars

M^1: BDC 4-21 (sin.), BDC 5-14 (sin.), Plate 6 (A3)

M^2: BDC 5-6 (dex.), Plate 6 (A4)

M^3: BDC 2-2 (sin.), BDC 2-3 (dex.), Plate 6 (A6)

The width is greater than the length for all specimens except BDC 2-3 where M^2 have the largest width among the others. The specimens show different degrees of wear in which it is much worn in BDC 5-6 and BDC 2-3 than the others.

The anterior lobe with paracone and protocone appears more oblique lingually than the posterior lobe with metacone and hypocone. This lobe is damaged in BDC 4-21 and more pointed in BDC 2-3. The parastyle and mesostyle are well developed. The pillar of the paracone is more marked than that of the metacone in M^1 while both present in M^3 and absent in M^2. Central fossae are U-shaped and surrounded by internal folds. The lingual cusps have a rounded cross-section while the buccal cusps are sharp and pointed. Two fused roots are preserved lingually and buccaly in BDC 5-6 with small contact facet at the tip of the anterior side.

Lower incisor

I_3: BDC 5-9 (sin.), Plate 6 (A7)

The incisor teeth are different in size with the lateral three incisors being smaller and narrower than the median incisor tooth on the same side as observed from the reference specimens. The mesial edge is more or less straight with traces of contact facets while the distal edge is more rounded with relatively pointed and worn cutting edges. It has a flattened buccal surface. The lingual surface is more declined towards the base of the crown which contains two mesial- distal elongated grooves running along both edges. The tooth has a unique root. It is difficult to allocate such material to a particular species because the lower incisors of deer's have approximately the same dental pattern.

3.6.2.1.2 Remarks

Most taxonomy of the Cervidae is based on characteristic features of the antlers. Since the antlers are not preserved in the collections this makes their identification rather difficult, especially from just isolated fossil teeth.

I was able to compare the fossil materials recovered in this study with the recent and fossil specimens in the collections in the museums and institutes (Table 3.22).

The following observations were made:

1) A shallow groove that separates the protocone from the hypocone is very marked on the upper premolars P^2 and P^3 for *Muntiacus muntjak* while there is no groove in *Muntiacus reevesi* and *Muntiacus feae* (Tougard, 1998).

2) The posterior lobe of the upper molars is higher and somewhat wider than the anterior lobe which it is more oblique lingually which give some indication for chewing and this point can be readily used to distinguish the correct orientation for the isolated upper molar teeth.

3) There are no major morphological differences between the upper molars from both sites at Batu Caves and Lenggong Valley. They are differentiated only by their size with M^2 slightly larger in size compared to the others. It was noted that the upper third molars from Lenggong Valley, BDC 2-2 and BDC 2-3 are much bigger in size than VC 4-26 from Batu Caves and larger than all the recent specimens from reference collections (Table 3.22).

4) The third lower molars collected only from Batu Caves (Cistern Cave)

CC 3-3 and CC EX7 are similar to specimens in the National Museum of Natural History (Leiden) of *Muntiacus muntjak* specimens from Padang Highland caves (Sumatra) in terms of their general morphological features (both have minor buccal interlobe columns) and by their larger dimensions of length identical with the upper limit of length variation of the Lang Trang materials (de Vos & Long, 1993). They have an overlap area with the upper limit length dimensions of *Muntiacus* fossils from Padang Caves (Sumatra) as shown in table (3.22).

5) The incisor teeth are different in size with the three lateral incisors being smaller and narrower than the median incisor tooth on the same side. The third lower incisor from Badak Cave C matches those from the Sibrambang Cave, Padang Highland Caves (Sumatra) based on its dimensions and morphological features.

Table 3.22 Comparative measurements of well-preserved *Muntiacus muntjak* teeth in this study with other modern and prehistoric material.

	P^3	**M^1**	**M^2**	**M^3**	**I_3**	**M_3**
Modern						
Zoological Museum (University of Malaya)						
N	1	2	2	1		1
L	8.7	10.8 - 12.1	11.4 - 13.2	12.2		15.4
W	11.4	10.5 - 11.5	10.7 - 12.7	11.7		8.1
Institute of Biodiversity,Wildlife & National Parks Department (Malaysia)[1]						
N	1	2	2	1		1
L	8.6	10.2 - 13.0	11.7 - 14.7	12.3		17.9
W	11.6	10.4 - 12.1	9.3 - 14.2	12.8		9.2
Museum of National Zoo (Malaysia)[1]						
N	3	3	3	3		3
L	8.0 - 9.5	10.6 - 11.5	11.4 - 14.1	12.0 - 13.8		15.5-19.1
W	9.9 - 11.6	10.8 - 13.5	11.1 - 13.6	11.6 - 12.8		7.9 -9.2
Prehistoric						
National Museum of Natural History (Leiden) Padang Highland Caves (Sumatra)						
N		24	16	9		107
L		7.6 -15.2 $dP^4/M^1/M^2/M^3$*	9.9 - 14.8	11.2 - 13.4		13.6 -21.1
W		9.4 - 18.4 $dP^4/M^1/M^2/M^3$*	11.0 - 16.0	10.8 - 14.3		7.0 - 9.8
Padang Highland Caves (Sumatra)[2]						
N						110
L						10.5 -27.2
W						7.3-19.0
Sibrambang Cave(Sumatra)[2]						
N					2	31
L					5.0 - 5.3	15.2-19.5
W					3.8 - 5.0	7.7-10.3

Table 3.22, continued

	P^3	M^1	M^2	M^3	I_3	M_3
Punung (Java)[3]						
N		5	12	7		9
L		10.0 - 11.0	10.5 - 12.7	10.0 - 15.0		16.1 -19.4
W		13.0 - 13.5	13.5 - 15.1	12.0 - 15.5		8.5-10.0
Wajak Cave (Java)[4]						
N	1	6		2		1
L	9.0	9.2-13.6 M^1/M^2*		10.8 - 11.5		15.2
W	10.3	12.0-14.9 M^1/M^2*		12.9 - 14.1		8.6
Lang Trang Caves (Vietnam)[2]						
N						22
L						16.2-20.4
W						7.7 -10.9
Duoi U'Oi Cave (Vietnam)[5]						
N	7	30				12
L	7.0 - 10.0	9.2-13.7$M^1/M^2/M^3$*				14.1-18.8
W	10.0 - 13.0	10.5-16.0 $M^1/M^2/M^3$*				7.3- 9.6
Phnom Loang (Cambodia)[6]						
N						1
L						16.0
W						8.0
Thum Wiman Nakin (Thailand) [7]						
N	10	1	7	11		3
L	8.0 - 9.4	13.0	9.9 - 15.2	10.5 - 17.1		17.2˜
W	10.5 - 12.0	13.3	12.0 - 16.1	10.6 - 16.5		8.9 -12.1
In this study						
Batu Caves^						
N		1	2	1		2
L		11.7	10.6 - 13.8	11.7		20.0-20.6
W		13.3	12.8 - 14.8	11.8		8.5-10.2
Lenggong Valley^						
N	2	2	1	2	1	
L	8.8 - 9.1	10.0 - 11.7	13.5	12.3 - 14.0	4.8	
W	9.3 - 10.7	12.2 - 13.3	15.0	12.6 - 13.7	4.0	

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

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

[2] De Vos & Long (1993); the materials from Lang Trang cave were identified as *Muntiacus* sp. and from Sibrambang Cave as *Muntiacus muntjak*.
[3] Badoux (1959)
[4] Brink (1982)
[5] Bacon *et al*. (2008b)
[6] Beden & Guérin (1973); the materials from Phnom Loang identified as *Muntiacus* sp.
[7] Tougard (1998)
* The measurements are for the unclassified group
˜ Only one measured for length
^Refer to (Table 3.21) for more details

3.6.2.2 Subfamily Cervinae Goldfuss, 1820, Plate 4 (C1-C4)

The subfamily Cervinae has many representatives current corresponding to the genera *Cervus* and *Axis* in Southeast Asia (Nowak, 1991; Corbet & Hill, 1992). Among these representatives, some species are endemic to the islands of Indonesia or the Philippines and one species is now considered extinct. They are:

- *Cervus nippon* Temminck, 1836, isolated populations of south-eastern Siberia to eastern China, northern Vietnam, Japan and Taiwan.

- *Cervus duvaucelii* Cuvier, 1823, isolated populations of northern India to the south-western Nepal as well as central India.

- *Cervus eldii* M'Clelland, 1842, isolated populations in Cambodia and Hainan, but main population previously recorded through Myanmar, Thailand, Vietnam and southeastern China.

- *Rusa unicolor* Kerr, 1792, India to southern China, Hainan and Taiwan to Sumatra, Borneo.

- *Rusa timorensis* Blainville, 1822, Sulawesi, Java through the small Sunda Islands.

- *Rusa mariannus* Desmarest, 1822, Philippines.

- *Rusa alfredi* Sclater, 1870, Philippines.

- *Cervus shomburgki* Blyth, 1863, considered extinct but previously recorded in Thailand.
- *Axis axis* Erxleben, 1777, India.
- *Axis porcinus* Zimmermann, 1777, in Pakistan and northern India to Myanmar, southwestern Yunnan, Thailand, Laos and South Vietnam.
- *Axis kuhlii* Temminck, 1836, Bawean Island and Java.
- *Axis calamianensis* Heude, 1888, Calamian Island in the Philippines.

Sambar *Rusa unicolor* is a large deer native to Southeast Asia. The nomenclatural history of the Sambar is complicated because of its wide distribution and occurs from southern Nepal and Myanmar throughout southern China and southeastern Asia to the Pacific Coast and the islands of Borneo, Hainan, and Taiwan with probable local extinctions, notably in Vietnam, Laos, Thailand, Cambodia, Myanmar, Peninsular Malaysia, and Sumatra (Timmins *et al*., 2008); its varied body mass, color, and antler characteristics and similarity to other sympatric Asian cervids. Sexes of *C. unicolor* are distinguished by larger male body mass, unique antlers of mature males on short pedicles (Figure 3.26, A) and generally lighter color of females (Figure 3.26, B).

Figure 3.26 Mature male (A) and mature female (B) of *Rusa unicolor*, source: www.ardea.com

Seven subspecies of *Rusa unicolor* are currently recognized (Groves & Grubb, 1987; Grubb, 2005): *C. u. brookei, C. u. cambojensis, C. u. dejeani* , *C. u. equine*, *C. u. hainana*, ,*C. u. swinhoii* , *C. u. unicolor*. Other species, now extinct, and were commonly endemic in Java are *Axis lydekkeri*, *Rusa hippelaphus* and *Cervus oppenoorthi* (Koenigswald, 1939; de Vos, 1983; Aimi & Aziz, 1985).

A fossil *Cervid*, which was comparable but larger than extant *C. unicolor*, has been found in caves in northern Vietnam and dated Middle Pleistocene or 80,000 –169,000 years ago (Bacon *et al*., 2004), in Java (de Vos, 1983), Borneo (Harrison, 1996), and caves of Paleolithic origin in China (Huang *et al*., 1995).

The combined analysis of morphological characters of the teeth together with the dimensions measured (Table 3.23) allowed for the identification of some of the material represented in the faunas from Batu Caves and Lenggong Valley as *Cervus unicolor*.

Table 3.23 Dimensions of the upper and lower teeth attributed to *Rusa unicolor* in this study.

Tooth type	**No.**	**L**	**W**
M^1 (dex.)	VC 3-3	22.1	22.4
M^2 (dex.)	BDC 5-11	24.0	18.8
M^1/M^2 (dex.)*	BDC 1-20	-	15.5
M^3 (sin.)	BDC 5-18	21.8	18.7
P_3 (sin.)	CC 7-1	15.5	8.6
P_3 (sin.)	VC 4-5	14.4	10.0
M_3 (dex.)	NC 1-6	29.9	13.7

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

3.6.2.2.1 Teeth description (Figure 3.25)

A. *Rusa unicolor* in Batu Caves

Upper molar

$M^{1:}$ VC 3-3 (dex.), Plate 4 (C1)

The crown has two lobes, moderately worn: anterior lobe with paracone and protocone and posterior lobe with metacone and hypocone. The first lobe has a nearly rectangular outline on the occlusal view while the second lobe has a square outline. The ligual cusps are separated by two small interlobe columns which start from the inner base of these cusps and rise upward. The posterior inner surface of the first lobe is clearly constricted toward the paracone. The paracone pillar is narrower than the metacone pillar. The parastyle and metastyle are broad with a salient mesostyle. A shallow cingulum can be seen along the anterior surface at the first lobe and absent at the posterior surface. A crescent wall surrounds the inner surface of the lingual cusps. Contact facets are observed on the anterior side. Gnaw marks are preserved on the root fragments.

Lower premolars

P_3: CC 7-1 (sin.), Plate 4 (C2), VC 4-5 (sin.)

Both samples are highly worn and VC 4-5 is more fragmented thus reducing many characters in its dentine morphology. The maximum width of the crown is found at the posterior half for both teeth. The metaconid is elongated and oblique transversally and separated between two valleys: the first which is between the paraconid and metaconid is shallower and not closed as the second valley which is between the metaconid and entoconid. These two valleys look more elongated towards the buccal wall in VC 4-5 and open towards the lingual wall in both samples. Fused paraconid with parastylid and entoconid with entostylid are observed. A convex gingival line with vertical shallow groove is clearly present at both the buccal and lingual surface in CC 7-1. Posterior contact facets and traces of two fragmentary roots are present in both samples.

B. *Rusa unicolor* in Lenggong Valley

Upper molars

M^1/M^2: BDC 1-20 (dex.)

M^2: BDC 5-11 (dex.), Plate 4 (C3)

M^3: BDC 5-18 (sin.)

The crown is sub-rectangular in outline in occlusal view. These three samples show different degrees of wear and preservation from not worn and well-preserved in BDC 5-11, relatively worn and damaged in BDC 5-18, and much worn and incomplete in BDC 1-20. BDC 1-20 cannot be identified as M^1 or M^2 as only the anterior with a U shaped fossa and small interlobe columns are preserved. Both BDC 5-11and BDC 5-18 show similarity in morphological features except in size with the second upper molar being relatively larger in size than the third upper molar. Only these two identified molars will be described. Two obvious lobes are present: the anterior lobe with paracone and protocone look smaller and is less wide than the posterior lobe with metacone and hypocone. Two small fused interlobe columns with a triangular outline lie in between these two main lobes. A trace of the cingulum is rarely seen on both samples on the anterior side of the protocone. The upper molars have well developed parastyle and mesostyle. However, the metastyle is not clearly seen. The edge of the metacone with metastyle extends distally in both samples. Traces of four fragmentary roots are preserved in both samples. One fused anterior root and contact facet is present in BDC 1-20.

Lower molar

M_3: NC 1-6 (dex.), Plate 4 (C4)

The third lower molar has three distinct unworn lobes: the first anterior lobe (protoconid with metaconid) and the second lobe (hypoconid with entoconid) are both separated by a small interlobe column compared to the upper molar, ending with a damaged last posterior lobe (hypoconuild) all forming the largest molar compared with the first and second lower molars which are almost the same in length. The sample is compressed transversally. The para and metastylids are well developed while the entostylid is not preserved. The anterior cingulid fold is attached to the anterior part of the protoconid.

3.6.2.2.2 Broken teeth of Deer

Fragments of broken deer teeth that cannot be specifically identified:

SC 2-3: part of lower tooth (premolar? molar?)

VC 1-4: small part of tooth enamel

BDC 4-19: tooth fragment

BDC EX13: three parts of fragmented tooth; one of them looks like the buccal side.

3.6.2.2.3 Remarks

The specific identification for deer are based on differences in their antlers and color, so with only isolated teeth it is not possible for specific identifications to be made with absolute certainty.

The cheek teeth of the Cervinae have complicated structure and are bigger in size than in Muntiacinae with well developed buccalstyles.

The two anterior and posterior upper molar lobes are easy differentiated by their size and height (similar with the *Muntiacus muntjak*) with small fused interlobe columns lying between these lobes appearing only in upper molar samples of *Cervus unicolor* in this study. This feature seems highly variable but can be used as a general trend to differentiate the species in comparative study. The big lobe (hypoconulid) of the third lower molar beside the mesial and distal groove of I_1 and I_2 was used by Tougard (1998) to distinguish between *Cervus unicolor*, *Axis porcinus*, and *Cervus eldii*. Comparative measurements of the fossil teeth in this study with the other recent and fossil teeth are given in the (Table 3.24) below. It will be seen that the dimensions of the cervid teeth from this study are larger than those from Punung (Java) and from Thum Wiman Nakin (Thailand) in some cases especially for the first upper and last lower molars, and smaller for the lower jaw than the Vietnamese specimens from Lang Trang Caves and Duoi U'Oi Cave and fall within the limits of variation for the fossils from Sumatra Caves. The third upper molars from Phnom Loang (Cambodia) are larger in size than all the other fossils and recent samples.

Table 3.24 Comparative measurements of well-preserved *Rusa unicolor* teeth recovered on the present study with other modern and prehistoric material measurements.

	M^1	M^2	M^3	P_3	M_3
Modern					
Zoological Museum (University of Malaya)					
N	2	2	1	2	1
L	12.1- 23.3	23.5 - 25.4	22.4	15.7 - 18.5	28.6
W	20.3- 22.3	19.3 - 24.0	20.8	9.3 - 10.3	15.5
Institute of Biodiversity,Wildlife & National Parks Department (Malaysia)[1]					
N	2	2	2	3	4
L	15.8 - 15.9	16.5 - 20.8	21.8 - 23.5	12.4 - 15.9	29.4 -31.5
W	19.6 - 21.5	19.9 - 23.5	20.9 - 23.3	8.0 - 9.3	12.8-14.4
Prehistoric					
National Museum of Natural History (Leiden) Padang Highland Caves Lida Ajer Cave (Sumatra)•					
N				20	1
L				13.1-23.1 P_1/P_2*	33.3
W				7.1-14.8 P_1/P_2*	17.0
Padang Highland Caves Sibrambang Cave(Sumatra)•					
N				32	
L				11.0-18.3$P_1/P_2/P_3$*	
W				4.8-12.4$P_1/P_2/P_3$*	
Padang Highland Caves (Sumatra)[2]					
N					116
L					20.6–37.0
W					12.4-18.8
Punung (Java)[3]					
N	1	1	1	2	
L	17.0	19.0	16.5	11.5	
W	21.0	21.5	20.0	7.5 - 8.5	
Lang Trang Caves (Vietnam)[2]					
N	87				26
L	16.7-30.3$M^1/M^2/M^3$*				30.0-32.9
W	18.3-28.0$M^1/M^2/M^3$*				15.1-16.6

Table 3.24, continued

	M^1	M^2	M^3	P_3	M_3
Duoi U'Oi Cave (Vietnam)[4]					
N	24			4	18
L	21.1-27.9$M^1/M^2/M^3$*			16.5 - 20.1	29.9-38.1
W	19.4-28.6 $M^1/M^2/M^3$*			10.1 - 11.4	15.9-17.9
Phnom Loang (Cambodia)[5]					
N			2		
L			22.5 - 24.0		
W			24.0		
Thum Wiman Nakin (Thailand)[6]					
N	1	1	3	1	2
L	17.1	24.7	19.0- 22.5	13.1	12.3˜
W	15.1	25.6	16.9 - 18.1	8.9	8.9-12.1
In this study					
Batu Caves^					
N	1			2	
L	22.1			14.4 - 15.5	
W	22.4			8.6 - 10.0	
Lenggong Valley^					
N	1	1	1		1
L	-	24.0	21.8		29.9
W	15.5 M^1/M^2*	18.8	18.7		13.7

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

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

[2] De Vos & Long (1993); materials identified as *Cervus sp.*

[3] Badoux (1959); materials identified as *Cervus sp.*

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

[5] Beden & Guérin (1973)

[6] Tougard (1998)

• The materials from Lida Ajer Cave and Sibrambang Cave are identified as *Rusa* sp. indet.

* The measurements are for the unclassified group

˜ Only one measured for length

^Refer to (Table 3.23) for more details

3.6.3 Family Bovidae Gray, 1821

The bovid family, native to Asia, Africa, Europe and North America, are widespread and diverse. Its members include the bison, African buffalo, antelopes, gazelles, sheep, goats, muskoxen, and domestic cattle. The males in all species have horns, and in many the females do too. The horns of the females are usually smaller than those of males, and are sometimes of a different shape. The largest number of modern bovids is found in Africa, while substantial but less diverse populations are found in Asia and North America. The bovid family is known through fossils from the Early Miocene around 20 million years ago. Recently, the bovid family has been subdivided into ten subfamilies. Two subfamilies have been recognized in Southeast Asia and these belong to Bovinae and Caprinae.

In this study, two groups of fossils can be recognized. The first group, the Bovinae, has complex dental characters and larger in size roughly like the size of a Water Buffalo and larger (≥400kg). The second group is the Caprinae that has simple dental characters and are small to medium sized roughly like the size of *Capricornis* and smaller (≤150 kg) (Bekken *et al.*, 2004).

3.6.3.1 Subfamily Bovinae Gray, 1821, Plate 7 (A1-A11)

There is significant sexual dimorphism in this subfamily: in some species, males may weigh twice as much as females. Horns are found in the males of all species. Females have smaller and thinner horns than those of males.

Many bovine species have been domesticated by humans, like the domestic cattle, *Bos taurus*, which are now found worldwide and raised for meat, leather, and milk. This subfamily is represented in Southeast Asia at present by:

- Saola *Pseudoryx nghetinhensis*, in Vietnam and Laos.

- Wild Water Buffalo *Bubalus arnee* (Figure 3.27), (wild form of the Domestic Water Buffalo, *Bubalus bubalis*) in India, Nepal, Thailand and Cambodia with an unconfirmed population in Myanmar. They have been extirpated in Laos and Vietnam. Its wild form probably occurred in Sumatra and Java.
- Tamaraw *Bubalus mindorensis* is endemic to the island of Mindoro, Philippine.
- *Bubalus depressicornis* in Sulawesi, Indonesia.
- *Bubalus quarlesi* in Sulawesi, Indonesia.
- Gaur *Bos gaurus* (wild form of the Domestic Gayal, *Bos frontalis*) in Cambodia, Peninsular Malaysia, Myanmar, Thailand, and Vietnam.
- Banteng *Bos javanicus* in Cambodia, Indonesia, Myanmar, Thailand, and Vietnam, not confirmed in Peninsular Malaysia.
- Kouprey *Bos sauveli* in Cambodia, possibly extinct in Thailand and Vietnam.
- Domestic Cattle *Bos taurus* widespread in Asia and North Africa.
- Zebu *Bos indicus*, domestic cattle originated from South Asia particularly the Indian subcontinent.

Figure 3.27 Wild Water Buffalo *Bubalus arnee,* source: ne.wikipedia.org

Fossils of this subfamily is represented from different sites in Quaternary Southeast Asia like Sumatra and Java (Koenigswald, 1939; de Vos, 1983), Borneo (Harrison, 1996), Thailand (Tougard, 1998), Vietnam (Bacon *et al*., 2008b) and South China (Kahlke, 1961; Olsen & Ciochon, 1990).

Some of these fossils have been found in small quantities or are extinct nowadays like specimens from South China tentatively referred to as *Bubalus brevicornis* (Young, 1936), *Bibos geron* and the sub-species *Bos gaurus grangeri* (Colbert & Hooijer, 1953).

Duboisi santeng was an endemic species from the Middle Pleistocene, found in Tambun (Peninsular Malaysia) and in Trinil and the sub-species *Bubalus bubalis palaeokerabau* and *Bos javanicus palaeosondaicus* (Hooijer, 1958) were endemic in Java.

Generally, the literatures available conclude that it is very hard, however, to find some features distinguishing dental characters for both *Bibos* and *Bubalus* genera. The dimensions of the isolated Bovinae teeth collected in this study show in (Table 3.25).

Table 3.25 Dimensions of the upper and lower teeth attributed to Bovinae in this study.

Tooth Type	**No.**	**L**	**W**
P^4 (dex.)	BDC 4-16	16.4	18.7
P^4 (sin.)	BDC EX17	11.8	15.8
M^1 (sin.)	BDC 1-6U	26.5	20.1
M^1 (sin.)	BDC 4-3	23.3	23.8
P_4 (dex.)	SC 2-2	24.0	11.8
P_4 (dex.)	VC 3-1b	20.4	11.1
dP_4 (sin.)	BDC 1-4U	20.7	10.5
M_2 (sin.)	BDC 4-4	35.4	14.6
	BDC 1-8L	32.3	20.3

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

3.6.3.1.1 Teeth description (Figure 3.25)

A. Bovinae in Batu Caves

Lower premolars

$P_{4:}$ SC 2-2 (dex.), Plate 7 (A4), VC 3-1b (dex.), Plate 7 (A5)

This tooth is the most diagnostic tooth as it is easily distinguish by its general morphology from the other lower premolars and the molars. The crown is moderately worn in VC 3-1b and much worn in SC 2-2. It is more hypsodont and compressed transversely in VC 3-1b. The metaconid is well developed compared to other cusps transversely plunging into the distal part of the tooth and with an extended pronounced metastylid. The entoconid is connected to the hypoconid at the posterior end by a slightly flat surface in SC 2-2 while this surface appears more curved and depressed in VC 3-1b. There is a compressed posterior lingual inner valley between metaconid and the entoconid. This valley is shallower in SC 2-2 and deeper in VC 3-1b due to the difference in degree of tooth wear. Generally, the posterior end with entoconid and hypoconid is wider than the anterior end with paraconid and parastylid.

The buccal surface is somewhat flat with only one vertical groove running at the posterior end between the protoconid and hypoconid while the lingual surface has three vertical grooves, two minor shallower grooves near both the anterior and posterior edges and a major deeper third groove running between the metaconid and paraconid. Two broken roots are present at the base the crown of VC 3-1b.

B. Bovinae in Lenggong Valley

Upper premolars

P^4: BDC 4-16 (dex.), Plate 7 (A1), BDC EX17 (sin.)

Two samples of different sizes but similar in shape probably belonging to different individuals were collected from Lenggong Valley (Badak Cave C). BDC 4-16 has a larger missing buccal surface than BDC EX17. For this reason the buccal styles (para- and mesostyle) in BDC 4-16 are not very developed compared with BDC EX17, especially for the parastyle. The area situated between the paracone and parastyle is slightly flat with a more or less convex buccal edge in BDC 4-16 while its forms an acute angle with the paracone near the anterior side in BDC EX17. The lingual side has an oval swollen shape in both samples. Shallow vertical groove is present between the protocone and hypocone in BDC EX17. Lingual tubercles are not present in both samples. A large central U-shaped fossa is clearly present on the worn flat occlusal surface in BDC 4-16 and less clear on the less worn occlusal surface of BDC EX17. The small constriction present at the lower boundary of this fossa can used to distinguish the posterior side. Remnants of roots and contact facets are found at both the anterior and posterior sides of BDC EX17.

Upper molars

M^1: BDC 1-6U (sin.), Plate 7 (A2), BDC 4-3 (sin.), Plate 7 (A3),

The crown in BDC 1-6U is moderately worn and more hypsodont than in BDC 4-3. The interlobe column (the hyopocone) on the lingual posterior face of BDC 4-3 is broken. This column situated lingually between the anterior and the posterior lobe is not very clear in BDC 1-6U. The posterior lobe (with metacone, hypocone and metastyle) is higher, wider, and more rounded than the anterior lobe (with paracone, protocone and parastyle) as seen in the occlusal view of BDC 1-6U. The posterior style (metastyle) is more pronounced than the anterior style (parastyle) and both are well developed in the two samples. Only traces of the U-shaped fossa can be observed between the anterior and posterior lobes of BDC 1-6U as a major part was damaged during the extraction of the fossil. This fossa is very clear in BDC 4-3. Generally, this fossa appears clearer when the degree of wear of the tooth is advance which is the case for BDC 4-3. The buccal vertical grooves on the anterior and the posterior lobes are asymmetrical in both samples. There is a deep vertical groove running buccaly between these two lobes. It is reflected as a clear small curved line on the internal edge of the top crown of the anterior lobe in BDC 4-3. This depression can be used to distinguish the anterior part of the tooth from my observation. A small contact facet is present at the tip of the posterior lobe in BDC 1-6U while a contact facet is present on the anterior edge of BDC 4-3 with traces of gnaw marks at the base of the broken roots.

Lower premolar

dP_4: BDC 1-4U (sin.), Plate 7 (A6)

This specimen has the same features as P_3 but is smaller in size and has elongated sharp cusps. The paraconid with the parastylid is very well preserved lingually while the anterior metaconid is the best preserved among the posterior cusps with a deep vertical groove separating them. The other posterior features are not very well preserved as the sample was damaged at the posterior end. A sharp protoconid with a clear posterior vertical groove is present bucally. A small inner valley is present between metaconid and damaged entoconid. No roots are preserved.

Lowe molars

M_2: BDC 4-4 (sin.), Plate 7 (A7), BDC 1-8L (sin.), Plate 7 (A8)

Both specimens have moderately worn hypsodont crowns. BDC 4-4 is better preserved than BDC 1-8L. Two lobes with four cusps can be clearly observed. The anterior lobe with metaconid and protoconid and posterior lobe with entoconid and hypoconid are separated by an elongated interlobe column covered with hard matrix in BDC 4-4 and broken in BDC 1-8L. The tip of this column in BDC 4-4 is compressed and does not reach the area between the two lobes.

In BDC 4-4, the lingual stylids of the anterior lobe (parastylid and metastylid) are more prominent than the lingual stylids of the posterior lobe while they are not prominent in BDC 1-8L. Two fossae are present on both lobes in BDC 4-4 but not in BDC 1-8L. These fossae are not U or V shaped but is more elongated at the center of the occlusal surface. A medial groove with two lateral grooves and two parallel major ridges run along the lingual side in both halves of the lobes. A minor ridge only runs along the anterior half but does not reach the bottom. The medial groove with the minor ridge is not clear in BDC 1-8L. Small contact facets are only present on the anterior side of the anterior lobe in BDC 4-4. Both samples have no roots.

3.6.3.1.2 Broken teeth of Bovid

VC 4-13: small part of tooth fragment.

BDC 4-6: part of lingual side of the lower molar with vertical ridge and groove.

BDC 1-13U: few broken pieces of a small part of lingual side tooth with groove.

BDC 3-7: fragment of premolar or molar.

3.6.3.1.3 Bones

BDC 4-1a and BDC 4-1b, Plate 7 (A9 & A10)

Parts of the fragmented bones were found stuck to the roof of Badak Cave C, Lenggong Valley, Perak. It appears to be a long bone broken into two of a large animal trapped within the hard strongly cemented cave deposits from which complete extraction would require considerable time and effort.

Two big complementary pieces of hard rock, BDC 4-1a and BDC 4-1b containing parts of this long bone with a number of scattered pieces of other broken bones were collected.

Examination of the transverse section of this bone through the separation area reveals that the two pieces one larger than the other, represent the metapodial bone of Bovinae based on the shape and remarkable size and length of the bone.

The two pieces of the bone in BDC 4-1a and BDC 4-1b were measured and added up according to the convention in von den Driesch (1976).

Measurements for BDC 4-1a and BDC 4-1b:

Greatest length (GL) = 193.1 mm

Greatest width of the proximal end (Bp) = 63.5 mm.

Greatest width of the distal end (Bd) = 84.9 mm.

Smallest width of the diaphysis (SD) or middle width = 43.0 mm.

BDC 4-22, Plate 7 (A11)

The third sample BDC 4-22 was found in the same cluster as BDC 4-1a and BDC 4-1b. It is composed of two fragments joined together with both proximal and distal ends broken away. This sample is not sufficient clear for determination but could probably be part of the radius, ulna, tibia or fibula.

Measurements for BDC 4-22:

Greatest length (GL) = 37.0 mm.

The greatest width of cross section= 50.3 mm.

3.6.3.1.4 Remarks

Teeth and bone fragments are the only remains of these animals in this study. No horn-cores were found in the material recovered. Therefore, more specific identification of these specimens is difficult since the dentition of the various bovines like Banteng and Gaur show close similarity.

Nine out of the 13 specimens collected are attributable to large Bovine teeth (Table 3.25), the others are too fragmented for identification. Unfortunately, there is not enough modern and fossil material in the available reference collections for comparison with my material to differentiate the morphological characters between the taxa. Previous studies by others on these differences in teeth structure between genera are included below for discussion.

When Colbert and Hooijer (1953) and Hooijer (1958) tried to compare between a series of adult dentitions of *Bibos gaurus* (Seladang previously referred to as *Bibos gauris*) and *Bubalus bubalis*, they found that the anterior lower premolar in P_2 in the gaur is more reduced in size than in the water buffalo. It is more simply built with the posterior inner valley in *Bubalus* deeper than in *Bibos*. Badoux (1959) agreed with them except for a small difference in structure of the P_2 which has an outer vertical groove in the posterior buccal side of the *Bubalus* that is absent in *Bibos*. De Vos & Long (1993) relied on the same character in P_2 to attributed the Lang Trang specimens to *Bubalus bubalis.* Unfortunately, the second lower premolar is not present in my collection.

Some data from other references are not applicable or used in this study because either the dental identification was too general such as the data from Cambodia (Voeun, 2007) or the materials discovered were too worn or fragmentary and could not be matched with the types of the teeth under study (Bouteaux, 2005; Bacon *et al*., 2008b).

Some fossils, for example, *Duboisia santeng,* an endemic species of Middle Pleistocene age, cannot be used for comparative study as it is of intermediate skull size and dental character between the last survivors of the Indian forms *Boselaphus* and *Tetracerus* (Hooijer, 1958) and both extant species have relatively primitive anatomical and behavioral characteristics.

Another example is the large bovine material referred to as *Bibos geron* from South China might belong to either *Bibos gaurus* or to *Bubalus bubalis* (Colbert and Hooijer, 1953).

No differentiating characters are present except for a difference in size for the endemic sub-species of Java *Bubalus bubalis palaeokerabau* and *Bos javanicus palaeosondaicus* (Hooijer, 1958) and between *Bos gaurus grangeri* (Colbert and Hooijer, 1953).

Two specimens BDC 4-16 and BDC EX17 are represented by the upper premolars in my collection. $P^3$and P^4 have similar structure but the latter is smaller in size than the P^3 and closer to BDC 4-16. BDC 4-16 is larger in size than BDC EX17 and the latter is the smallest specimen among my Bovinae collection and smaller than all the comparative material available to me. The measurements for this sample (length and width) are closer to $P^4$of Cervinae. This sample, however, do contain some features suggestive of Bovids like:

the acute angle between the paracone and parastyle near the anterior side, simple central depression not normal in Cervinae but present in Bovids especially *Bos frontalis* (Tin

Thein, 1974 in Tougard, 1998), shallow vertical groove between the protocone and hypocone that occurs in *Bubalus bubalis* and *Bos sauveli* (Tougard, 1998).

P_4 is present in my collection as samples SC 2-2, VC 3-1b and BDC 1-4U. BDC 1-4U has a few characters different from the other two (see above for detailed description) and is relatively similar in size and shape with the deciduous fourth lower premolar teeth of (Bovidae gen. et sp. indet.) from the Sibrambang Cave (Padang Highland, Sumatra) in National Museum of Natural History (Leiden) hence its placement under the deciduous teeth (Table 3.26).

Both SC 2-2 and VC 3-1b have some distinct morphological features (vertical groove in buccal side, paraconid and metaconid not close to each other, shallow valley between the metaconid and entoconid deeper in VC 3-1b). These characters are not very related to those mentioned by Tougard (1998) for P_4 to differentiate between *Bos javanicus, B. sauveli*, and *B. frontalis*.

The dimension of the crowns of the upper premolar BDC 4-16 as well as those of the lower premolars SC 2-2 and VC 3-1b show that they are close in size to those of *Leptobos* fossils from the Chinese excavation (Table 3.26), at the same time the upper premolar BDC 4-16 falls within the limits of variation of the fossil Bovinae from Punung (Java) (Badoux, 1959) (Table 3.26), while the lower premolars fit very well within the unclassified group of fossils from Padang Highland Caves (Sumatra) in the National Museum of Natural History (Leiden).

Molar teeth is represented in this study by four samples, two upper molars, BDC 1-6U and BDC 4-3 and two lower molars, BDC 4-4 and BDC 1-8L from the Lenggong Valley caves (Badak Cave C). Tougard (1998) used the shape of the cusps and the interlobe column with the degree of developed style/ stylid to distinguish between the different species of Bovinae. These characters do not correspond very well with my samples of upper and lower molars as the occlusal surface in all my samples (outlines of the outside edge and internal fossettes) are simple and not very complex, except in BDC 4-3, and the interlobe columns are either not very clear or broken in all my samples.

BDC 4-3 differs from the other molars by being more complex in general morphological structure than the rest beside the difference in dimensions especially of the height. The maximum height of the crown of BDC 4-3 (15.7 mm) is less than half of the maximum height of the BDC 1-6U (39.2 mm) when we compare the heights of the two upper molars from the same site. Although the height of the BDC 4-3 is much lower than BDC 1-6U it remains within the range for Bovids calculated for the index for hypsodont teeth according to the method of Heintz (1970):

I_h = (height of the molar metacone x 100) / length of the molar at the top.

The hypsodon index rarely reaches the value of 100 for the Cervides molar while this index is always greater than 100 in the Bovides molar (Heintz, 1970). For BDC 4-3, this index is (136.0).

In length the upper molar teeth in my collection falls within the range of some unclassified group of fossil under the general and uncertain identification as *Bibos* (?) cf. *sondaicus* like those from the Irrawaddy Valley (Myanmar) and *Leptobos* sp. from the Qinghaigonghe site in China.

The same was observed for its width dimensions which are close to the unclassified group of fossils from different sites like *Bos* (*Bibos*) sp. from Yunnan (China), *Bubalus bubalis* from Phnom Loang (Cambodia) and unidentified fossils from Lida Ajer and Sibrambang Caves (Padang Highland Caves, Sumatra). It fits very well within the range of recent *Bos gaurus* (Table 3.26).

The length of the lower molar sample in my collection fits very well within the range of the lengths of the lower molar for the living *Bos gaurus* species.

A very obvious character of the lower molar teeth in my collection was their great in hypsodont and length (Table 3.26) that is longer than any recent or fossil ones available in the collections examined.

Generally, the size and occlusal complexity of Bovine teeth increase over time. The occlusal pattern in any molar, upper or lower is simpler in early and late wear than the middle wear, and this pattern will be simpler in the smaller species (personal communication with Dr. Alan Gentry, Department of Palaeontology, Natural History Museum, London, 2010).

Since I have only a few isolated teeth from the fossil sites to compare with the limited reference materials, and without any horn core for positive identification and there are at least 5 other taxa of fossil Bovids reported from other Southeast Asian sites with identical structure of their teeth and no other reliable characters, it is not possible for me to identify the bovid to species level. Differences in size of teeth are not usable for distinguishing species so no specific identification could be done with the Bovine material in my collection. The absence of complete long bones in my collection with lack of the reference bone data disallowed more specific identification for BDC 4-1a and BDC 4-1 and the problematic bone was simply identified as a ‘metapodial’.

The skeleton of the metapodium (metacarpus and metatarsus) of cattle is known to develop through a fusion of two initially independent bones. The fusion is completed later still in animal bones in relation to their age (Paral *et al*., 2004).

In most cases, it is very difficult to distinguish between metacarpal and metatarsal as regards the measurements due to fragmentation of individual bones especially when the morphological expression of the different functions of the two kinds of limb is missing.

There are three factors shown in (Table 3.27) that can be used to distinguish between *Bubalus* and *Bibo* metapodials. These are: the length, distal width, and the ratio of distal width to length. We can conclude that both the metacarpals and metatarsals of *Bubalus* are shorter and more expended distally than those of *Bibos.*

My sample is shorter than all fossil and recent *Bibos* species in the reference collections and is similar to that of the metacarpals of *Bubalus bubalis* from the Middle Pleistocene of Yenchingkou from China, in which the ratio of distal width to length ranges from 0.42 to 0.46 corresponding with my ratio of 0.44. The considerable expansion at the distal end of the metacarpal and metatarsal of Chinese *Bubalus* fossils is also present. BDC 4-1a and BDC 4-1b, therefore, represents the metacarpal bone with measurements falling within the range of *Bubalus* not *Bibos.*

If the metapodial fossil bone from Badak Cave C belongs to *Bubalus bubalis* (Linnaeus) and not some other species, the presence of Water Buffalo at Peninsular Malaysia must be accepted.

During the Pleistocene, remnant populations of Wild Water Buffalo were found at single sites in southern Nepal, western Thailand, eastern Cambodia, and northern Myanmar, and at several sites in India (IUCN, 2011).

Laos, Cambodia, and Vietnam were not included within the range of Wild Water Buffalo given in Corbet and Hill (1992) but was probably extinct in Vietnam and almost certainly in Laos (Groves 1996; Grubb 2005).

On the islands of Sumatra and Java, it is believed to be regionally extinct (IUCN, 2011) with little doubt that all the apparently wild buffaloes now living on Java and Sumatra are descended from domestic animals, or from Wild Water Buffaloes that have interbred with domestic and/or feral buffaloes. Mason (1974) and Corbet and Hill (1992) did not list Borneo within the historic range of the species, while Von Koenigswald (1958) listed the occurrence of two isolated teeth from the Great Cave in Niah leading to the consider probability of the presence of these animals among the endemic Borneo fauna.

Since a little work has been done in the Malaysian (Mak, 1973) it appears that there were no Wild Water Buffaloes in Peninsular Malaysia (Tan *et al.*, 1980) and the habitat of the domestic buffalo is swamp or marsh land.

What does seem certain, however, if the species is indigenous to any island in Southeast Asia the true of Wild Water Buffalo seems to not occur today since they would have been genetically swamped by the numerous feral animals some of which were descended from buffaloes introduced from outside the region.

Table 3.26 Comparative measurements of well-preserved Bovinae teeth in this study with other modern and prehistoric material.

	P^4	M^1	P_4	M_2
Gaur (*Bos gaurus*)				
Modern				
Institute of Biodiversity,Wildlife &National Parks Department (Malaysia)[1]				
N	2	2	3	3
L	18.6 - 19.4	26.8 - 27.8	22.0 - 33.0	30.6 - 36.0
W	19.5 - 20.5	20.0 - 23.4	11.9 - 16.1	15.5 - 21.1
American Museum of Natural History (A.M.N.H.)[2]				
N	2	2	2	2
L	17.0 - 20.0	24.0 - 28.0	21.0	27.0 - 28.0
W	21.0 - 24.0	26.0 - 28.0	15.0	19.0 - 20.0
Prehistoric				
American Museum of Natural History (A.M.N.H.) (Yenchingkou fauna, China)[2]				
N	1	2	2	2
L	22.0	29.0	24.0 - 26.0	29.0 - 31.0
W	22.0	28.0 - 30.0	16.0	21.0 - 23.0
Thum Wiman Nakin (Thailand) [3]				
N			1	
L			26.0	
W			15.1	
Banteng (*Bos javanicus*)				
Modern				
Sabah Museum[1]				
N				2
L				23.7 - 30.0
W				16.4 - 22.2

Table 3.26, continued

	P^4	**M^1**	**P_4**	**M_2**
National Museum of Natural History (Leiden)[4]				
N	1	2	2	2
L	15.0	22.0	23.0	28.0
W	16.0	17.0 - 20.0	13.0	18.0
Prehistoric				
Thum Wiman Nakin (Thailand)[3]				
N		1	2	2
L		24.2	24.3 - 25.6	25.6 - 26.1
W		24.3	13.0 - 14.2	16.9 - 17.1
Kouprey				
(*Bos sauveli*)				
Prehistoric				
Thum Wiman Nakin (Thailand) [3]				
N		1	1	1
L		27.8	25.8	31.0
W		23.4	12.9	20.6
***Bos* (*Bibos*) sp.**				
Yunnan (China)[5]				
N	1	7		2
L	15.5	24.0 - 28.0 M^{I-3}*		23.0 - 25.0 M_{I-2}*
W	17.5	20.0 - 24.0 M^{I-3}*		14.0 - 16.5 M_{I-2}*
Upper Irrawaddy beds (Myanmar)[6]				
N		4		2
L		21.0 - 29.0 M^{I-3}*		29.0 – 31.0
W		22.0 - 24.0 M^{I-3}*		17.0 - 21.5
Water Buffalo				
(Bubalus bubalis)				
Modern				
American Museum of Natural History (A.M.N.H.)[2]				
N	2	2	2	2
L	18.0 - 20.0	27.0 - 31.0	24.0 - 25.0	31.0 - 34.0
W	22.0 - 25.0	25.0 - 29.0	16.0 - 18.0	19.0

Table 3.26, continued

Prehistoric	**P^4**	**M^1**	**P_4**	**M_2**
Thum Wiman Nakin (Thailand)[3]				
N				2
L				30.0 - 30.6
W				21.7 - 22.1
Lang Trang Caves (Vietnam)[7]				
N	4	3	3	3
L	20.3–21.5 P^2/P^3*	32.7 - 33.5 $M^1/M^2/M^3$*	22.7-23.5 P_2/P_3*	25.4-31.0 M_1/M_2*
W	19.4-20.9 P^2/P^3*	26.3 - 28.3 $M^1/M^2/M^3$*	14.7-15.4 P_2/P_3*	17.3–20.0 M_1/M_2*
American Museum of Natural History (A.M.N.H.) & Chicago Natural History Museum (C.N.H.M.) (Yenchingkou fauna, China)[2]				
N	2	2	2	1
L	19.0 - 18.0	26.0 - 31.0	23.0 - 25.0	33.0
W	23.0	28.0	15.0 - 16.0	20.0
Phnom Loang (Cambodia)[8]				
N		6		3
L		25.0 - 35.0 M^{I-3}*		29.0-34.0 M_{I-3}*
W		10.0-28.0(N=9) M^{I-3}*		15.0-19.0 M_{I-3}*
Chinese Data[1]				
Bubalus				
Nanjing Man site[9]				
L	17.5 – 18.0		21.5 - 23.5	28.6 - 33.2
W	22.5 – 24.0		11.5 - 17.5	21.0 - 22.0
Maba Man site[9]				
L	18.5			34.0
W	21.6			20.0
Yunxi Man site[9]				
L	17.8 - 18.9		22.3 - 24.2	29.1 - 34.3
W	22.9 - 24.7		12.0 - 18.0	22.1 - 23.5
Leptobos				
Longdan site[10]				
L	16.8 - 18.0	21.2 - 23.0		
W	18.8 - 20.8	25.0 - 26.0		
Qinghaigonghe site[10]				
L	15.5 - 18.3	20.8 - 26.8		
W	19.6	22.5 - 24.0		

Table 3.26, continued

	P^4	**M^1**	**P_4**	**M_2**
Yunxi Man site[9]				
L	17.8	22.6 - 25.2	23.1	24.6 - 28.8
W	19.2	22.4 - 25.3	10.7	20.7 - 25.0
Jianshi Man site[9]				
L	14.8 - 21.7	21.7 - 25.9	20.3 - 24.1	24.0 - 30.7
W	16.7 - 24.4	21.6 - 26.4	12.1 - 14.6	16.0 - 20.4
Tuozidong site[11]				
L				28.3
W				15.6
Gongwangling site[12]				
L	16.8˜	23.3˜	22.2˜	24.4˜
W	17.3˜	21.6˜	10.8˜	15.6˜
Renzidong Cave[12]				
L	17.2 - 18.5	21.8 - 23.9	20.8 - 22.4	25.2 - 30.6
W	18.5 - 21.3	21.6 - 24.7	13.3 - 13.4	16.2 - 17.6
Hemibos				
Longdan site[10]				
L	15.0	19.5		
W	20.5	25.4		
Epileptobos groeneveldtii				
National Museum of Natural History (Leiden), Dubois Collection[3]				
N	2	2		
L	15.0 - 16.0	22.0 - 24.0		
W	15.0 - 19.0	18.0 - 21.0		
Leptobos falconeri				
Modern				
Natural History Museum (London) [4]				
N	2	2		
L		21.0 (N=1)		
W	16.0 - 17.0	19.0 - 20.0		

Table 3.26, continued

Bovidae gen. et sp. indet.	P^4	M^1	P_4	M_2
National Museum of Natural History (Leiden) Padang Highland Caves (Sumatra)				
Lida Ajer Cave				
N		3	3	2
L		25.9-31.7 $M^1/M^2/M^3$*	18.7-23.0 P_2/P_3*	23.0- 27.8 $M_1/M_2/M_3$*
W		20.0-25.4 $M^1/M^2/M^3$*	11.0 - 14.1 P_2/P_3*	13.0-13.4 $M_1/M_2/M_3$*
Sibrambang Cave				
N		5	2	5
L		26.4 - 31.3 M^1/M^2*	21.3 - 24.4 P_2/P_3*	28.3-33.5 M_1/M_2*
W		19.0 - 24.1 M^1/M^2*	11.2 - 14.0 P_2/P_3*	12.9-16.6 M_1/M_2*
Sibrambang Cave				
N		8	9	
L		24.2 -31.3$M^1/M^2/M^3$*	20.3 - 25.3 dP_3	
W		18.3-24.7 $M^1/M^2/M^3$*	11.2 - 14.0 dP_3	
Djamboe or Sibrambang Cave				
N		4		
L		28.8-30.7 $M^1/M^2/M^3$*		
W		16.7-21.6 $M^1/M^2/M^3$*		
Bovinae gen. et sp. indet.				
Punung (Java)[13]				
N	2		4	3
L	14.0 - 17.0		24.0 - 25.0	25.0 - 31.0
W	16.0 - 21.0		12.0 - 13.0	16.0 - 18.0
In this study				
Batu Caves^				
N			2	
L			20.4 - 24.0	
W			11.1 - 11.8	
Lenggong Valley^				
N	2	2	1	2
L	11.8 - 16.4	23.3 - 26.5	20.7 dP_3	32.3 - 35.4
W	15.8 - 18.7	20.1 - 23.8	10.5 dP_3	14.6 - 20.3

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] Colbert & Hooijer (1953)

[3] Tougard (1998)

[4] Hooijer (1958)

[5] Colbert (1940)

[6] Colbert (1943); the materials from Irrawaddy beds (Myanmar) identified as *Bibos* (?), cf. *sondaicus*
[7] De Vos & Long (1993)
[8] Beden & Guérin (1973)
[9] Wu Xianzhu (Ed.), 2006
[10] Qiu Zhanxiang *et al*. (2004)
[11] Nanjing Museum & Institute of Archaeology, Jiangsu Province, 2007
[12] Jin Changzhu & Liu Jinyi (Eds.), 2009
[13] Badoux (1959)
* The measurements are for the unclassified group
˜ Average value
^ Refer to (Table 3.25) for more details

Table 3.27 Comparative measurements of the metacarpus and metatarsus bones in this study with other modern and prehistoric material.

METACARPALS	**Length**	**Proximal width**	**Middle width**	**Distal width**	**Ratio:Distal width/length**
Bubalus					
Modern					
Bubalus bubalis					
National Museum of Natural History (Leiden)[1]	173.0 - 175.0(N=2)	61.0 - 68.0(N=2)	35.0 - 40.0(N=2)	66.0 - 74.0(N=2)	0.38 - 0.43(N=2)
American Museum of Natural History (A.M.N.H.)[2]	230.0 - 237.0(N=2)	76.0 - 83.0(N=2)	51.0 - 57.0(N=2)	86.0 - 92.0(N=2)	0.37 - 0.39(N=2)
Prehistoric					
Bubalus bubalis					
American Museum of Natural History (A.M.N.H.) Yenchingkou fauna, China[2]	186.0 - 215.0(N=6)	76.0 - 91.0(N=5)	51.0 - 62.0(N=6)	84.0 - 97.0(N=6)	0.42 - 0.46(N=6)
B. teilhardi					
Young, 1932a (large)[2]	295.0	91.0	53.0	91.0	0.31

Table 3.27, continued

	Length	**Proximal width**	**Middle width**	**Distal width**	**Ratio:Distal width/length**
Young, 1932a (small)[2]	260.0	79.0	46.0	86.0	0.33
Zdansky, 1928[2]	259.0	89.0	56.5	91.5	0.35
American Museum of Natural History (A.M.N.H.)[2]	273.0	85.0	50.5	-	-
B. wansjocki					
Boule and Teilhard de Chardin, 1928[2]	210.0	90.0	70.0	100.0	0.47
B. mephistopheles					
Teilhard de Chardin and Young, 1936[2]	205.0	72.0 - 79.0	50.0 - 59.0	86.0 - 90.0	-
Bubalus palaeokerabau					
Dubois Collection[1]	195.0 - 208.0(N=2)	83.0	56.0 - 59.0(N=2)	95.0 - 103.0(N=2)	0.49 - 50.0(N=2)
Bibos					
Modern					
Bibos javanicus					
National Museum of Natural History (Leiden)[1]	215.0 - 241.0(N=5)	59.0 - 73.0(N=5)	34.0 - 45.0(N=5)	56.0 - 69.0(N=5)	0.26 - 29.0(N=5)
B. gaurus					
American Museum of Natural History (A.M.N.H.)[2]	259.0 - 271.0(N=2)	60.0 - 63.0(N=2)	38.0 - 39.0(N=2)	64.0 - 67.0(N=2)	0.24 - 0.26(N=2)
Prehistoric					
B. g. grangeri					
American Museum of Natural History (A.M.N.H.) Yenchingkou fauna, China[2]	301.0 - 312.0(N=5)	59.0 - 72.0(N=5)	38.0 - 47.0(N=5)	63.0 - 77.0(N=5)	0.20 - 25.0(N=5)
METATARSALS					
Bubalus					
Modern					
Bubalus bubalis					
National Museum of Natural History (Leiden)	200.0 - 204.0(N=2)	52.0 - 62.0(N=2)	31.0 - 39.0(N=2)	61.0 -70.0(N=2)	0.30 - 0.35(N=2)

Table 3.27, continued

	Length	**Proximal width**	**Middle width**	**Distal width**	**Ratio:Distal width/length**
American Museum of Natural History (A.M.N.H.)	260.0 - 265.0(N=2)	68.0 - 67.0(N=2)	45.0 - 48.0(N=2)	82.0 - 83.0(N=2)	0.31 - 0.32(N=2)
Prehistoric					
Bubalus bubalis					
American Museum of Natural History (A.M.N.H.) Yenchingkou fauna, China	213.0 - 226.0(N=3)	64.0 - 72.0(N=3)	46.0 - 50.0(N=3)	81.0 - 87.0(N=3)	0.37 - 0.38(N=3)
B. teilhardi					
Young, 1932a	290.0	73.0	46.5	81.0	0.28
B. wansjocki					
Boule and Teilhard de Chardin, 1928	250.0	75.0	56.0	85.0	0.34
B. mephistopheles					
Teilhard de Chardin and Young, 1936	230.0	60.0	42.0	60.0	0.26
Bubalus palaeokerabau					
Dubois Collection	245.0 - 246.0(N=2)	60.0 - 63.0(N=2)	42.0 - 44.0(N=2)	71.0 - 76.0(N=2)	0.29 - 0.31(N=2)
Bibos					
Modern					
Bibos javanicus					
National Museum of Natural History (Leiden)	238.0 - 271.0(N=5)	52.0 - 61.0(N=5)	31.0 - 39.0(N=5)	53.0 - 65.0(N=5)	0.22 - 0.24(N=5)
B. gaurus					
American Museum of Natural History (A.M.N.H.)	259.0 - 271.0(N=2)	60.0 - 63.0(N=2)	38.0 - 39.0(N=2)	64.0 - 67.0(N=2)	0.24 - 0.26(N=2)
Prehistoric					
B. g. grangeri					
American Museum of Natural History (A.M.N.H.) Yenchingkou fauna, China	301.0 - 312.0(N=5)	59.0 - 72.0(N=5)	38.0 - 47.0(N=5)	63.0 - 77.0(N=5)	0.20 - 0.25(N=5)
In this study					
Lenggong Valley					
BDC 4-1a+ BDC 4-1b	193.1	63.5	43.0	84.9	0.44

All measurements in mm after:
[1] Hooijer (1958); [2]Colbert & Hooijer (1953)

3.6.3.2 Subfamily Caprinae Gray, 1821, Plate 7 (B1-B5)

Most species belonging to this subfamily are medium to small sized bovids. Until recently, the genus *Nemorhaedus* (gorals) or *Naemorhedus* included the genus *Capricornis* or Serow, and both groups are very close to each other (Corbet & Hill, 1992). The Caprinae is currently represented in Southeast Asia by:

-*Budorcas taxicolor* in Bhutan, north Assam, north Myanmar, and southern China.

-*Naemorhedus goral* is native to the Himalayas from northern Pakistan and Kashmir to the east of Assam.

-*Naemorhedus caudatus* is found mostly in China, southern Myanmar and northern Thailand.

-*Naemorhedus baileyi* is distributed in Yunnan province of China, Tibet, and northeastern India through northern Myanmar.

-*Naemorhedus griseus*, in Myanmar, China, India, Thailand, Vietnam, and possibly Laos.

-*Naemorhedus swinhoei* or *Capricornis swinhoei* is endemic to Taiwan.

-*Naemorhedus sumatrensis* or *Capricornis sumatraensis* also known as the Southern Serow (Figure 3. 28) is native to the Thai-Malay Peninsula and on the Sumatra.

-Chinese Serow, *Capricornis milneedwardsii* is native to China, Cambodia, Laos, Myanmar, Thailand, and Vietnam.

- Red Serow, *Capricornis rubidus* is native to Myanmar.

- Himalayan Serow, *Capricornis thar* is native to Bangladesh, the Himalayas, India, Nepal, and probably western Myanmar.

The last three species are considered a subspecies of *C. sumatraensis*.

Figure 3.28 *Capricornis sumatraensis* from Taiping zoo

Capricornis remains had been recorded as fossils of *Naemorhedus goral* and as a fossil subspecies of *Capricornis sumatraensis kanjereus*, from the Middle Pleistocene of Szechwan, China (Colbert & Hooijer, 1953). *Naemorhedus sumatrensis* remains had been discovered in Vietnam (de Vos & Long, 1993; Bacon *et al*., 2008b), Sumatra Hooijer (1958), and Laos (Bacon *et al*., 2008a). Seven isolated teeth collected from the study area identified as *Capricornis sumatraensis* with the dimensions show in (Table 3.28).

3.6.3.2.1 Teeth description, Figure (3.25)

A. Caprinae in Batu Caves

Upper premolar

P^1/P^2: SC 6-1 (dex.)

One premolar teeth was found in (Swamp Cave) at Batu Caves the rest are molars. Unfortunately this premolar is not complete and damaged at the lingual posterior end making it difficult to know its exact position. Its inner lingual basin is closed at the anterior side and broken at the posterior side. The buccal cusps are not clear. The anterior and posterior halves are assymmetrical on the buccal side. No roots were preserved.

Table 3.28 Dimensions of the upper and lower teeth attributed to *Capricornis sumatraensis* in this study.

Tooth Type	**No.**	**L**	**W**
P^2/P^3 (dex.)*	SC 6-1	13.5	10.9
P^3 (dex.)	BDC 4-18	10.0	10.3
M^1 (dex.)	SC 1-3	15.4	15.2
M^1 (sin.)	SC 1-6	17.7	16.9
M^1 (sin.)	BDC 4-14	15.8	14.0
M^1 (sin.)*	BDC 5-10	12.3	11.7
M_3 (sin.)	CC 5-6	24.8	10.2

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

Upper molars

M^1: SC 1-3 (dex.), Plate 7 (B2), SC 1-6 (sin.), Plate 7 (B3)

Both samples are from the Swamp Cave (Batu Caves). The specimens look semi- squarish in shape at the occlusal view. The anterior and posterior main lobes are well preserved. The anterior lobe with paracone and protocone cusps is lower in height and more elongated than the posterior lobe with metacone and hypocone cusps, the latter lobe being higher and wider in both samples. The protocone is triangular in shape while the hypocone is more oval. A U-shape fossette can be observed clearly at the centre of the posterior lobe of SC 1-6.

The interlobe lingual column is present between the two main lobes in both samples but not very distinct in SC 1-3. It is more prominent in SC 1-6 starting from the base of the hypocone and rising upward attached to the inner side of the protocone. Traces of the anterior groove appear on the outer side of the anterior lobe in SC 1-3, corresponding with similar traces on the outer side of the posterior lobe in SC 1-6. Contact facets are present at the tip of the anterior lobe in SC 1-3 and in the middle of the same lobe in SC 1-6. Both samples are moderately worn but SC 1-6 look more worn than SC 1-3. Both have damaged roots.

<u>Lower molar</u>

M_3: CC 5-6 (sin.)

It is narrow and elongated tooth with three distinct lobes. The lingual cusps (metaconid and entoconid) are aproximately equal in size with sharp triangular shaped buccal cusps (protoconid and hypoconid) while the last lobe (hypoconulid) is lower in height and more flattened. This molar does not possess any interlobe column and the stylids are not prominent. The anterior side is more flattened compared to the posterior end which has a sharp edge. The first two lobes are more swollen buccaly than the last lobe. The surface of the lingual side is almost smooth and without distinct pillars. The sample is relatively worn so the U-shaped fossette appears very fine in the center of the second lobe and clearer in the center of the first lobe. Three incomplete roots are still attached.

B. Caprinae in Lenggong Valley

<u>Upper premolar</u>

P^2: BDC 4-18 (dex.), Plate 7 (B1)

This sample looks swollen in the much worn lingual face with indistinct buccal and lingual cusps. No vertical groove was present on the lingual surface. The parastyle and metastyle are very distinct buccaly. The sample is worn leading to a more flattened occlusal surface with fine fossette at the middle. No pillars are seen at the buccal side. A small contact facet is present at the tip of the posterior side. Two root bases are present at the buccal side and one at the lingual side.

Upper molars

M^1: BDC 4-14 (sin.), Plate 7 (B4), BDC 5-10 (sin.)

Two samples were collected from Badak Cave C (Lenggong Valley). BDC 4-14 is a complete sample, while BDC 5-10 is incomplete with only the posterior lobe preserved while the anterior lobe is broken off. BDC 4-14 is described here. It is an unworn sample with two hypsodont lobes. The general morphology for this sample is very similar to the upper molar samples from Batu Caves except that there is no interlobe column present. The buccal cusps with paracone and metacone have sharp triangular shapes while the lingual cusps with paracone and hypocone are slightly oval in shape. The parastyle and metastyle are preserved at the anterior and posterior ends respectively. A shallow curved crack runs vertically through the posterior side while the anterior side is flattened and smooth. The pillars of the buccal cusps are not developed. Generally, the crown increases in transverse diameter from top to base. No roots and contact facets are preserved.

3.6.3.2.2 Remarks

Teeth belonging to this subfamily are of medium size and have a simpler dental pattern compared with Bovinae’s teeth. Unfortunately, the materials available to me for comparison were only modern and fossil specimens of *Capricornis sumatraensis*.

Some data are not useful for comparison because the dimensions given are for rows of teeth like for the Chinese fossils of *Capricornis suimatraensis kanjereus* and *Naemorhedus* *goral* (Colbert & Hooijer, 1953). They thought there is no difference in individual tooth size between the fossil and the recent forms and the difference must be an average difference only. Despite this, the materials from the present study do show a high morphological similarity to the *Capricornis sumatraensis* specimens available for comparison.

Two samples, SC 6-1 and BDC 4-18, represented the upper premolars in my collection. The first is in a very bad state of preservation, so it will not be taken into account in the comparative study.

Four samples represented the upper molars, two from Batu Caves (Swamp Cave) SC 1-3 and SC 1-6 and two from Lenggong Valley (Badak Cave C) BDC 4-14 and BDC 5-10. BDC 5-10 is not a complete sample as the anterior lobe is lost and it is not included in the comparative measurements in (Table 3.29).

The following morphological characters were observed:

- In the upper premolars, no lingual vertical groove can be seen between the protocone and hypocone of the serow. This groove is very clear in the upper premolars of *Muntiacus muntjak.*

- Both mandible and maxillary teeth have unmarked cusps pillar at the lingual and buccal side respectively. This feature can be observed among both premolars and molars. Tougard (1998) and Bacon *et al.* (2008b) also described this feature on an upper molar from Thum Wiman Nakin (Thailand) and Duoi U'Oi Cave (Vietnam). In all my samples, the lingual side of the lower teeth and the buccal side of the upper teeth are relatively smooth without pillars (ridges). They are not rough as in cervids and thus do not belong to a *Muntiacus*. This character was noted after comparison with modern and fossil teeth of *Capricornis sumatraensis.*

- My samples of upper molars with the solitary upper premolar BDC 4-18, are almost square in general outline with the lengths almost equal to the width (Table 3.28).

The rectangular shape of the lobes that Tougard (1998) described for the upper molars from Thailand is different from my samples, while Bacon *et al.* (2008b) thought that the posterior lobes are much more squarish in occlusal outline than the anterior lobes. Generally the lobes in my collection are triangular in shape especially when the samples had suffered varying degrees of wear.

- In specimens with two lobes, the anterior lobe is often of lower height and more elongated than the posterior lobe.
- In the lower M_3, three lobes are present. The third lobe is smaller compared to the first and second lobes. The buccal side is smooth and without an interlobe column. This column is present clearly in both M^1 samples, SC 1-3 and SC 1-6, from Swamp Cave while it is absent in the Badak Cave C sample BDC 4-14. This column (=basal pillar in Hooijer, 1958) occurs regularly in the posterior outer valley of DM_4 in recent skulls of the Sumatran Serow, *Capricornis sumatraensis sumatraensis* (Bechstein) in the Leiden Museum collection. Schlosser (1903) under *Nemorrhaedus* in Hooijer (1958) noted that the basal pillars occur mostly in M_1, and it is only in the first molars that the base, and thereby the basal pillar may be exposed in a skull. Several specimens of M^2, $M^3$and M_1 possess basal pillars among the collection of isolated *Capricornis* molars from the limestone caves of Central Sumatra (Hooijer, 1958). In some cases these pillars are attached to the anterior inner cusps as in SC 1-6.
- A shallow curved groove runs through the posterior side of the upper molar in SC 1-6 and BDC 4-14 while it is on the anterior side in SC 1-3 which is similar to the groove on the posterior lobe mentioned by Tougard (1998).

The teeth from the current study have more characters in common with the recent and fossil *Capricornis sumatraensis* available.

The small number of samples to study and lack of data relating to sexual dimorphism renders the characters listed above limited for comprehensive study. More material is needed to establish these characters with distinctiveness beyond any doubt.

The dimensions of the teeth are compared to modern and fossil data from various sites in (Table 3.29). The upper molars have semi-square shapes with the lengths sub-equal to the widths. These measurements are similar to the dimensions of the recent Sumatran Serow, *Capricornis sumatraensis sumatraensis*. The specimens from Batu Caves are larger than those of the recent Sumatran Serow but falls within the range of the subfossil teeth of *Capricornis sumatraensis* from the Sumatran cave (Hooijer, 1958) (Table 3.29).

Table 3.29 Comparative measurements of well-preserved *Capricornis sumatraensis* teeth in this study with other modern and prehistoric material.

	P^2	P^3	M^1	M_3
Modern Zoological Museum (University of Malaya)				
N	1	1	1	1
L	13.5	13.9	18.9	25.1
W	9.4	12.9	13.5	9.1
Institute of Biodiversity,Wildlife & National Parks Department (Malaysia)[1]				
N		1	1	
L		12.5	16.5	
W		9.3	14.0	
Museum of National Zoo (Malaysia)[1]				
N		2	2	1
L		8.4 - 9.6	10.3 - 13.2	12.8
W		10.0 - 10.8	11.9 - 14.9	10.5

Table 3.29, continued

National Museum of Natural History (Leiden)[2]	P^2	P^3	M^1	M_3
N			10	12
L			12.0 - 16.0	19.0 - 25.0
W			12.0 - 16.0	9.0 - 11.0
Prehistoric				
National Museum of Natural History (Leiden)				
Padang Highland Caves (Sumatra)				
N				20
L				22.0 - 32.5
W				10.1 - 13.4
Sibrambang Cave(Sumatra)				
N				3
L				23.1 - 25.5
W				11.9 - 12.1
Lida Ajer Cave (Sumatra)				
N				2
L				22.5 - 28.6
W				8.0 - 14.4
Djamboe Cave				
N				2
L				25.6 - 25.7
W				12.0 - 12.3
Sumatran Cave[2]				
N				32
L			16.0-19.0 (N=16)	23.0 - 28.0
W			12.0-18.0 (N=15)	10.0 - 12.0
Lang Trang Caves (Vietnam)[3]				
N			11	4
L			17.0 - 19.9 M^1/M^2*	25.0 - 27.8
W			12.4 - 17.5 M^1/M^2*	11.2 - 12.4
Duoi U'Oi Cave (Vietnam)[4]				
N			4	4
L			17.4 - 19.9 M^1/M^2*	25.4 - 26.8
W			14.5 - 18.3 M^1/M^2*	10.5 - 11.6
Thum Wiman Nakin (Thailand)[5]				
N			1	
L			15.5	17.2-20.8(N=2)
W			10.6	8.0-13.7 (N=5)

	P^2	**P^3**	**M^1**	**M_3**
In this study				
Batu Caves^				
N			2	1
L			15.4 - 17.7	24.8
W			15.2 - 16.9	10.2
Lenggong Valley^				
N		1	1	
L		10.0	15.8	
W		10.3	14.0	

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] Hooijer (1958)
[3] De Vos & Long (1993)
[4] Bacon *et al*. (2008b)
[5] Tougard (1998)
* The measurements are for the unclassified group
^Refer to (Table 3.28) for more details

3.7 Unidentifiable teeth/ bone fragments

Samples include teeth and bone fragments which are not possible to identify them listed in in Appendix B.