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Early Pleistocene large-mammal assemblage associated with *Gigantopithecus* at Chuifeng Cave, Bubing Basin, South China

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ABSTRACT

Chuifeng Cave is one of the typical representatives of the *Gigantopithecus*-bearing mammalian assemblages in southern China. The Chuifeng mammalian assemblage, including 92 *Gigantopithecus blacki* teeth fossils, is important to construct the biochronological and paleobiogeographic framework for the Pleistocene mammalian assemblage in mainland Southeast Asia. Except for the *G. blacki* teeth fossils, the left 721 identified mammalian fossils have never been described in detail until now. Here, we present taxonomic descriptions of the rest mammalian fossils from Chuifeng Cave. The Chuifeng mammalian assemblage consists at least of 28 large mammal taxa, including the Neogene relict species, *Sinomastodon* sp. and *Hippopotamodon ultimus*, and the species for their first appearances in the Pleistocene, *Hystrix magna, Stegodon huananensis, Ailuropoda microta, Rhinoceros fusuiensis, Tapirus sanyuanensis, Sus peii, Sus xiaozhu, Cervus fenqii* and *Megalovis guangxiensis*. Comparisons to already-dated early Pleistocene mammalian assemblages in southern China indicate that the age of this assemblage is around 1.9 Ma, which is consistent with the ESR/U-series and paleomagnetic dating results. The occurrences of *Equus* in the Chuifeng, Liucheng *Gigantopithecus*, Longgudong and Longgupo sites imply that *G. blacki* may survive in an open woodland environment with grasslands nearby in the middle and north parts of southern China.

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Early Pleistocene; Guangxi; *Gigantopithecus*; mammal assemblage

Introduction

As the best-known and representative Quaternary mammalian assemblage in East Asia, the *Gigantopithecus*-bearing assemblage is distinguished by the occurrence of typical member *Gigantopithecus blacki* (Woo 1962; Huang and Fang 1991; Ciochon et al. 1996; Zheng 2004; Wang et al. 2005, 2007a, 2007b; Zhao et al. 2008; Jin et al. 2009; Wang 2009, 2014; Zhang et al. 2014, 2015, 2016, 2017). *G. blacki* is the largest hominoid that ever lived on Earth. It was named as a new hominoid genus and species by von von Koenigswald Ghr (1935) based on a huge lower third molar collected from a Chinese pharmacy in Hong Kong. After the first in situ *G. blacki* fossils was unearthed from the Daxin Hei Cave in Guangxi Zhuang Autonomous Region in 1955 (Pei and Woo 1956), more than one thousand and five hundred teeth fossils and four partial mandibles were excavated and collected from more than eighteen karst cave sites (Zhang and Harrison 2017). Extensive field and excavation works in the last seventy years revealed that the *Gigantopithecus*-bearing assemblage was widely distributed in southern China and mainland Southeast Asia with a range of more than 10 latitudinal zones and an area of more than 600,000 km^2 (Zhang and Harrison 2017). From the northernmost Longgupo site located just south of the Yangtze River to the southernmost Xinchong site on Hainan Island in the South China Sea, the *Gigantopithecus* assemblage has evolved over a period of approximately 1.7 million years, from ~ 2.0 Ma to ~ 0.3 Ma (Zhang and Harrison 2017).

Except for the *G. blacki* fossils, abundant mammalian fossils of Primates, Carnivora, Proboscidea, Perissodactyla and, Artiodactyla etc. are important components of the *Gigantopithecus* assemblage (Jin et al. 2014; Wang et al. 2014; Shao et al. 2015). The continuous and periodic evolutionary process of these mammalian fossils since the Early Pleistocene is the main feature of mammal evolution in southern China and mainland Southeast Asia. For the *G. blacki* itself, studies on more than one thousand teeth fossils have proved that its dental size tends to become larger from the Early Pleistocene to the Middle Pleistocene (Zhang et al. 2015). Some mammal species, such as *Sinomastodon jiangnanensis, Ailuropoda microta*, and *Tapirus sanyuanensis* that first appeared in the early Early Pleistocene, gave their way to *Sinomastodon yangziensis, Ailuropoda wulingshanensis* and *Tapirus sinensis* in the middle Early Pleistocene. And then, they were replaced by *Stegodon orientalis, Ailuropoda baconi* and *Megatapirus augustus* during the late Early Pleistocene and early Middle Pleistocene period (Jin et al. 2014). Thus, the *G. blacki* and associated mammalian fossils are essential materials to chart the biochronological and paleobiogeographic history of mammals in southern China and mainland Southeast Asia during the Pleistocene period.

With the research progress in depth, new mammalian species have been identified in the *Gigantopithecus*-bearing assemblage in recent years (Tong and Guérin 2009; Yan et al. 2014; Zhu et al. 2014, 2016; Jiangzuo et al. 2018a). Together with the previously identified mammalian species also being revised, thus, the *Gigantopithecus*-bearing assemblage that is lack detailed taxonomic descriptions deserves further study. In this paper, we provide taxonomic descriptions of large mammalian fossils from the Chuifeng Cave in which the famous *G. blacki* of the early Early Pleistocene was discovered. This mammalian assemblage is compared with those from other contemporaneous southern China sites, and the results are used to improve the biochronological and paleobiogeographic framework for the *Gigantopithecus*-bearing assemblage followed by further discussion of the palaeoecological condition for *G. blacki*.

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Geological background

The Chuifeng Cave (23°34′27″ N, 107°0′22″ E) is located in the Bubing Basin, in west Guangxi Zhuang Autonomous Region, South China (Figure 1). The cave entrance is about 77 m above the local valley floor. Chuifeng Cave penetrates the late Paleozoic limestone hill from southeast to northwest, being 19 m in length, 0.5–2 m in width, and 1.5–5 m in height. The fossiliferous deposit consisting of greyish-brown sandy clay is well-preserved in this cave with an average depth of 1.3 m. Details of the excavation process and the dating result of the Chuifeng Cave are present in Wang (2009) and Shao et al. (2014).

Material and method

More than 1000 mammalian fossils of Primates, Rodentia, Proboscidea, Carnivora, Perissodactyla and Artiodactyla are discovered from the Chuifeng Cave. All fossil specimens are preserved at Natural History Museum of Guangxi, of which 92 *G. blacki* fossil teeth have been studied by Wang (2009). In this study, we present taxonomic descriptions and metric data of the rest 712 identified mammalian specimens mainly composed of teeth and rare partial mandibles. The maxillary teeth and mandibular teeth were represented by upper case `M′ and lower case `m′, respectively. In terms of the dental nomenclature and metric measurement, we relied on Deng et al. (1999)

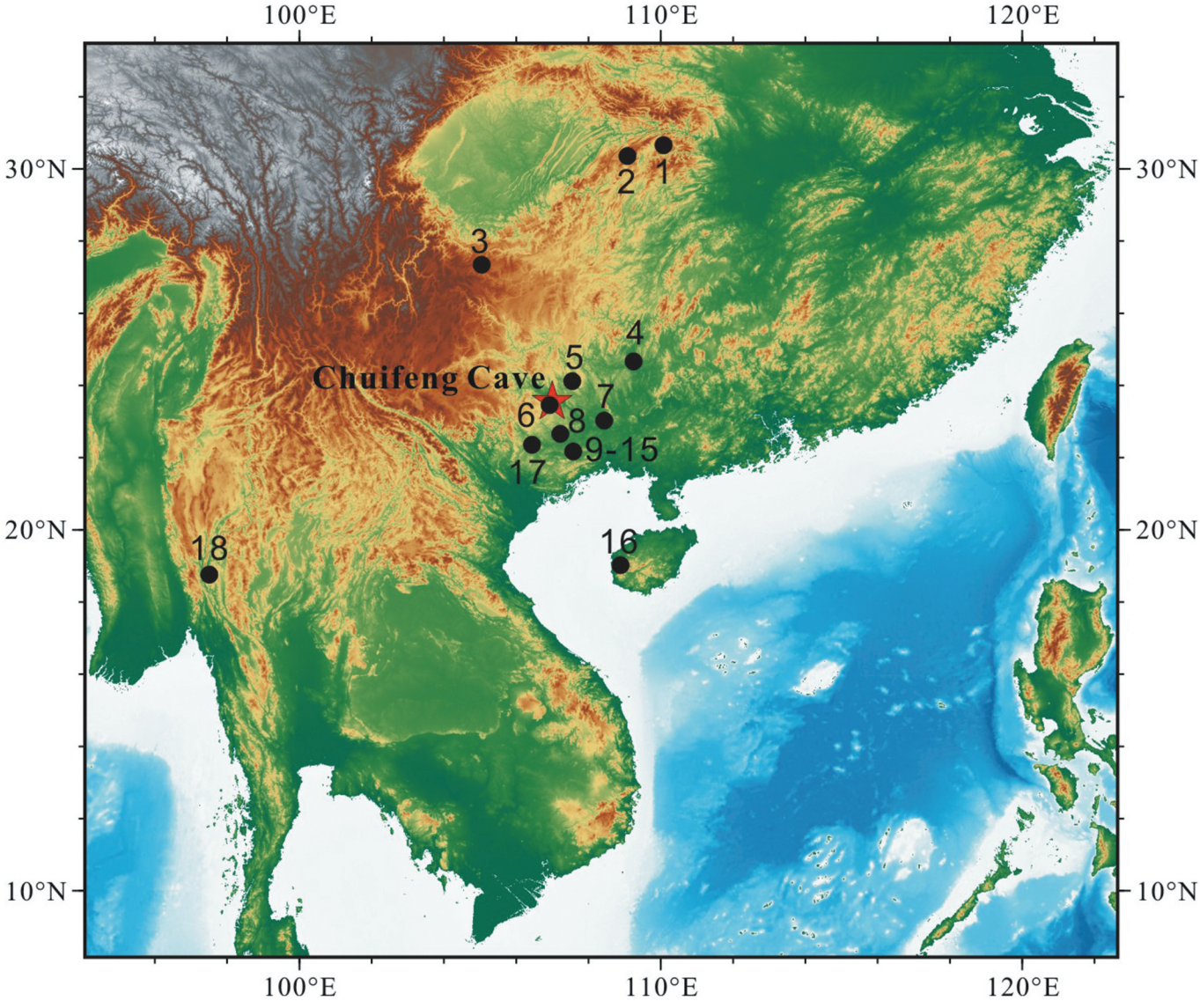

Figure 1. Location of the Chuifeng Cave with other *Gigantopithecus*-bearing sites in southern China and mainland Southeast Asia. 1. Longgudong Cave; 2. Longgudong site; 3. Ba'eryan Cave; 4. Liucheng Gigantopithecus Cave; 5. Bama Gigantopithecus Cave; 6. Mohui Cave; 7. Bulalishan Cave; 8. Daxin Hei Cave; 9–15,. Baikong Cave, Yanliang Cave, Boyue Cave, Sanhe Cave, Queque Cave, Shuangtan Cave and Hejiang Cave; 16,. Xinchong Cave; 17,. Tham Khuyen Cave; 18,. Pha Bong site. The *Gigantopithecus*-bearing sites are according to .Zhang and Harrison (2017) and Wang et al. (2017).

for the proboscideans, Jiangzuo et al. (2018b) for canids, Jiangzuo et al. (2018a) for badgers, Qiu et al. (1987) for equids, Tong (2005) for tapirs, Yan et al. (2014) for the rhinoceroses, and van der Made (1996) for the suids and, Suraprasit et al. (2016) and Zhang et al. (2018b) for ruminants.

Results

Systematic palaeontology
Class Mammalia Linnaeus, 1758
Order Primates Linnaeus, 1758
Suborder Haplorrhini Pocock, 1918
Family Hylobatidae Gray, 1870
Genus *Nomascus* Miller, 1933

Nomascus sp

Referred material (Figure 2)
A left M3, CF281.

Material description
The left M3 is broader than its length with well-rounded corners. The tooth is low-crowned with four low and rounded cusps with strong distal tapering. Compared with protocone and paracone, the hypocone and metacone are greatly reduced in size. The protocone and metacone are connected by a low crista obliqua. A cingulum is on the buccal side of the paracone.

Taxonomic remarks and comparisons
The only M3 of Chuifeng Cave has same features of the upper third molar of extant hylobatids. The dimensions of this M3 are larger than the dental sizes of extant *Hylobates*, and are comparable to those of extant *Nomascus* and *Nomascus* fossils from Pleistocene cave sites of Chongzuo area in southern China (Zhang et al. 2018b). Since there is only one tooth, we cautiously assigned this specimen to *Nomascus* sp.

Family CERCOPITHECIDAE Gray, 1821
Genus *Macaca* Lacépède, 1799

Macaca sp

Referred material (Figure 2)
A left male C, CF282; a right P3, CF283; a left P4, CF284; a left M2, CF285; a right i1, CF286; two left p3, CF287 and CF288; a right p3, CF289.

Material description
In the mesial part of crown, upper male canine has a marked and deep groove which extends from cusp to the base of the crown. The P3 and P4 both have a higher paracone on the buccal side and a lower protocone on the lingual side. The paracone and protocone are connected by a transverse ridge or loph which divides the oval crown to a smaller mesial fovea and a wider and deeper distal fovea. The M2 is low-crowned, typical bilophodont with a rectangular outline. The protocone and paracone in the mesial part and the hypocone and metacone in the distal part are connected by transverse ridges or lophs. A cingula is present on the mesiolingual part of the crown. The i1 is heavily worn. The p3s are sectorial and mesiodistally elongated, in the view from the buccal side. Dental enamel sharply downwards to the mesial part of the crown. The lingual cingulum is well-preserved.

Taxonomic remarks and comparisons
The teeth fossils from Chuifeng Cave preserve typical dental characters of the cercopithecoids, such as lophodont P3 and P4, low-crowned and bilophodont M2, sectorial and mesiodistally

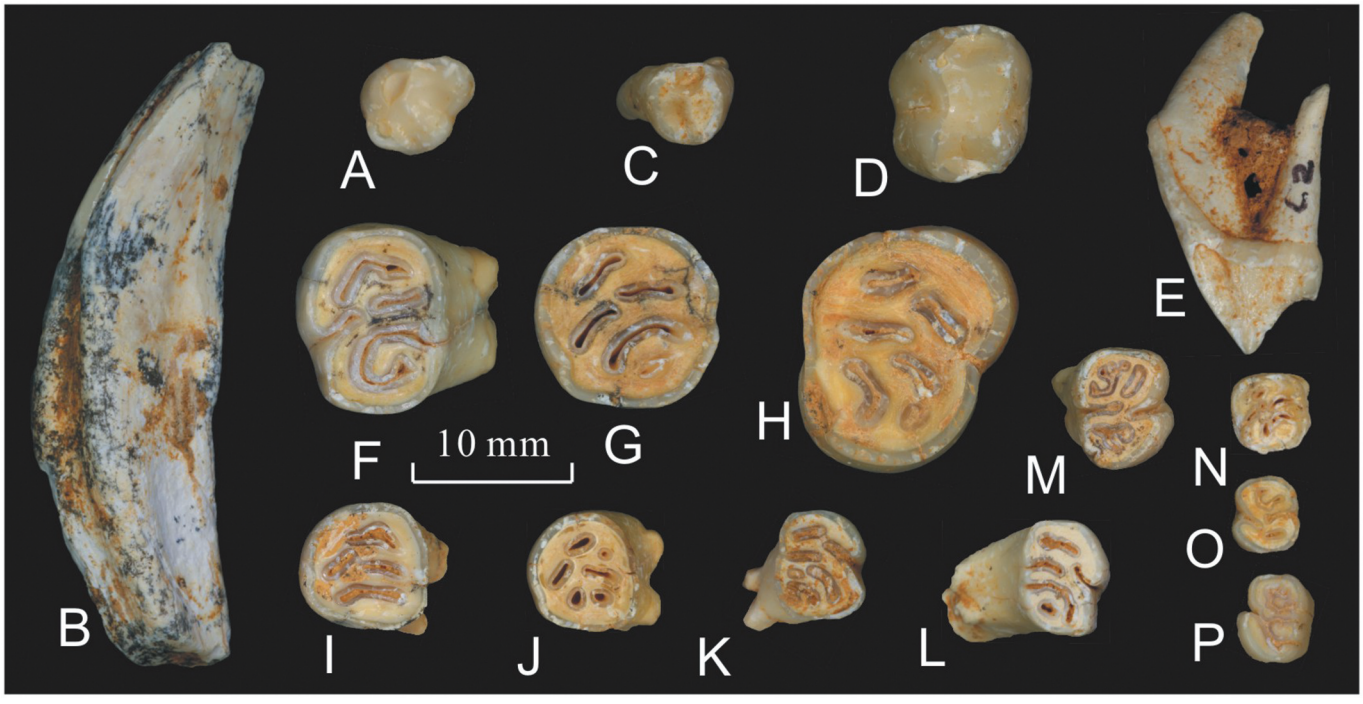

Figure 2. Primates and Rodentia from Chuifeng Cave. *Nomascus* sp.: A, Left M3 (CF281); *Macaca* sp., B-E: B, Left C (CF282); C, Left P4 (CF284); D, Left M2 (CF285); E, Left p3 (CF287); *Hystrix magna*, F-H: F, Left M1/M2 (CF204); G, Left M1/M2 (CF206); H, Left p4 (CF208); *Hystrix kiangsenensis*, I-M: I, Left P4 (CF226); J, Left P4 (CF227); K, Right M1/M2 (CF237); L, Right M3 (CF242); M, Right m1/m2 (CF269); *Atherurus* sp., N-P: N, Left M1/M2 (CF317); O, Left m1/m2 (CF327); P, Left m3 (CF331).

elongated p3s. As only teeth are available, we attribute this material to *Macaca* sp.

Order Rodentia Bowdish, 1882
Family Hystricidae Burnett, 1830
Genus *Hystrix* Linnaeus, 1758
Hystrix magna Pei, 1987

Referred material (Figure 2)
Left I1s, CF161 and CF162; Right I1s, CF158, CF159 and CF160; A right P4, CF202; Left M1/M2s, CF204, CF205 and CF206; A right M1/M2, CF203; A right M3, CF207; A left i1, CF163; A left p4, CF208; Right m1/m2, CF209 and CF210; Left m3s, CF211 and CF212.

Material description
Maxillary cheek teeth are curved towards the labial side. Mandibular cheek teeth are straight and not curved. For maxillary cheek teeth, there is a deep hypofelexus opening backward in the lingual side on slightly abraded specimen. The paraflexus, mesoflexus and metaflexus are in the labial side. On deeply abraded specimen, the paraflexus, mesoflexus and metaflexus are replaced by three enamel rings in the lingual side. For mandibular cheek teeth, there is a deep hypoflexid opening forward in the labial side on slightly abraded specimen. The paraflexid, mesoflexid and metaflexid are in the lingual side. For the P4 and p4, the elliptical interproximal facet is on the distal face of the crown. There are elliptical interproximal facets on the mesial and distal faces of M1/M2, and m1/m2. There is an elliptical interproximal facet on the mesial face of M3 and m3.

Taxonomic remarks and comparisons
Hystrix magna is firstly established by Pei (1987), based on the larger size of the *Hystrix* teeth fossils from the Liucheng *Gigantopithecus* Cave. The *Hystrix* fossils with large dental size from the Logupo, Longgudong, Mohui and Juyuan sites are classified as this species (Huang and Fang 1991; Zheng 2004; Wang et al. 2014; Shao et al. 2015). The large *Hystrix* fossils from the Chuifeng Cave have the same crown features and sizes with the *Hystrix magna* in southern China, and thus are identified as this species.

Hystrix kiangsenensis Wang, 1931

Referred material (Figure 2)
Left I1s, CF168, CF169, CF170, CF171 and CF172; Right I1s, CF164, CF165, CF166 and CF167; Left P4s, CF219, CF220, CF221, CF222, CF223, CF224, CF225, CF226, CF227, CF228 and CF229; Right P4s, CF213, CF214, CF215, CF216, CF217 and CF218; Left M1/M2s, CF238 and CF239; Right M1/M2s, CF230, CF231, CF232, CF233, CF234, CF235, CF236 and CF237; Left M3s, CF245 and CF246; Right M3s, CF240, CF241, CF242, CF243 and CF244; Left i1s, CF171 and CF172; Left p4s, CF248, CF249 and CF250; Right p4s, CF251, CF252 and CF253; Left m1/m2s, CF254, CF255, CF256, CF257, CF258, CF259, CF260, CF261, CF262, CF263 and CF264; Right m1/m2s, CF265, CF266, CF267, CF268, CF269, CF270, CF271 and CF272; Left m3s, CF273 and CF274; Right m3s, CF275, CF276 and CF277.

Material description
The crown features of *Hystrix kiangsenensis* specimens are similar to *Hystrix magna* but with medium teeth sizes.

Taxonomic remarks and comparisons
Based on metrical data of *Hystrix* specimens from the Liucheng *Gigantopithecus*, Xiaoyan, Yanhui, Wazhuwan, Longgupo and Zhoukoudian sites, Van Weers and Zheng (1998) suggested that the *Hystrix* specimens which are larger than *Hystrix lagrelli* and smaller than *Hystrix magna*, belong to *Hystrix kiangsenensis*. The *Hystrix* specimens of medium sizes from Chuifeng Cave are within the size variation range of *Hystrix kiangsenensis*, we therefore assign these specimens to *Hystrix kiangsenensis*.

Genus *Atherurus* Cuvier, 1929

Atherurus sp.

Referred material (Figure 2)
Left I1s, CF181, CF182, CF183, CF184, CF185, CF186, CF187 and CF188; Right I1s, CF173, CF174, CF175, CF176, CF177, CF178, CF179 and CF180; Left P4s, CF312, CF313, CF314, CF315 and CF316; Right P4s, CF309, CF310 and CF311; Left m1/m2s, CF317, CF318, CF319 and CF320; Left m3s, CF321 and CF322; A right m3, CF323; Left i1s, CF189, CF190, CF191, CF192 and CF193; Right i1s, CF194, CF195, CF196, CF197, CF198, CF199, CF200 and CF201; Left p4s, CF324, CF325 and CF326; Left m1/m2s, CF327, CF328 and CF329; A right m1/m2, CF330; Left m3s, CF331 and CF332; Right m3s, CF333, CF334, CF335, CF336, CF337 and CF338.

Material description
The crown features of *Atherurus* specimens are similar to *Hystrix kiangsenensis* but with very small teeth sizes.

Taxonomic remarks and comparisons
The *Atherurus* specimens of the Chuifeng Cave have similar crown features and teeth sizes as the *Atherurus* sp. from the Liucheng *Gigantopithecus* site (Pei 1987), we, therefore, assign these specimens to *Atherurus* sp.

Order Proboscidea Illiger, 1811
Family Stegodontidae Osborn, 1918
Genus *Stegodon* Falconer and Cautley, 1857
Stegodon huananensis Chen, 2011

Referred material (Figure 3)
A left DP2, CF247; A left Dp2, CF247-1; A left m2, CF247-2.

Material description
Crown profile of the DP2 is circulara circular triangle, and narrow at the front and wide at the back. The DP2 has two lophs and a posterior talonid. The pretrite and posttrite are present in the first loph. There is no cement in the valleys between the ridges. The Dp2 is trapezoidal in outline with a wider posterior part. It has five ridges and an anterior cingulum. The number of mammillae in the fifth ridge are 12. Little cement is preserved in the valleys between the ridges. The m2 trapezoidal in outline with a wider posterior part. It preserves six ridges and an anterior cingulum. The number of mammillae in the ridges are from 9 to 10. Little cement is preserved in the valleys between the ridges. Valleys between the ridges are 'V' shape.

Taxonomic remarks and comparisons
A new species *Stegodon huananensis* was established by Chen (2011) to distinguish the Early Pleistocene *Stegodon* specimens from the Liucheng *Gigantopithecus*, Longgupo, and Longgudong

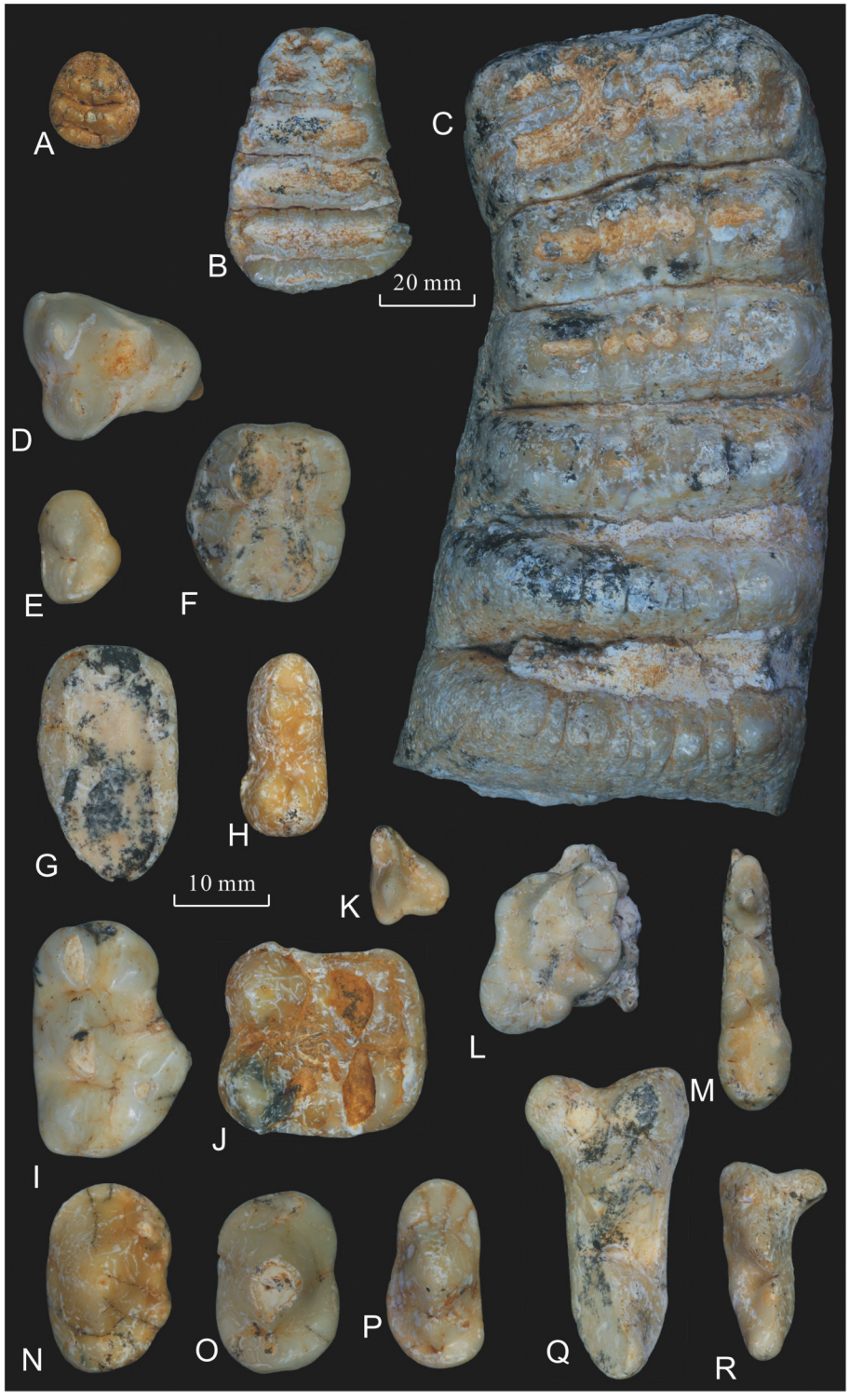

Figure 3. Proboscidea and Carnivora from Chuifeng Cave. *Stegodon huananensis*, A-C: A, Left DP2 (CF247); B, Left Dp3 (CF247-1); C, Left m2 (CF247-2); *Sinicuon dubius*, D, Right M1 (CF293); *Ursus thibetanus*, E-H: E, Right P4 (CF148); F, Right M1 (CF151); G, Right M2 (CF153); H, Right m1 (CF156); *Ailuropoda microta*, I-J: I, Right P4 (CF144); J, Right M1 (CF146). *Meles magnus*, K-M: K, Left P4 (CF297); L, Left M1 (CF302); M, a partial mandible with p4 and m1 (CF308); *Pachycrocuta brevirostris licenti*, N-O: N, Right P2 (CF291); O, Left p2 (CF290);*Panthera pardus*, P-Q: P, Left P3 (CF292-1); Q, Left P4 (CF292); *Felis teilhardi*, R, Right P4 (CF294). The scale bars are 20 cm for Proboscidea and 10 cm for Carnivora, respectively.

sites, from the *Stegodon orientalis*. *Stegodon* fossils from the Baikong, Juyuan, Sanhe, and Mohui Caves are also assigned to this species (Wang et al. 2014; Shao et al. 2015). The specimens from the Chuifeng Cave resemble that of *Stegodon huananensis* including the DP2 with two lophs and a posterior talonid, pretrite and posttrite in the first loph, and m2 with little cement filled in the valleys. ThusThus, those specimens from the Chuifeng Cave can be allocated to *S. huananensis*.

Order Carnivora Bowdich, 1821
Family Canidae Fischer de Waldheim, 1817
Genus *Sinicuon* Kretzoi, 1941

Sinicuon dubius

Referred material (Figure 3)
A right M1, CF293.

Material description
Crown profile of the M1 is sub-triangular with relatively straight mesial and buccal sides. Central part of posterior margin recesses forward. The paracone is the most developed cusp with a small but distinct parastyle located at its antero-buccal side. The buccal cingulum is weak but throughout the buccal side of the crown. The paraconule and metaconule are developed and ridge-like. In the lingual slope of the paracone and metacone, weak ridges are also developed. The lingual cingulum consists of two parts, a weak part in the mesial side of the protocone and a well-developed part around the posterior side of the protocone, forming the weak hypocone. There are three roots for M1, a strongest lingual root and two buccal roots.

Taxonomic remarks and comparisons
The M1 from the Chuifeng Cave represents a large size species with typical characteristic of *Sinicuon* such as the weak hypocone apparently as part of the lingual cingulum. And its dental size is within the size range of *Sinicuon dubius* from the Liucheng *Gigantopithecus*, Longgupo and Longgudong sites (Pei 1987; Huang and Fang 1991; Zheng 2004). Therefore, it can be assigned to *Sinicuon dubius*.

Family Ursidae Fischer de Waldheim, 1817
Genus *Ursus* Linnaeus, 1758
Ursus thibetanus Cuvier, 1823

Referred material (Figure 3)
A left P4, CF150; Right P4s, CF148 and CF149; Right M1s, CF151 and CF152; Right M2s, CF153 and CF154; A left m1, CF155; A right m1, CF156.

Material description
The crown of P4 is triangular. The paracone is larger than metacone and hypocone. Cingulum is present on the anterior lingual and buccal sides of the crown. The crown of M1 is near rectangle. The width of the crown in the metacone is slightly larger than the width in the paracone. Parastyle and metastyle are present. Cingulum is present on the anterior lingual and buccal sides of the crown. The crown of M2 is trapezoid. The M2 is longer than M1 with the elongated talon. The m1 is long and narrow. The protoconid is the highest cusp. The metaconid is low, and the premetaconid is slightly higher than the metaconid. The premetaconid forms an angle with the anterior ridge of the metaconid. The posterior ridge of the metaconid is connected to the posterior ridge of the protoconid. The cingulid is present on the buccal side of the hypoconid.

Taxonomic remarks and comparisons
Compared with the *Ursus malayanus*, the differences of the Chuifeng *Ursus* specimens including their larger dental sizes, P4 with developed hypocone, M1 with less developed lingual cingulum, M2 with wide and elongated talon basin, and m1 with long and narrow crown. The Chuifeng *Ursus* specimens are smaller than the *Ursus* fossils from northern China, such as *Ursus deningeri* (Jiangzuo et al. 2018c). The Chuifeng *Ursus* specimens have similar dental sizes and crown features as the *Ursus thibetanus* from the Liucheng *Gigantopithecus*, and Longgupo sites (Pei 1987; Huang and Fang 1991), and, we, therefore, assign this specimen to *Ursus thibetanus*.

Family Ailuropodidae Pocock, 1921
Genus *Ailuropoda* Milne-Edwards, 1870
Ailuropoda microta Pei, 1987

Referred material (Figure 3)
Right P4s, CF144 and CF145; A right M1, CF146; Left p2s, CF157 and CF157-1; A right m2, CF147.

Material description
The P4 has five cusps, two cusps on the lingual side and three cusps on the buccal side. The protocone is located on the lingual side between the parastyle and paracone. The protocone is smaller than the hypocone that is ridge-shaped in anterior-internal and posterior-external direction. Three small cusps are located on the lingual cingulum between the protocone and hypocone. The paracone is higher than the parastyle and labialwards positioned metacone. The crown of M1 is near square. The anterior side is slightly concave to back. The posterior side is straighter. The parastyle is located in the anterior part of the paracone. The paracone is slightly lower than and with the same size as metacone. The lingual cingulum is well-developed. The lingual side of the p2 is convex with a relatively flat labial side. The paraconid is represented by a small ridge extending downward from the protoconid. The hypoconid is separated from the protoconid by a shallow notch. The p2 has two roots.

Taxonomic remarks and comparisons
The *Ailuropoda* specimens from Chuifeng Cave are characterised-characterized by their sizes (Table 1). Compared with *Ailuropoda wulingshanensis*, the Chuifeng specimens have a P4 with protocone smaller than parastyle, M1 with more-developed anterior cingulum and lingual cingulum cutted by medial groove. The Chuifeng *Ailuropoda* specimens have similar dental sizes and crown features

Table 1. Dental dimensions of *Ailuropoda microta* from Chuifeng Cave and other species (mm). Data for comparisons are from Zheng (2004), Jin et al. (2007) and Wang et al. (2017).

	P4		M1		p2	
	L	W	L	W	L	W
Chuifeng Cave	24.4	16.2	20.3	21.9	8.5–8.7	5.1–5.1
Ailuropoda microta	19.4–22.5	12.0–16.0	17.7–23.0	16.5–23.2		
Ailuropoda wulingshanensis	20.8–25.9	14.1–18.6	20.0–26.3	21.8–27.5		
Ailuropoda baconi	24.8–30.5	16.5–21.8	25.1–29.0	26.0–31.5	10.8–15.9	6.3–9.2
Ailuropoda melanoleuca	22.6–26.7	16.8–20.1	22.4–26.2	25.1–29.6	10.4–12.3	6.0–7.3

as the *Ailuropoda microta* from the Liucheng *Gigantopithecus* and Longgupo sites (Pei 1987; Huang and Fang 1991), we assign this specimen to *Ailuropoda microta*.

Family Mustelidae Fischer de Waldheim, 1817
Genus *Meles* Brisson, 1762
Meles magnus Jiangzuo, Liu, Wagner and Chen, 2018

Referred material (Figure 3)
Left P4s, CF296 and CF297; A right P4, CF295; Left M1s, CF302, CF303, CF304, CF305, CF306 and CF307; A partial mandible with p4 and m1, CF308.

Material description
The crown of P4 is triangular. The paracone is the highest cusp. The parastyle is weak. The protocone developed well, while the protoconule did not.Thenot. The middle point of the inner lobe lies a little before the tip of the paracone. Labial incisions of M1 are weakly-developedweakly developed and between paracone and metacone, between metacone and metaconule and posterior to metaconule. The anterior margin of inner cingulum lies between anteriorthe anterior tip of paracone and apexthe apex of paracone. The protocone is subdivided into three cusps, the anterior one is smallest and inclines antero-labially, while the posterior two are in line and subequal in size. Paraconid of m1 is the highest cusp. There is a notch between paraconid and protoconid. The anterior margin of hypoconid lies a little behind apex of metaconid. There are two entoconids with the larger anterior entoconid.

Taxonomic remarks and comparisons
The Badger specimens of the Chuifeng Cave clearly show the dental features of *Mele* (Jiangzuo et al. 2018a), including P4 with parastyle and forward position of the middle point of the inner lobe, M1 with weakly developed labial incision between posterior to metaconule, forward position of the anterior margin of inner cingulum. The Chuifeng Badger specimens have similar dental sizes and crown features as the *Meles magnus* from the Liucheng *Gigantopithecus* site (Jiangzuo et al. 2018a), we, therefore, assign this specimen to *Meles magnus*.

Family Hyaenidae Gray, 1869
Genus *Pachycrocuta* Kretzoi, 1938
Pachycrocuta brevirostris Gervais, 1850
Pachycrocuta brevirostris licenti Pei, 1934

Referred material (Figure 3)
A right P2, CF291; A left p2, CF290.

Material description
The P2 has a large main central cusp. Two lateral ridges extend from the tip of main cusp to the base of crown at the anterior lingual side and posterior sideside, respectively. The anterior and posterior accessory cuspids are well-developed at the base of anterior and posterior ridgesridges, respectively. They are separated from the main cusp by a shallow notch. Cingulum are obvious on the anterior and lingual sides of the crown. The p2 has a large main central cusp. Two lateral ridges extend from the tip of main cusp to the base of crown at the anterior side and posterior sideside, respectively. The anterior accessory cuspid is absent. The posterior accessory cuspid is well-developed at the base of posterior ridge. It is separated from the main cusp by a shallow notch. Cingulum are present on the anterior and lingual sides of the crown.

Taxonomic remarks and comparisons
The *Pachycrocuta* specimens of Chuifeng Cave are characterisedcharacterized by their large sizes, well-developed anterior accessory cuspid on P2, and the cingulum on the anterior and lingual sides of the crowns. The P2 and p2 are larger than the *Crocuta crocuta* in China and mainland Southeast Asia. Although they are in the size distributions of later *Pachycrocuta brevirostris brevirostris* and *Pachycrocuta brevirostris sinensis* (Liu et al. 2021), they can be separated from these two species by the occurrence of anterior accessory cuspid on P2, the well-developed cingulum and elongated crown of p2. Based on their older age, larger dental size and crown features feather, we identify these two specimens asthat belong to *P. b. licenti*.

Family Felidae Fischer de Waldheim, 1817
Genus *Panthera* Oken, 1816
Panthera pardus Linnaeu, 1875

Referred material (Figure 3)
A left P3, CF292-1; A left P4, CF292.

Material description
The P3 has a large main central cusp. The anterior ridge extends from the tip of main cusp to the base of crown at the anterior lingual side. A small anterior accessory cuspid is developed at the base of anterior ridge. A posterior accessory cuspid are well-developed. It is separated from the main cusp by a shallow notch. Cingulum areis obvious on the anterior and posterior sides of the crown. The protocone of P4 is strong. Its anterior margin is slightly more back than parastyle. There is a concave depression in the anterior side of the crown between the protocone and parastyle. The tips of paracone and metastyle are comparable in height. There are three roots. The two anterior roots below the protocone and parastyle are strongestrong. The posterior root is longitudinal flattening.

Taxonomic remarks and comparisons
The *Panthera* specimens of the Chuifeng Cave have similar dental sizes and crown features as the specimens of *Panthera pardus* from the Liucheng *Gigantopithus*, Longgupo and Longgudong sites (Pei 1987; Huang and Fang 1991; Zheng 2004), we assign these specimens to *Panthera pardus*.

Genus *Felis* Linnaeus, 1758
Felis teilhardi Pei, 1934

Referred material (Figure 3)
A right P4, CF294.

Material description
The protocone of P4 is strong. Its anterior margin is slightly further back than the parastyle. There is a concave depression in the anterior side of the crown between the protocone and parastyle. The tips of paracone isare higher than metastyle. There are three roots. The two anterior roots below the protocone and parastyle are stronge. The posterior root is longitudinal flattening.

Taxonomic remarks and comparisons
The *Felis* specimen of the Chuifeng Cave are comparable in their sizes and crown features with the specimens of *Felis teilhardi* from the Liucheng *Gigantopithus* and Longgupo sites (Pei 1987; Huang and Fang 1991), we assign these specimens to *Felis teilhardi*.

Order Perissodactyla Owen, 1848
Family Equidae Gray, 1821
Genus *Equus* Linnaeus, 1758

Equus sp.

Referred material (Figure 4)
A left P3/P4, CF279; a right m1/m2, CF280.

Material description
The crown of the left P3/P4 is well-preserved, nearnear-square in outline with its length slightly longer than width. The parastyle is obvious and extends labially, with a shallow groove in the mesial buccal corner from top to bottom. The pli protoloph, pli protoconule, pli prefossette and pli postfossette are all well-developed. The protocone is narrow and middle-grooved with sharp anterior and posterior ends. The pli caballine and hypoconal groove are obvious. The parastylid of the p3/p4 is small and simple and extends lingually. The metaconid long oval shape and the metastylid have square-shaped posterolingual angle. The lingual flexid is narrow and V-shaped. The pli caballinid is present on the buccal side. The ectoflexid reaches the opening of the isthmus with a tip that extends posteriorly.

Taxonomic remarks and comparisons
The P3/P4 is larger than those of the *Equus Yunnanensis* from the Yuanmou and Longgupo sites (Pei 1961; Huang and Fang 1991). The *Equus* specimens have similar dental sizes and crown features as the specimens *Equus* sp. from the Longgudong site (Shao et al. 2014), we assign these specimens to *Equus* sp.

Family Rhinocerotidae Owen, 1840
Subfamily Rhinocerotinae Owen, 1845
Genus *Rhinoceros* Linnaeus, 1758
Rhinoceros fusuiensis Yan, Wang, Jin and Mead, 2014

Referred material (Figure 4)
A right DP3, 009468; A right P3, 009464; A right P4, 009476; A right M1, 009446; A left M1, 009474; Two left M2s, 009445 and 009457; A right Dp1, 009536; A left Dp1, 009778; A right Dp2, 009613;

Figure 4. Perissodactyla from Chuifeng Cave. *Equus* sp., A-–B: A, Left P3/P4 (CF279); B, Right m1/m2 (CF280); *Rhinoceros fusuiensis*, C-H: C, Right P3 (009464); D, Right P4 (009476); E, Left M2 (009445); F, Right p4 (009472); G, Right m2 (009452); H, Right m3 (009475); *Tapirus sanyuanensis*, I-K: I, Left P2 (CF132); J, Left P4 (CF133); K, Right M3 (009448).

Three left Dp2s, 009642, 009664 and 009715; A left Dp3, 009458; Two right Dp3s, 009467 and 009484; A left Dp4, 009454; A left p2, 009764; A right p3, 009478; A right p4, 009472; A left p4, 009453; Two right m1s, 009456 and 009489; Two right m2s, 009452 and 009477; A right m3, 009475; A left m3, 009460.

Material description

The DP3 is trapezoidal in occlusal outline with a wider buccal side than the lingual side. The paracone and metacone ribs are present on the buccal side. The crochet and crista are well-developed but not connected each other. There are gaps between protoloph, crochet and crista. The base of the protoloph is inflated, which occupies two-thirds of the lingual side of the crown. The well-developed postfossette is shallower than the median valley which has a broad entrance to the buccal side with no tuber. The protocone constriction is weak. The width of P3 is longer than its length. The paracone rib is more prominent than the metacone rib. The parastyle is more distinct than the metastyle. The crochet is well-developed and not connected to protoloph. The crista is absent. The anterior, lingual and posterior cingulua are developed. The P4 has more distinct anterior and posterior cingulua than P3. Accessory tips are developed in the anterior and posterior cingulua. The crochet is well-developed and connected to protoloph. The M1s are nearly square in occlusal outline. The parastyle and metastyle are well-developed on the anterior and posterior ends of the ectoloph. The post part of ectoloph is prominently inclined to the lingual side. The crochet is well-developed but not connected to protoloph. The anterior and posterior cingulua are developed without lingual cingulum. Except for larger size, the dental morphology of M2 is similar to that of M1. The Dp1s are very small. They have two lobes, the metalophid and the hypolophid. The anterior and the posterior valleys are shallow and open, and the latter is more distinguished than the former. The ectoflexid is present. The Dp2s are similar and larger than Dp1.

The right Dp2 has the posterior valley closed on the lingual side and the left Dp2s are open. The anterior valley is very narrow. The ectoflexid of Dp2 is more distinguished than that of Dp1. The Dp3s are larger than Dp2, with more developed anterior and posterior valleys. The talonid basin is wider and deeper than the trigonid basin. The ectoflexid is obvious. The Dp4 has the largest size among all the deciduous teeth with its high degree of molarisationmolarization. The p2 is small and simple in dental morphology. The trigonid and talonid are traced by small and shallow V-shaped valleys. The ectoflexid on the buccal side is slight but can be observed. The p3 has a larger size than p2. The trigonid, talonid and ectoflexid are developed. The dental characters of p4 to m3 are similar to each other. The paralophid is more developed than in p3. The trigonid, talonid and ectoflexid are well-developed. The trigonid basin is narrower and shallower than the talonid basin.

Taxonomic remarks and comparisons

The *Rhinoceros* specimens from the Chuifeng Cave represent a small dental size *Rhinoceros* species. The *Rhinoceros* specimens are comparable in their sizes and crown features with the specimens of *Rhinoceros fusuiensis* from the Yanliang Cave (Yan et al. 2014), we assign these specimens to *Rhinoceros fusuiensis*.

Family Tapiridae Burrett, 1830
Genus *Tapirus* Brisson, 1762
Tapirus sanyuanensis Huang et al., 1991

Referred material (Figure 4)

A left P2, CF132; A left P4, CF133; A right M3, 009448.

Material description

The crown of P2 is near trapezoidal. The buccal side is wider than the lingual side. The buccal cusps, paracone and metacone, are more robust than the lingual cusps, protocone and hypocone. The parastyle and metastyle are well-developed. Metaloph meets the ectoloph between paracone and metacone. The protoloph is shorter than the metaloph. The anterior cingulum is well-developed. The crown of P4 is oblique quadrilateral. The four main cusps equally developed, and the metacone is more lingually positioned. The parastyle and metastyle are developed. Metaloph meets the ectoloph between paracone and metacone. The protoloph is longer than the metaloph. The anterior cingulum is well-developed. The posterior cingulum is discontinued at the metacone. The crown of M3 is oblique quadrilateral. The lingual cusps, protocone and hypocone, are more robust than the buccal cusps, paracone and metacone. The parastyle is well-developed, but the metastyle is not present. Metaloph meets the protoloph and ectoloph in front of the paracone and metacone respectively. The protoloph is longer and stronger than the metaloph. The anterior and posterior cingula are well-developed.

Taxonomic remarks and comparisons

The *Tapirus* specimens from the Chuifeng Cave are smaller than the *Tapirus sinensis* and *Megatapirus augustus* (Table 2). The *Tapirus* specimens are comparable in their sizes and crown features with the specimens of *Tapirus sanyuanensis* from the Yanliang, Longgupo and Longgudong sites (Huang and Fang 1991; Zheng 2004; Yan et al. 2016), we assign these specimens to *Tapirus sanyuanensis*.

Table 2. Dental dimensions of *Tapirus sanyuanensis* from Chuifeng Cave and other species (mm). Data for comparisons are from Yan et al. (2016). Wa, width of anterior lobe; Wp, width of posterior lobe.

		Chuifeng Cave	*Tapirus sanyuanensis*	*Tapirus sinensis*	*Megatapirus augustus*
P2	L	23.4	19.5–23.0	21.0–22.0	22.0–26.0
	Wa	24.5	22.0–24.5		27.0–32.0
	Wp	27.6	20.0–27.5	22.5–25.0	28.0–35.0
P4	L	22.3	20.8–24.1	26	29.0–33.0
	Wa	30.0	26.5–33.0	30.5	38.0–40.0
	Wp	26.8	25.0–30.1		36.0–39.0
M3	L	29.5	25.0–30.5	24.0–33.0	34.0–38.0
	Wa		28.2–33.6	29.5–37.0	39.0–41.0
	Wp	24.7	23.5–28.0	28.0–30.0	31.0–33.0

Order Artiodactyla Owen, 1848
Family Suidae Gray, 1821
Genus *Sus* Linnaeus, 1758
Sus xiaozhu Han, Xu et Yi, 1975

Referred material (Figure 5)

Right P3, CF92; Right P4s, CF93, CF94, CF95 and CF96; Left M1s, CF98 and CF99; Right M1, CF97; Left M2s, 009367, CF102, CF103, CF104 and CF105; Right M2s, CF100 and CF101; Left M3, CF110; Right M3s, CF106, CF107, CF108 and CF109; Right p2, CF114; Left p3, CF115; Right p3, CF116; Right m1, CF117; Part of right mandible with m1 and m2, CF118; Left m2s, CF119, CF120, CF121, CF122 and CF123; Right m2s, CF124, CF125, CF126 and CF127; Left m3s, CF128 and CF129; Right m3s, CF130 and CF131.

Material description

The P3 has a well-developed paracone, metacone, protocone and prestyle without primocone. The outline of P4 is roughly square or rectangle. The crown consists of three main cusps, a strong lingual

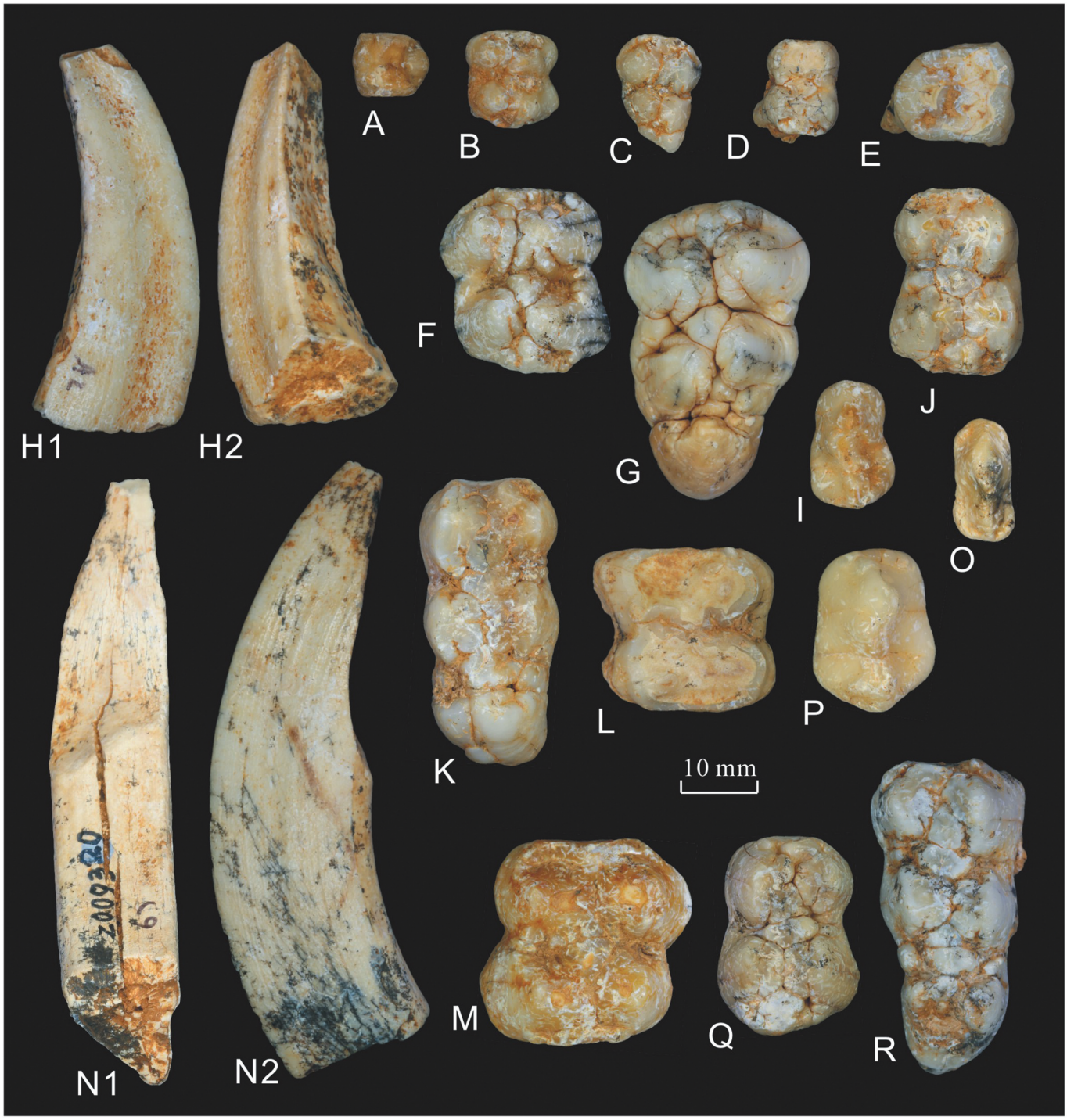

Figure 5. Suidae from Chuifeng Cave. *Sus xiaozhu*, A-–D: A, Right P4 (CF93); B, Right M2 (CF100); C, Right M3 (CF107); D, Left m2 (CF119); *Sus peii*, E-–K: E, Left P4 (009327); F, Right M2 (009427); G, Left M3 (009369); H, Left c (009338); I, Right p4 (009706); J, Left m2 (009414); K, Right m3 (009332); *Hippopotamodon ultimus*, L-–R: L, Left M1 (009359); M, Left M2(009341); N, Right c1(009320); O, Right p2(CF344); P, Right p4(009559); Q, Right m2(009348); R, Left m3(009433).

protocone and the paracone and metacone in the buccal side. The preconule and protofossa are present. M2 is similar to M1 in crown features with four main cusps and larger size. The M2 has more developed anterior cingulum and pentapreconule than M1. M3 has a triangular outline and five main cusps with the well-developed anterior cingulum. p2 has two cusps, the paraconid and protoconid, and two roots. The p3 is similar to p2. m1 has a rectangle outline. Four main cuspids, i.e. protoconid, metaconid, hypoconid and entoconid are well-developed. The m2 is larger and has a more developed preconulid and pentaconid than the m1. The m3 is similar to m2 in its the first and second lobe. The third lobe of the m3 is generally composed of a large cusp and with/without fewer small cusps.

Taxonomic remarks and comparisons

The *Sus* specimens from the Chuifeng Cave are characterisedcharacterized by their extremely small dental sizes. These specimens are comparable in their sizes and crown features with the specimens of *Sus xiaozhu* from the Liucheng *Gigantopithus*, Longgupo and Longgudong sites (Han 1987; Huang and Fang 1991; Zheng 2004), we assign these specimens to *Sus xiaozhu*.

Sus peii Han, 1987

Referred material (Figure 5)

Left P3s, 009526, 009510, 009514, 009739 and 009748; Right P3s, 009556, 009580, 009690 and CF339; Left P4s, 009327, 009335, 009407, 009410, 009421, and 009428; Right P4s, 009366, 009370, 009409 and 009419; Left M1s, 009343 and 009394; Right M1s, 009395 and 009406; Left M2s, 009319, 009345, 009347, 009353, 009357, 009378, 009383, 009405, 009412, 009416 and 009437; Right M2s, 009337, 009340, 009387, 009391, 009413, 009424 and 009427; Left M3s, 009349, 009350, 009354, 009360, 009369, 009372, 009384, 009430 and 009432; Right M3s, 009322, 009325, 009361, 009382, 009435 and 009441; A left i1, 009565; Left i2s, 009561, 009564, CF340 and CF342; Right i2s, CF341 and CF343; A left c, 009338; Left p2s, 009368 and 009520; Right p2s, 009375, 009429, 009508, 009509 and 009502. Left p3s, 009386–2 and 009417; Right p3s, 009321, 009493, 009546 and 009673; Left p4s, 009496, 009537, 009687, 009697, 009785 and CF346; Right p4s, 009334, 009504, 009629, 009706, 009714, 009732, CF347 and CF348; Left m1s, 009330, 009401, 009404 and 009411; Right m1s, 009329, 009342, 009346, 009351, 009371, 009389, 009396, 009415 and 009402; Left m2s, 009373, 009376, 009399, 009403, 009414, 009420 and 009425; Right m2s, 009339, 009348, 009397 and 009431; Left m3s, 009324, 009358, 009385, 009386–1, 009434, 009439 and 009470; Right m3s, 009332, 009356, 009377, 009380, 009381, 009392, 009436 and 009444.

Material description

The P3 has a well-developed paracone, metacone, protocone and prestyle with primocone of varying degrees of development. The outline of P4 is roughly square or rectangle. The crown consists of three main cusps, a strong lingual protocone and the paracone and metacone in the buccal side. The preconule and protofossa are present. M2 is similar to M1 in crown features. Four main cusps, protocone and hypocone in the lingual side and paracone and metacone in the buccal side. Compared with M1, the M2 has more developed anterior cingulum and pentapreconule. M3 has a triangular outline. Five main cusps are well developed. Anterior cingulum is present on the anterior base of paracone. Lower incisors are chisel-like with long roots. i2 has the developed distal groove. The cross section of the lower canine of the male specimen is the 'intermediate' morphotype with the lingual surface being the broadest and the labial surface being slightly larger than the enamel-less posterior surface. In p2, the paraconid and protoconid are well developed. The ridge behind the protoconid is divided to three cusps. The p3 is similar to p2. The traces of ridges at the anterior and posterior corners are present in p3. The p4 has four major cuspids: a small paraconid, large protoconid, metaconid and hypoconid with a slight hypoendocristid. A vertical ridge is present at the posterior corner in the lingual side and two vertical ridges are present at the anterior and posterior corners respectively. No cingulum is present on the anterior part of the crown. The m1 has four main cuspids, i.e. protoconid, metaconid, hypoconid and entoconid with complex occlusal patterns. Except for 009346, the left m1s all have pentaconid. The m2 is larger and has a more developed preconulid and pentaconid than the m1. The m3 is similar to m2 in its the first and second lobe. The third lobe of the m3 is generally composed of a large cusp and with/without fewer small cusps.

Taxonomic remarks and comparisons

The *Sus* specimens from the Chuifeng Cave represent a larger dental size *Sus* species. Their dental sizes are much larger than *Sus xiaozhu*. The Chuifeng specimens can be separated from *Sus scrofa* by their lower canine of 'intermediate' morphotype. These specimens have similar dental sizes and crown features as the specimens of *Sus peii* from the Liucheng *Gigantopithus*, Longgupo and Longgudong sites (Han 1987; Huang and Fang 1991; Zheng 2004), we assign these specimens to *Sus peii*.

Genus ***Hippopotamodon*** Lydekker, 1877

Hippopotamodon ultimus Han, 1987

Referred material (Figure 5)

A left M1, 009359; A left M2, 009341; A right c, 009320; A right p2, CF344; A left p4, 009756; Two right p4s, 009559 and CF345; Left m1s, 009333 and 009422; Right m1, 009323; Right m2s, 009339, 009348, 009397 and 009431; Left m3s, 009365 and 009433.

Material description

M2 is similar to M1 in crown features. Four main cusps, protocone and hypocone in the lingual side and paracone and metacone in the buccal side. Compared with M1, the M2 has more developed anterior cingulum and pentapreconule. The cross section of the lower canine of the male specimen is clearly the 'verrucose' morphotype with the lingual surface being the broadest and the posterior face being the narrowest and enamel-less. The p2 has two cuspids: protoconid and hypoconid. Protoconid is slightly higher than the hypoconid. Two vertical ridges are present at the posterior corner in the lingual and buccal sidessides, respectively. A trace of cingulum representinged by a small cusp, is present on the anterior lingual part of the crown. The p4 has four major cuspids: a small paraconid, large protoconid, metaconid and hypoconid with a hypoendocristid. A vertical ridge is present at the posterior corner in the lingual side and two vertical ridges are present at the anterior and posterior corners in the buccal side respectively. A cingulum splitting to four small cusps at its top, is present on the anterior part of the crown. The m1 has four main cuspids, ie., protoconid, metaconid, hypoconid and entoconid with simple occlusal patterns. The precingulum is present on the anterior part of metaconid. The m2 is larger and has a more developed preconulid and pentaconid than the m1. The m3 is similar to m2 in itsthe first and second lobe with well-developed anterior cingulid. The third lobe of the m3 is composed of two large cusps.

Taxonomic remarks and comparisons

The *Sus* specimens from the Chuifeng Cave represent a larger dental size *Sus* species. Their dental sizes are larger than *Sus peii*.

The lower canine of the male specimen is clearly the 'verrucose' morphotype. The *Sus* specimens have more developed cingulum in p2, p4 and lower molars than *Sus peii*. These specimens are comparable in their sizes and crown features with the specimens of *Hippopotamodon ultimus* from the Liucheng *Gigantopithus* and Longgupo sites (Han 1987; Huang and Fang 1991), we assign these specimens to *Hippopotamodon ultimus*.

Family Cervidae Gray, 1821
Genus *Muntiacus* Rafinesque, 1815

Muntiacus sp.

Referred material (Figure 6)

Left P2s, CF06, CF07, CF08 and CF09; Right P2s, CF01, CF02, CF03, CF04 and CF05; Left P3s, CF15, CF16 and CF17; Right P3s, CF10, CF11, CF12, CF13 and CF14; Right P4s, CF18 and CF19; Right M1s, CF33, CF34, CF35, CF36 and CF37; Left M2s, CF41, CF42, CF43, CF51, CF52, CF53, CF54, CF55, CF56 and CF57; Right M2s, CF38, CF39, CF40, CF44, CF45, CF46, CF47, CF48, CF49 and CF50; Left M3s, CF58, CF59, CF60, CF61, CF62, CF64, CF65 and 999CF66; A right M3, CF63; Left p2s, CF21, CF22, CF27, CF29 and CF69; Right p2s, CF23, CF24, CF25, CF26 and CF28; A left p3, CF30; Left p4s, CF31 and CF32; Left m1s, CF70, CF71 and CF72; A right m1, CF73; Left m2s, CF74, CF75, CF76, CF77, CF78 and CF79; Right m2s, CF80, CF81, CF82, CF83 and CF84; Left m3s, CF85, CF86 and CF87; Right m3s, CF89, CF90 and CF91.

Material description

P2 has a rhomboid crown. The metastyle is stronger than parastyle. The paracone rib is well-developed. The entoflexus is weak or absent. The medial crista is developed. The occlusal outline of P3 is near square. The metastyle is more prominent than parastyle. The

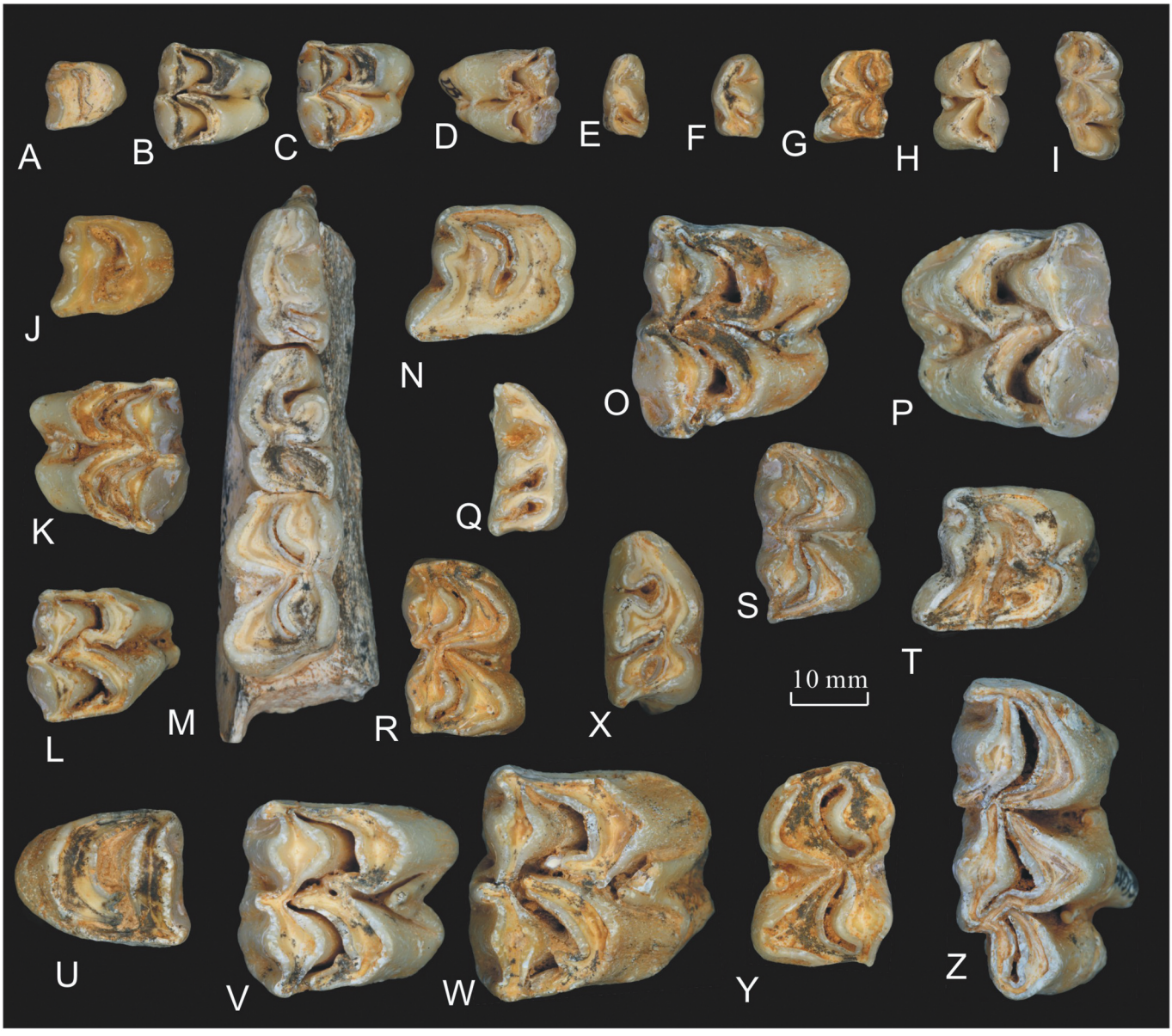

Figure 6. Cervidae from Chuifeng Cave. *Muntiacus* sp., A-–I: A, Right P3(CF10); B, Right M1(CF37); C, Right M2(CF40); D, Left M3(CF61); E, Left p3(CF30); F, Left p4(CF32); G, Left m1(CF71); H, Left m2(CF75); I, Right m3(CF89); *Cervus fenqii*, J-–M: J, Right P3(009717); K, Left M2(009624); L, Right M2(009713); M, partial left mandible with p3 to m1 (009568); *Cervus (Rusa) yunnanensis*, N-–S: N, Right P3 (009711); O, Right M2 (009555); P, Left M3 (009553); Q, Right p4 (009720); R, Right m1 (009672); S, Right m2 (009619); *Cervus (Rusa) unicolor*, T-–Z: T, Right P3 (009614); U, Left P4 (009730); V, Right M1 (009721); W, Right M2 (009598); X, Right p4 (009691); Y, Left m1 (009621); Z, Right m3 (009571).

paracone rib is well-developed. The entoflexus is absent. The trace of cingula is present on the lingual side in CF13 and CF16. The occlusal outline of P4 is rectangle. The parastyle, metastyle and paracone rib are developed. In upper molars, the parastyle, mesostyle, and metastyle are more developed in M2 and M3 than in M1. Entostyle is absent or weak in M1. Entostyles are developed but weak in M2s and M3s. The occlusal outline of p2 is near rectangle. The paraflexid is absent. The trigonid basin is widely open. The hypoflexid is developed. The metaconid of p3 is slightly inflated and extends backward. The entoconid is fused with entostylid. The entoflexid is narrowly open. The hypoflexid is developed. The metaconid of p4 is inflated and extends forward and backward. The hypoflexid is moderately developed. The mesotylid and anterior cingulid are more developed in m2 and m3 than the m1. The posterior ectostylid of m3 is weak or absent. *Palaeomeryx* fold on protoconid and *Dorcatherium* fold on metaconid are not present in lower molars.

Taxonomic remarks and comparisons

The *Muntiacus* specimens from the Chuifeng Cave are characterisedcharacterized by their small dental sizes, absent or weak-developed entostyle in upper molars, and lower molars without *Palaeomeryx* fold and *Dorcatherium* fold. These specimens are comparable in their sizes and crown features with the specimens of *Muntiacus* sp. from the Longgupodong site (Zheng 2004), we assign these specimens to *Muntiacus* sp.

Genus *Cervus* Linnaeus, 1758
Cervus fenqii Han, 1987

Referred material (Figure 6)

A left P3, 009532; Right P3s, 009710 and 009717; Left P4s, 009513 and 009594; Right P4, 009522; A right M1, 009682; Left M2s, 009584, 009624 009632, 009733 and 009792; Right M2s, 009631, 009636, 009684 and 009713; A left M3, 009701; A right M3, 009596; Left p2s, 009521, 009548 and 009587; A partial mandible with p3 to m1, 009568; Left p3s, 009516, 009716 and 009745; Right p3s, 009527, 009761 and 009769; Left p4s, 009498, 009525 and 009747; Right p4s, 009494, 009505, 009689 and 009752; Left m1s, 009653 and 009679; Right m1s, 009625 and 009680; Right m2s, 009699; 009741; A right m3, 009623.

Material description

The occlusal outline of P3 is near square. The metastyle is more developed than parastyle. The paracone rib is well-developed. The entoflexus and medial crista are present. The neocrista is weak. The occlusal outline of P4 is rectangle. The parastyle, metastyle and paracone rib are developed. The entoflexus is weak or absent. The medial crista is well-developed. The neocrista is absent. The upper molars have four crescentic cusps. The parastyle, mesostyle, metastyle and precingulum are well-developed. All upper molars have entostyles on their lingual side. Spur is present in the M1 (009682), two M2s (009584 and 009684) and the M3 (009596). Neocrista is well-developed in 009596. The occlusal outline of p2 is near rectangle. The paraflexid is not present. The trigonid basin is widely open. The entoflexid and talonid basin are slightly open. The hypoflexid is weakly developed. Except for 009527, the p3s have paraflexid. The metaconid is not fused with the paraconid. The entoflexid is narrowly open. The hypoflexid is slightly developed.

The metaconid of p4 is inflated and extends forward and backward. The hypoflexid is moderately developed. The m1 is composed of two lobes. The mesotylid and anterior cingulid are weak or absent in m1. *Palaeomeryx* fold on protoconid and *Dorcatherium* fold on metaconid are not present. The ectostylid is well-developed on the buccal side. The crown features of m2 is similar to m1. Compared with m1, m2 has more developed styles, anterior cingulids. The m3 has three lobes. The posterior ectostylid is absent.

Taxonomic remarks and comparisons

The *Cervus* specimens from the Chuifeng Cave are characterised-characterized by their medium dental sizes, well-developed entostyle in molars, and lower molars without *Palaeomeryx* fold and *Dorcatherium* fold. These specimens have similar dental sizes and crown features as the specimens of *Cervus fenqii* from the Liucheng *Gigantopithus* and Longgupo sites (Han 1987; Zheng 2004), we assign these specimens to *Cervus fenqii*.

Cervus (*Rusa*) *yunnanensis* Lin, Pan et Lu, 1978

Referred material (Figure 6)

A left P3, 009775; A right P3, 009711; A left P4, 009605; Right P4s, 009718, 009731 and 009742; Left M1s, 009577 and 009707; Right M1s, 009592 and 009670; Left M2s, 009563, 009597, 009646 and 009663; Right M2s, 009555 and 009734; A left M3, 009553; Right M3s, 009671 and 009794; Left p2s, 009519, 009543 and 009777; Right p2s, 009497, 009500 and 009503; Left p3s, 009515, 009517 and 009704; Right p3s, 009610 and 009729; A left p4, 009709; Right p4s, 009661, 009720, 009738, 009759 and 009770; Left m1s, 009588, 009667 and 009677; Right m1s, 009608, 009650, 009672 and 009694; Left m2s, 009616 and 009649; Right m2s, 009619, 009675, 009688, 009719, 009724, 009760 and 009776; Left m3s, 009570, 009641, 009643, 009674 and 009723.

Material description

The occlusal outline of P3 is near square. The metastyle is more prominent than parastyle. The paracone rib is well-developed. The entoflexus divides the lingual side into two cusps with nearly the same size. The medial crista is present. The occlusal outline of P4 is rectangle. The parastyle, metastyle and paracone rib are developed. Cingulum is present on the lingual side in 009178 and 009742. The medial crista is developed in 009605 and 009731. In upper molars, the parastyle, mesostyle, metastyle and precingulum are more developed in M2 and M3 than in M1. Entostyle is absent or weak in M1. Except for one M2 (009566) and one M3 (009794), entostyles are well-developed and bifurcated in left M2s and M3s. Only one M3 (009794) has spur. Spur and neocrista are absent in the left upper molars. The occlusal outline of p2 is near rectangle. The paraflexid is not present. The trigonid basin is widely open. The entoflexid and talonid basin are slightly open. The hypoflexid is developed. The p3 has paraflexid. The metaconid is slightly inflated and extends backward. The entoflexid is narrowly open. Except for 009517, the hypoflexid is moderately developed. The metaconid of p4 is inflated and extends forward and backward. The hypoflexid is moderately developed. The mesotylid and anterior cingulid are well-developed in m1. *Palaeomeryx* fold on protoconid and *Dorcatherium* fold on metaconid are not present. Except for 009588, the ectostylid is present on the buccal side. The m2 has more developed styles, anterior cingulids than m1. The m3 has three lobes. The posterior ectostylid is weakly developed or absent.

Taxonomic remarks and comparisons

The *Cervus* specimens from the Chuifeng Cave are larger than *Cervus fenqii* in their dental sizes. Except for their larger dental sizes, they are different from *Cervus fenqii* in the following aspects: P3 with more developed entoflexus, P4 with developed cingulum on the lingual side, M1 with weak developed parastyle, mesostyle and

metastyle, M2 with bifurcated entostyle, and without spur and neocrista, p4 with more developed hypoflexid. These specimens are comparable in their sizes and crown features with the specimens of *Cervus (Rusa) yunnanensis* from the Liucheng *Gigantopithus* and Longgudong sites (Han 1987; Zheng 2004), we assign these specimens to *Cervus (Rusa) yunnanensis*.

Cervus (*Rusa*) *unicolor* Kerr, 1792

Referred material (Figure 6)

A right P2, 009767; Left P3s, 009606 and 009779; Right P3s, 009614, 009743 and 009660; Left P4s, 009730 and 009780; A right P4, 009558; Left M1s, 009554, 009575, 009583, 009589, 009590 and 009735; Right M1s, 009569, 009603, 009609, 009635, 009685 and 009721; Left M2s, 009566, 09622, 009628, 009658, 009693, 009712, 009722 and 009758; Right M2s, 009598, 009633, 009639, 009657 and 009737; A left M3, 009708; A right M3, 009662; Right p2s, 009518 and 009791; A left p3, 009702; Right p3s, 009652, 009783 and 009800; Left p4s, 009612 and 009762; Right p4s, 009640 and 009691; A left m1, 009621; A right m1, 009668; Left m2s, 009582, 009654, 009726 and 009797; Right m2s, 009572, 009595, 009602, 009618 and 009799; Left m3s, 009573; 009585; 009593; 009665 and 009700; Right m3s, 009571, 009574 and 009727.

Material description

In occlusal view, the P2 is rhomboid. The metastyle is stronger than parastyle. The paracone rib is well-developed. The well-developed entoflexus divides the lingual side into two cusps, i.e. protocone and metaconule. The occlusal outline of P3 is near square. The metastyle is more prominent than parastyle. The paracone rib is well-developed. The entoflexus divides the lingual side into two cusps with nearly the same size. Except for 009779, P3s have entostyles in the entoflexus. The medial crista and additional crista are well-developed. The occlusal outline of P4 is rectangle. The parastyle, metastyle and paracone rib are developed. The trace of cingula is present on the lingual side in 009558 and 009730. The medial crista is developed. The parastyle, mesostyle, metastyle and precingulum of the upper molars are well-developed. All upper molars have entostyles on their lingual side. The upper molars have spurs. The spur is strongly developed in 009693. Neocrista is absent in the upper molars. The occlusal outline of p2 is near rectangle. The paraflexid is not present. The trigonid basin is widely open. The entoflexid is small and close at a third of the height of the crown and the talonid basin is close. The p3 has paraflexid. The metaconid is slightly inflated and extends backward. The entoconid is fused with entostylid. The entoflexid is narrowly open. The hypoflexid is developed. The metaconid of p4 is inflated and extends forward and backward. The hypoflexid is moderately developed. The mesotylid and anterior cingulid are developed in m1. *Palaeomeryx* fold on protoconid and *Dorcatherium* fold on metaconid are not present. The ectostylid is present on the buccal side. The m2 has more developed styles, anterior cingulids than m1. The m3 has three lobes. The posterior ectostylid is developed or absent.

Taxonomic remarks and comparisons

The *Cervus* specimens from the Chuifeng Cave have the largest dental sizes compared with *Cervus fenqii* and *Cervus (Rusa) yunnanensis*. Except for their larger dental sizes, they are different from *Cervus (Rusa) yunnanensis* in the following aspects: P3 with developed entostyles and medial crista, M1 with more developed parastyle, mesostyle and metastyle, p3 and p4 with higher crowns. These specimens are comparable in their sizes and crown features with the specimens of *Cervus (Rusa) unicolor* from the Longgudong site (Zheng 2004), we assign these specimens to *Cervus (Rusa) unicolor*.

Family Bovidae Gray, 1821
Caprinae Gill, 1872
Genus *Megalovis* Schaub, 1923
Megalovis guangxiensis Han, 1987

Referred material (Figure 7)

A right P2, CF141; A right M1, CF142; A left M2, 009552; A right M2, 009473; Left m1s, 009461, 009486 and CF143; A right m1, 009479; A left m2, 009638; A left m3, 009483.

Material description

The crown of P2 is high. In occlusal view, the P2 is rhomboid. The metastyle is stronger than parastyle. The paracone rib is well-developed. The entoflexus is weak. The neocrista and cingulid are absent. The crown of M1 is near square. The parastyle and mesostyle are more developed than the metastyle. Spur and cingula are absent. The M1 has entostyle. Cements are present on its mesial, lingual and buccal sides. The crown of M2 is rectangle. The parastyle, mesostyle and metastyle are more developed than M1. Spur is well-developed. Cingula is absent. Entostyle is developeddeveloped, but its height does not exceed half the height of the crown. The m2 has more developed entostylid than m1. The ectostylid is present in 009461 and 009486 but absent in 009479. The m3 does not have ectostylid. Cements are present on its lingual and buccal sides.

Taxonomic remarks and comparisons

The *Megalovis* specimens from the Chuifeng Cave are characterisedcharacterized by their large dental sizes, high crown, molars with weak developed parastyle and mesostyle and metastyle appearing only in the upper 1/4 part of the crown. The *Megalovis* specimens from the Chuifeng Cave are different from the *Budorcas* sp. from the Longgupo site in their molars with developed entostyle. These specimens have similar dental sizes and crown features as the specimens of *Megalovis guangxiensis* from the Liucheng *Gigantopithus* and Longgupo sites (Han 1987; Zheng 2004), we assign these specimens to *Megalovis guangxiensis*.

Genus *Capricornis* Ogilby, 1837

Capricornis sp.

Referred material (Figure 7)

A left P3, 009750; Right P3s, 009539 and 009692; Left P4s, 009703 and 009781; Left M1s, 009683 and 009790; Right M2s, 009796 and 009560; A left M3, 009766; Right M3s, 009648 and 009659; A left p4, 009541; Right p4s, 009499 and 009511; A left m1, 009528; Right m1s, 009666, 009755 and 009531; A left m2, 009656; Right m3s, 009586, 009607 and 009615.

Material description

The P3 has a half-round crown. Its length is slightly larger than width. The parastyle and metastyle are well-developed. The paracone rib is closer to the parastyle than to the metastyle. The medial crista is present but weak in 009750 and 009692, and it is absent in 009539. The crown of P4 is near rectangle. Its length is smaller than width. The parastyle and metastyle are well-developed. The paracone rib is present but weaker than that of P3. The medial crista is present in 009781, and it is absent in 009703. In occlusal view, the M1 is near square. Its length is slightly larger than width. Parastyle

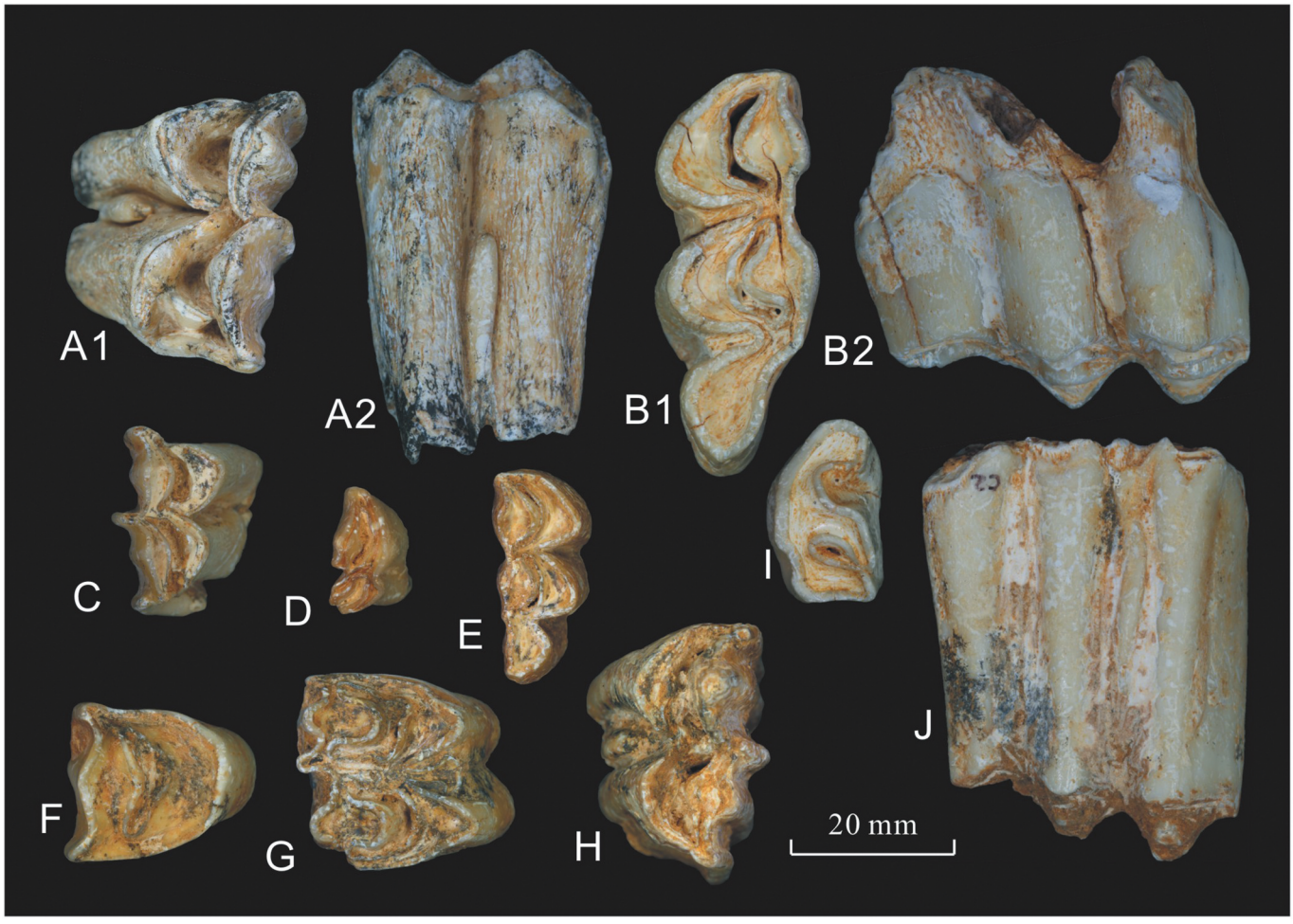

Figure 7. Bovidae from Chuifeng Cave. Megalovis guangxiensis, A-–B: A, Left M2 (009552); B, Left m3 (009483); *Capricornis* sp. C-–E: C, Right M3 (009659); D, Right p4 (009499); E, Right m3 (009586); *Bibos* sp., F-–J: F, Right P4 (009488); G, Left M1 (009550); H, Left M3 (CF137); I, Left p4 (009626); J, Left m3 (CF140).

and mesostyle are developed, but metastyle is weak. Spur is not present in the posterior fossette and entostyle is absent in the lingual side. The M2 is similar to M1 in its crown features with more developed parastyle, mesostyle and metastyle. Spur is present in 009684. The M3 is characterisedcharacterized by the metastyle developed into a winged shape. The p4 is molarisationmolarization and consists of two lobes. The anterior lobe is larger than the posterior lobe. The metaconid is the highest cusp. The parastylid, paraflexid and entoflexid are well-developed. The crown of m1 is rectangle with larger length. Parastylid, mesostylid and metastylid are weak or absent. Goat fold and ectostylid are not present. Mesostylid, and metastylid are developed in m2. Goat fold is present in 009596 but absent in 009786. The ectostylid is absent in m2. The m3 has three lobes. Goat fold and ectostylid are not present.

Taxonomic remarks and comparisons

The *Capricornis* specimens from the Chuifeng Cave are characterisedcharacterized by their small dental sizes, high crown, molars without entostyle, metastyle of M3 with a winged shape and lower molars with goat fold. The *Capricornis* specimens from the Chuifeng Cave are different from the *Budorcas* sp. from the Longgupo site in their molars with developed entostyle. These specimens are comparable in their sizes and crown features with the specimens of *Capricornis jianshiensis* from the Longgudong site (Zheng 2004) but without horn specimen, we assign these specimens to *Megalovis guangxiensis*.

Genus *Bibos* Linnaeus, *1758*

Bibos sp.

Referred material (Figure 7)

A right P4, 009488; Left M1s, 009550 and CF135; A left M2, CF136; A left m3, CF137; Left p3s, 009549 and 009789; A right p3, CF138; Left P4s, 009626, 009557 and 009757; A right p4, CF139; A left m3, CF140.

Material description

The P4 is subtriangular in outline with well-developed parastyle, paracone rib and metastyle. The M1 has a subsquare outline. An unbifurcated entostyle is present between the protocone and hypocone. The M2 has a rectangle outline and more developed styles than M1. The M3 has a well-developed metastyle projecting distally. An unbifurcated entostyle is present between the protocone and hypocone in upper molars. The p3 has paraflexid and a deep trigonid basin. The metaconid is slightly inflated and extends backward. The entoconid is fused with entostylid. The entoflexid is narrowly open. The hypoflexid is well-developed. The paraconid is separated from metaconid by the shallow trigonid basin. The postentocristid fuses with the posthypocristid. For m3, the ectostylid is well developed and not bifurcated with the absence of posterior ectostylid.

Taxonomic remarks and comparisons

The *Bibos* specimens from the Chuifeng Cave are characterisedcharacterized by their small dental sizes, high crown, molars with well-developed and unbifurcated entostyle. The *Bibos* specimens from the Chuifeng Cave are different from the *Leptobos* sp. from the Longgupo site in their molars with unbifurcated entostyle. These specimens have similar dental sizes and crown features as the specimens of *Bibos* sp. from the Liucheng *Gigantopithus* and Longgupo sites (Han 1987; Huang and Fang 1991), we assign these specimens to *Bibos* sp.

Discussion

Biochronological significance of Chuifeng mammalian assemblage

The Chuifeng mammalian assemblage has a biochronological significance in establishing the evolutionary sequence of Pleistocene fossil mammals in southern China and mainland Southeast Asia. The mammalian assemblage of Chuifeng Cave is composed of 28 species of large mammals. The Chuifeng mammalian assemblage has three important characteristics. First, the *G. blacki* is an important component of this mammalian assemblage, representing ~10% of the total collection of mammal fossils (Wang 2009); second, some Neogene relict species, such as *Sinomastodon* sp. and *Hippopotamodon ultimus*, are present in this mammalian assemblage; and third, the Chuifeng mammalian assemblage includes some species that appeared in the Pleistocene for the first time, such as *Hystrix magna, Stegodon huananensis, Ailuropoda microta, Meles magnus, Pachycrocuta brevirostris licenti, Rhinoceros fusuiensis, Tapirus sanyuanensis, Sus peii, Sus xiaozhu, Cervus fenqii*, and *Megalovis guangxiensis*. From an overall perspective, the Chuifeng mammalian assemblage shows an obvious species composition of the Early Pleistocene mammalian assemblage characteristics in southern China. Thus, the mammalian assemblage composition of Chuifeng Cave is consistent with its absolute age dating result of ~ 1.9 Ma using combined ESR/U-series and palaeomagneticpaleomagnetic dating methods (Shao et al. 2014).

Compared with the mammalian assemblages from the same region in Bubing Basin, the Chuifeng mammalian assemblage is similar to the Early Pleistocene Mohui mammalian assemblage (Wang et al. 2014) which is dated to ~ 1.8 Ma (Shao et al. 2015), by co-occurrence of the mammalian species including *G. blacki, Sinomastodon* sp., *Hystrix magna, Hystrix kiangsenensis, Stegodon huananensis, Ursus thibetanus, Ailuropoda microta, Pachycrocuta brevirostris licenti, Tapirus sanyuanensis, Sus peii, Sus xiaozhu, Cervus fenqii*, and *Megalovis guangxiensis*. The main differences between these two mammalian assemblages are represent by the occurrence of *Equus* sp. and *Hippopotamodon ultimus* and the absence of *Hesperotherium* sp. and *Dorcabune liuchengense* in the Chuifeng assemblage. The Chuifeng mammalian assemblage is remarkably different from the Middle Pleistocene mammalian assemblages from the Ganxian Cave (Liang et al., submitted) and Wuyun Cave (Chen et al. 2002). These two Middle Pleistocene mammalian assemblages are characterisedcharacterized by the disappearance of *G. blacki, Sinomastodon* sp., *Hystrix magna* and *Equus* sp. And the *Stegodon huananensis, Ailuropoda microta, Meles magnus, Pachycrocuta brevirostris licenti, Rhinoceros fusuiensis, Tapirus sanyuanensis*, and *Sus peii* are replaced by the *Stegodon orientalis, Elephas maximus, Ailuropoda melanoleuca baconi, Arctonyx collaris, Crocuta ultima, Rhinoceros sondaicus, Dicerorhinus sumatrensis, Tapirus sinensis, Megatapirus augustus* and *Sus scrofa* in the Middle Pleistocene period.

Comparisons between the Chuifeng mammalian assemblage and the Early Pleistocene mammalian assemblages from southern China further reveal its biochronological significance. In the southwest part of southern China, Chongzuo area, the Chuifeng mammalian assemblage is similar to the nearly contemporaneous Baikong mammalian assemblage (Jin et al. 2014) which is dated to ~ 2.0 Ma (Sun et al. 2014), by co-occurrence of the mammalian species including *G. blacki, Stegodon huananensis, Pachycrocuta brevirostris licenti, Ailuropoda microta* and *Tapirus sanyuanensis*. The main differences between these two mammalian assemblages are represented by the occurrence of *Equus* sp. and the absence of *Hesperotherium* and *Dorcabune* species in the Chuifeng assemblage.

The age of Chuifeng mammalian assemblage may be earlier than the Juyuan mammalian assemblage in Chongzuo area, indicating by the primitive species, *Ailuropoda microta* and *Tapirus sanyuanensis* in Chuifeng mammalian assemblage are replaced by more derived species, *Ailuropoda wulingshanensis* and *Tapirus sinensis* in Juyuan mammalian assemblage. The biochronological comparison between the Chuifeng and Juyuan mammalian assemblages is consistent with the absolute dating result of the relatively younger age for Juyuan mammalian assemblage (~ 1.8 Ma) (Sun et al. 2014). The later Sanhe and Queque *Gigantopithecus*-bearing mammalian assemblages in Chongzuo area are different from the Chuifeng mammalian assemblage in the occurrence of the more derived species, such as *Ailuropoda wulingshanensis, Tapirus sinensis*, and *Ailuropoda baconi* (Jin et al. 2014). In the middle part of southern China, the Chuifeng mammalian assemblage is similar the Liucheng *Gigantopithecus* mammalian assemblage by co-occurrence of many mammalian species including *G. blacki, Hystrix magna, Hystrix kiangsenensis, Atherusus* sp., *Sinomastodon* sp., *Stegodon huananensis, Ailuropoda microta, Meles magnus, Pachycrocuta brevirostris licenti, Equus* sp., *Tapirus sanyuanensis, Sus peii, Sus xiaozhu, Hippopotamodon ultimus, Cervus fenqii, Cervus* (*Rusa*) *yunnanensis, Cervus* (*Rusa*) *unicolor* and *Megalovis guangxiensis*. In the north part of southern China, the Chuifeng mammalian assemblage is similar the Longgupo mammalian assemblage which is placed at the very beginning of the Early Pleistocene using combined ESR/U-series and paleomagnetic dating methods (Han et al. 2015), by co-occurrence of the mammalian species including *G. blacki, Hystrix magna, Sinomastodon* sp., *Stegodon huananensis, Ailuropoda microta, Pachycrocuta brevirostris licenti, Equus* sp., *Tapirus sanyuanensis, Sus peii, Sus xiaozhu, Hippopotamodon ultimus* and *Megalovis guangxiensis* (Huang and Fang 1991). The age of Chuifeng mammalian assemblage may be earlier than the Longgudong mammalian assemblage in this area, indicating by the occurrence of more derived species, *Ailuropoda wulingshanensis, Rhinoceros sinensis* and *Tapirus sinensis* in Juyuan mammalian assemblage. Based on the results of the above comparisons, the Chuifeng, Baikong, Liucheng *Gigantopithecus* and Longgupo mammalian assemblages represent the earliest Early Pleistocene mammalian assemblages in north-west, southwest, middle and north parts of southern China, respectively.

Paleoecological significance of Chuifeng mammalian assemblage

During the Early Pleistocene period, the *Gigantopithecus*-bearing mammalian assemblages are widely distributed in southern China. In terms of faunal compositions of these *Gigantopithecus*-bearing mammalian assemblages, we can find a very interesting phenomenon that there may be a south-north divergence of *Gigantopithecus*-bearing assemblages. In the south part of the southern China, *Equus* sp. is absent in the *Gigantopithecus*-bearing assemblages, such as the Baikong, Juyuan, Sanhe and Queque mammalian assemblages in Chongzuo area (Jin et al.

2014; Shao et al. 2015). In the north part of the southern China, *Equus* species are associated with the *Gigantopithecus*-bearing assemblages, such as the Longgupo, Longgudong, Liucheng *Gigantopithecus* (Pei 1961; Huang and Fang 1991; Zheng 2004) and Chuifeng mammalian assemblages. And the Chuifeng assemblage represents the southernmost distribution of the northern branch of *Gigantopithecus*-bearing assemblage. The occurrences of *Equus* in northern branch of *Gigantopithecus*-bearing assemblage indicate that *G. blacki* is possible to survive in an open woodland environment with grasslands nearby. The lower $\delta^{13}C$ values of *Equus* fossils from the Liucheng *Gigantopithecus* site (Chen 2011; Liu et al. 2021) may be explained by the occurrence of C_3 grassland environment in the Early Pleistocene period. This result is the same as previous studies that the lower $\delta^{13}C$ values of *Equus* fossils from the Pleistocene Bajiazui, Xiashagou, Donggutuo, Shenquansi, Xinyaozi, Xujiayao, Loufangzi and Zhoukoudian sites in northern China indicate the occurrence of C_3 grassland environment (Deng et al. 1999, 2002). Of course, we need more evidence to prove the C_3 grassland environment in southern China in future research.

Conclusion

The Chuifeng mammalian assemblage is one of the typical early Early Pleistocene mammalian assemblages in southern China. This mammalian assemblage consists at least of 28 large mammal taxa. The discoveries of the 2 Neogene relict species and 11 species mark their first appearances in the Early Pleistocene. The *Equus* sp. from the Chuifeng Cave represent the southernmost distribution of *Equus* in *Gigantopithecus*-bearing assemblages. The close associations of *Equus* and *G. blacki* in the Chuifeng, Liucheng *Gigantopithecus*, Longgudong and Longgupo sites indicate that *G. blacki* may survive in an open woodland environment with grasslands nearby in the middle and northern parts of southern China.

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