

准噶尔盆地北缘顶山盐池组中新世哺乳动物¹⁾

吴文裕¹ 孟津^{1,2} 叶捷¹ 倪喜军¹ 毕顺东³ 魏涌澎¹

(1 中国科学院古脊椎动物与古人类研究所 北京 100044)

(2 美国自然历史博物馆 纽约 10024)

(3 美国宾夕法尼亚州印第安纳大学生物系 印第安纳 PA 15705)

摘要:顶山盐池组是在新疆准噶尔盆地北缘乌伦古河流域新建立的一个新近纪岩石地层单位(孟津等,2008)。2006年本文作者在该组地层中采集了以小哺乳动物为主的哺乳动物化石。这里记述的化石采自位于同一陡坎的相距约1.6 km的两个剖面上的3个化石点,分属两个层位。化石点XJ 200613(46°24.572'N; 87°28.541'E)和XJ 200617(46°24.479'N; 87°29.818'E)都位于顶山盐池组的底部层位;前者位于该组底界2.3 m之上,后者则位于该组底部砂岩透镜体中。除少数大哺乳动物外,从这两个地点采集到的化石都是由筛洗法获得的小哺乳动物。另一个化石层位位于剖面的上部,在建组剖面中位于距底界34.5 m、距顶界12.4 m处,在该层位的化石点XJ 200614(46°24.757'N; 87°28.476'E)采集到一些大哺乳动物的牙齿碎片。这里将底部和上部层位的化石分开描述。

顶山盐池组底部XJ 200613和XJ 200617两个化石点有相当多共同的小哺乳动物(见表5),同归于顶山盐池组底部动物群,放在一起描述。该动物群总共有22个小哺乳动物化石种和4个大哺乳动物种,分属食虫目、翼手目、兔形目、啮齿目、食肉目、奇蹄目和偶蹄目等7个目的16科:鼯鼠科、鼯鼠科、蝙蝠科、鼠兔科、沙鼠科、仓鼠科、睡鼠科、始鼠科、跳鼠科、林跳鼠科、松鼠科、梳趾鼠科、啮齿目不定科、鹿科、马科和熊科。其中小哺乳动物中有11个种和1个属与通古尔期的默尔根动物群分子相同(见表5):*Alloptox gobiensis*, *Desmatolagus* sp., *Heterosminthus orientalis*, *Protalactaga major*, *P. grabaui*, *Democricetodon lindsayi*, *D. tongi*, *Megacricetodon sinensis*, *M. pusillus*, *Plesiodipus leei*, *Miodromys* sp. 和 *Keramidomys fahlbuschi*。大型哺乳动物中能鉴定的属种 *Anchitherium* 和 *Hemicyon* cf. *H. stehlini* 也是通古尔动物群中曾有记载的属。此外有两种不能鉴定到属种的鹿科动物牙齿碎片。

邱铸鼎等(2006)基于近20年来对内蒙古地区新近纪哺乳动物群研究的新进展,将通古尔期的动物群进一步细分为推饶木、默尔根和铁木钦三个次级动物群。认为这三个动物群的产出层位和动物组成代表了时代早晚不同的序列。顶山盐池组底部动物群中不具有铁木钦动物群中较为进步的 *Plesiodipus progressus*, 也没有较早的推饶木动物群中所含有的从渐新世和早中新世延续下来的属,如 *Prodistylomys* 和 *Tachyorctoides*, 以及较为原始的食肉动物,其时代应与默尔根动物群相当。

在我国,与默尔根动物群时代相当的小哺乳动物群还有甘肃永登咸水河组上部的泉头沟动物群(邱铸鼎,2000,2001a,b)、青海西宁盆地的车头沟组及咸水河组动物组合(邱铸鼎等,

1) 中国科学院知识创新工程重要方向项目(编号:KZCX2-YW-120)和国家自然科学基金项目(编号:40472022)资助。

收稿日期:2009-03-27

1981, 2006; 李传夔等, 1981)。泉头沟动物群有 11 属 12 种小哺乳动物, 与顶山盐池组底部动物群相同的种有 7 个: *Heterosminthus orientalis*, *Protalactaga major*, *P. grabau*, *Megacricetodon sinensis*, *Plesiodipus leei*, *Ganocricetodon cheni* 和 *Paracricetulus schaubi*。其中前 5 个种是与默尔根动物群共有的, 而 *Ganocricetodon cheni* 和 *Paracricetulus schaubi* 仅为泉头沟和顶山盐池组底部动物群共有。此外, 泉头沟动物群中的沙鼠类 *Myocricetodon* 和 *Mellalomys* 在默尔根动物群中是没有的, 而在顶山盐池组底部动物群中有属于 *Myocricetodontinae* 的成员。

青海西宁盆地车头沟组和咸水河组的动物组合中目前已知的小哺乳动物很少。车头沟组内有 *Heterosminthus orientalis* 和 *Megacricetodon sinensis* (原来描述的 *Megacricetodon cf. sinensis* 无疑可归入 *Megacricetodon sinensis*), 咸水河组动物组合中小哺乳动物仅有 *Plesiodipus leei* 和 *Alloptox chinghaiensis*。结合与它们共生的大哺乳动物成分, 以及不具有较古老的动物分子的特点, 这两个哺乳动物组合的时代可与默尔根动物群大致相当。

此外, 顶山盐池组底部动物群也可与甘肃秦安剖面 148 m 处的 A4 组合 (Guo et al., 2002) 对比。A4 组合中 6 个属种内有 4 个属种可与顶山盐池组底部动物群比较: *Desmatolagus* sp., *Alloptox gobiensis*, *Plesiodipus leei* (原鉴定为 *Gobicricetodon* sp.) 和 *Cricetodon* sp.。笔者有机会观察到 A4 组合中的 *Cricetodon* sp. 很可能归属顶山盐池组底部动物群中的 *Cricetodon volkeri* sp. nov.。

因此顶山盐池组底部动物群可与我国内蒙古通古尔期默尔根动物群、甘肃的泉头沟动物群、青海西宁盆地的车头沟组和咸水河组动物组合及甘肃秦安剖面 A4 动物组合对比。这些动物群的时代应大体上和欧洲新近纪陆相哺乳动物分期中的 MN7+8 较早期相当, 为中中新世中期 (依邱铸鼎等, 2006)。

顶山盐池组底部动物群中具有泉头沟动物群中特有的沙鼠类和 *Paracricetulus schaubi*, 表明它们可能具有相同的生态环境: 比通古尔动物群的生态环境更为干旱和开阔 (邱铸鼎, 2001b)。

顶山盐池组上部层位中产出有一枚很可能为贺风三趾马 *Hipparion* (*Plesiohipparion*) *houfenense* 的下臼齿、不能鉴定的犀类、长鼻类的牙齿残片和鸵鸟蛋片。贺风三趾马在中国的生存时期为保德期至河间期 (或榆社期) (邱占祥等, 1987)。新近, 对 2008 年夏季采集的小哺乳动物的初步鉴定表明, 顶山盐池组上部层位的时代不会晚于晚中新世的最晚期。因此顶山盐池组上部含化石层位的时代可能为晚中新世晚期, 顶山盐池组的时代应该为中中新世中期至晚中新世晚期。

文内的测量数据, 若无特殊说明, 均为: 齿冠长度×宽度; 单位为毫米 (mm)。

古仓鼠属 *Cricetodon* Lartet, 1851

弗尔克古仓鼠 (新种) *Cricetodon volkeri* sp. nov.

(图 3A-D)

种的特征 M1 的前边尖仅轻度二分, 具短的前纵脊外距。M1、M2 的前尖后刺弱或缺失, 后脊舌端与后边脊的中部相交。M1 可能仅具三齿根。上下颊齿的横脊近于横向伸展, 上臼齿的内脊和下臼齿的下外脊近于前后方向伸展。

名称由来 纪念已故德国著名的古生物学家 Volker Fahlbusch 教授对仓鼠类化石研究的重要贡献。

正型标本 左 M1 (IVPP V 15621.1); 2.93×1.98。

副型标本 右 M1 前段 (V 15621.2) 和一枚未经磨蚀的右 M2 (V 15621.3; 2.25×2.05)。

模式地点 新疆准噶尔盆地北缘顶山盐池西北 XJ 200613 地点。

归入标本 左 m2 (V 15622; 2.27×1.71, 齿冠的最大高度在舌侧下后尖处, 为 1.32 mm)。

XJ 200617 地点。

关键词:准噶尔盆地北缘,中新世,顶山盐池组,哺乳动物

中图法分类号:Q915.873 文献标识码:A 文章编号:1000-3118(2009)03-0208-26

THE MIOCENE MAMMALS FROM DINGSHANYANCHI FORMATION OF NORTH JUNGGAR BASIN, XINJIANG

WU Wen-Yu¹ MENG Jin^{1,2} YE Jie¹ NI Xi-Jun¹ BI Shun-Dong³ WEI Yong-Peng¹

(1 Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences Beijing 100044

wuwenyu@ivpp.ac.cn)

(2 Department of Vertebrate Paleontology, American Museum of Natural History New York NY 10024)

(3 Department of Biology, Indiana University of Pennsylvania Indiana PA 15705)

Abstract Fossil mammals from two levels of the Dingshanyanchi Formation are described. The fauna from basal beds of the formation consists of 22 small and 4 large mammal species belonging to 16 families of 7 mammalian orders, inclusive of a new species *Cricetodon volkeri*. The basal Dingshanyanchi fauna is correlative to the Moergen fauna of Nei Mongol, Quantougou fauna of Gansu, assemblages from the Chetougou and Xianshuihe formations of Xining Basin, and is middle Tunggurian in age, i. e. middle Middle Miocene, roughly equivalent to the early period of the European land mammal age MN7+8. A fragmentary cheek tooth of a probable *Hipparion* (*Plesiohipparion*) *houfenense* is the only identifiable specimen from the upper level of the Dingshanyanchi Fm., indicating an age of late Late Miocene or Pliocene of the sediments. However, a preliminary identification of the small mammals collected from the top level of the Dingshanyanchi Formation in the 2008 field season precludes from an age of Pliocene of the sediments. The Dingshanyanchi Formation spans therefore a time period from middle Middle Miocene to late Late Miocene.

Key words North Junggar Basin, Miocene, Dingshanyanchi Fm., mammals

The Dingshanyanchi Formation is a set of reddish silts distributed in the area northwest to the Dingshan Salt Lake in the southern area of the Ulungur River, northern Junggar Basin, Xinjiang (Meng et al., 2008). It overlies the Halamagai Formation at its type locality. Fossil mammals were discovered from 3 sites of the formation in 2006, of which two are within the basal beds: one (XJ 200613, 46°24.572'N; 87°28.541'E) is 2.3 m above the base of the formation and the other (XJ 200617, 46°24.479'N; 87°29.818'E) is within a sandstone lens at the base. About 1.5 and 1.25 tons of matrix were collected and screenwashed from the two sites respectively. Mammal fossils collected from the two sites are therefore primarily small mammals, consisting of 22 species, of which most are found in both sites (Table 5). Given their similar compositions and stratigraphic positions, the fossil assemblages from the two sites are considered to be coeval and collectively called the basal Dingshanyanchi fauna.

The third site (XJ 200614, 46°24.757'N; 87°28.476'E) is from the upper beds of the formation, at the level of 12.4 m below the top of the formation, where only sparse fragments of large mammals were surface-collected, including hipparions, rhinocerotids, and proboscideans. Many fragmentary ostrich eggshells are also present in the upper beds. We present here a brief description of the mammals collected from these sites and a discussion on their implications for biostratigraphy of this area. Specimens are measured in millimeter with a Wild M7A stereomicroscope. Tooth measurements are expressed as length by width throughout the text unless otherwise specified. Photographs were taken using a JSM 6100 electronic scanning microscope. All described specimens are housed in the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), Chinese Academy of Sciences, Beijing.

1 Systematic description

1.1 The basal Dingshanyanchi fauna

Insectivora Bowdich, 1821

Family Soricidae Fischer von Waldheim, 1817

Soricidae gen. et sp. indet. (large species)

(Fig. 1A–D)

Referred specimens XJ 200613: right P4 and M1 (IVPP V 15591.1) from the same individual, which are yellowish but not pigmented; a fragmentary right lower incisor (V 15591.2); a fragmentary right mandible with m1–m2 and a partial alveolus of m3 (V 15592). XJ 200617: a left M1 (V 15593).

Measurements See Table 1.

Description P4 is slightly worn. The paracone is high, with a steep anterior slope; the paracone crista swings posterolabially. The parastyle is conical and low, and separated from the paracone by a deep valley. The parastylar crest is absent. The protocone is slightly higher than the parastyle, situated on the anterior border of the tooth, lingual to the parastyle and separated from it by a shallow valley. A low and short ridge stretches out from the parastyle along its lingual slope. The conical hypocone is low and in line with the parastyle and protocone but separated from the protocone by a deep valley. Both hypocone flange and posterior emargination are well developed. The posterior cingulum is well developed and tapers lingually and terminates at the mid axis of the tooth; its labial end is separated from the paracone crista by a notch.

Both M1s are slightly worn. The posterior arm of the paracone is slightly longer than the anterior one, while the posterior arm of the metacone is much longer than the anterior one. The parastyle is distinctive, and the mesostyle is unsplit. The protocone is well developed, its anterior and posterior arms form a wide-opened V-shape; the posterior end of the posterior arm is free and extends between the metacone and hypocone, separated from the latter respectively by a lingual and a labial valley. The conic hypocone is lower and smaller than the protocone. Both hypoconal flange and posterior emargination are distinctive. A cingulum is extended from anterior or posterolingual side of the protocone to the anterolingual side of the hypocone. The posterior cingulum is similar to that of the P4 but is much longer.

Table 1 Measurements of *Soricidae* gen. et sp. indet. (large species) from XJ 200613 and XJ 200617 (measure method after Reumer, 1984) (mm)

Inventory No.	Specimen	BL	LL	AW	PW	PE
V 15591.1	P4 dex	1.81	1.07	W 1.71		0.98
V 15591.1	M1 dex	1.48	1.51	—	1.85	1.17
V 15593	M1 sin	1.51	1.42	1.71	1.90	1.17
Inventory No.	Specimen	L	TRW	TAW	HM	
	right mandible			—		1.56
V 15592	m1	1.53	0.79	0.93		
	m2	1.41	0.97	0.98		

Abbreviations: BL. buccal length; LL. lingual length; W. width; AW. anterior width; PW. posterior width; PE. posterior emargination; L. length of tooth; TRW. width of trigonid; TAW. width of talonid; HM. height of mandible (at the level of mental foramen).

An unworn right lower incisor, probably from the same species judging from its size, is slender, bicuspluate and buccal-lingually flattened with superior sharp ridge. The cusplues are distinct and lie on the sharp ridge. The anterior tip of the incisor curves steeply upwards, diffe-

ring from *Oligosorex* in which the same cusp has a slightly curved anterior tip. The root is broken, and the retained part of the tooth crown measured 1.56 mm in length.

The mental foramen is below the trigonid of m1, at approximately halfway of the mandible height. The mandible is 1.56 mm in depth at the level of the mental foramen. The m1 and m2 are deeply worn. The talonid is distinctly lower than the trigonid. The oblique crest extends to the midpoint of the posterior arm of the protoconid. The lingual cingulum is absent, whereas the labial cingulum is present, extending anteriorly toward the paraconid and connecting posteriorly to the posterior cingulum that reaches the middle point of the hypolophid. The entoconid and entoconid crest are developed. The hypolophid extends lingually to the posterior side of the entoconid, but it is difficult to tell whether there is a gap between them because of the deep wear.

Lacking necessary information on mandible morphology and number of antemolars, a definite generic and specific determination is impossible.

Soricidae gen. et sp. indet. (small species)

Referred specimens XJ 200613: a right M1 (V 15594.1), a right m1/2 (V 15594.2), and a left fragmentary mandible with worn m1 (V 15594.3).

Description The M1 measures 1.12×1.32. The paracone of M1 (V 15594.1) is broken, leaving only its posterior arm that extends to the anterior base of the mesostyle. The posterior arm of the protocone is slightly longer than the anterior one, and is nearly parallel to the lingual margin of the tooth, extending until the lingual base of the metacone and being separated from the metacone by a shallow valley. The anterior arm of the metacone is shorter than the posterior one, and the labial end of the posterior arm is separated from the labial end of the posterior cingulum by a narrow groove. A metastyle is absent. A clear lingual cingulum is around the protocone lingually, and extends backwards to the anterior base of the hypoconal flange. No hypocone is visible but the ridge of the hypoconal flange is well developed and connects posteriorly the posterior cingulum. The mesostyle is not bifid.

The m1/2 (V 15594.2) probably belongs to the same species and is not well preserved. It measures about 0.94 mm in length (width not measurable), with its anterior and basal parts of the tooth broken. The metaconid and entoconid are preserved, with the latter being lower than the former. The entoconid crest is absent or very low. There is a valley between the entoconid and the hypolophid. The oblique crest extends to midway of the posterior arm of the protoconid.

The m1 on a fragmentary mandible (V 15594.3) is deeply worn (black in colour) and has nearly the same size as V 15594.2. The mental foramen of the mandible is below the trigonid of m1.

Talpidae gen. et sp. indet.

(Fig. 1E)

Referred specimen XJ 200613: a right m1 (V 15595.1) and a fragmentary left humerus (V 15595.2).

Description The m1 measures 1.95 (length), 1.02 (width at the trigonid), 1.37 (width at the talonid), 0.80 (length of the trigonid), and 1.08 (length for the talonid including the entostylid). The tooth is unihypsodont, long and narrow. The trigonid is distinctly narrower and higher than the talonid. The paraconid is low. The metaconid and protoconid are considerably higher than the hypoconid and entoconid. A well developed entostylid is posterior to and below the entoconid. The oblique cristid connects the posterior arm of the protoconid (metacristid) on the lingual margin of the tooth, posterior to and below the metaconid. The m1 morphology suggests probably a new taxon, but the fragmentary material prevents a precise taxonomic allocation for the specimen. An incomplete humerus (V 15595.2) is robust and short with all articular processes damaged. It has the typical morphology of a talpid. By its relative size, we tentatively associate it with V 15595.1.

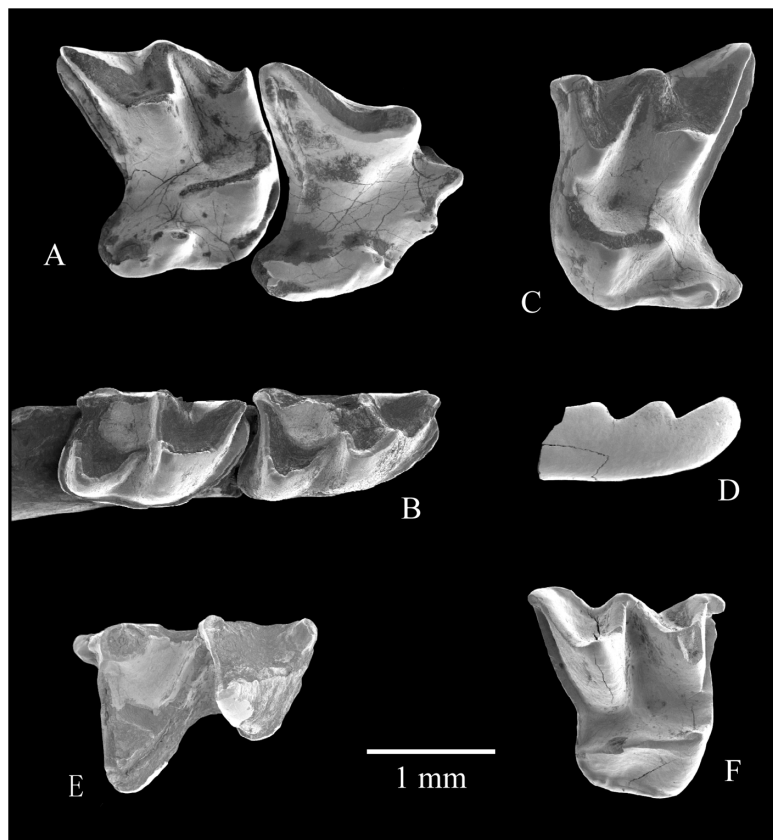


Fig. 1 Teeth of Soricidae gen. et sp. indet. (large sp.)(A-D), Talpidae gen. et sp. indet. (E) and *Myotis* sp. (F)

A. right P4 and M1 of the same individual (V 15591.1); B. right frag. mandible with m1-m2 (V 15592); C. l M1 (V 15593); D. right frag. lower incisor (V 15591.2); E. r m1 (V 15595.1); F. r M1 (V 15596)
A-C, E, F: occlusal view; D: labial view

Chiroptera Blumenbach, 1779

Vespertilionidae Gray, 1821

Myotis sp.

(Fig. 1F)

Referred specimen XJ 200617: a right M1 (V 15596) with measurements 1.51×1.73 .

Description This only specimen pertaining to Chiroptera of the fauna is well-preserved and unworn, but the top part of paracone is broken. The preparacrista and premetacrista are slightly shorter than the postparacrista and postmetacrista respectively. The paracone valley is shorter transversely than the metacone valley so that the tooth is slightly narrower anteriorly than posteriorly. The parastyle and metastyle are developed and stretch outwards. The protocone levels with the paracone. The preprotocrista is continued by the paracingulum that extends to the base of the parastyle, whereas the postprotocrista descends gently to the posterolingual corner of the tooth. A very tiny cusp is present posterior to the protocone on the postprotocrista, and there is a shallow vertical groove on the inner wall of the postprotocrista. Either hypocone or talon is absent. The basal cingulum starts from anteriorly below the preprotocrista, and then turns to the

lingual border of the tooth and continues into the metacingulum that reaches the metastyle at the base; it is weak at the anterolingual corner. Another piece of basal cingulum is present anterior to the metastyle and parallel to the postmetacrist. This tooth is 3-rooted; one lingual and two labial roots.

It is usually difficult to identify Chiroptera taxonomically based on only isolated tooth. Fortunately the studies on Chiroptera by Baudelot (1972) and Sevilla (1988) have provided rather detailed description and good figures that enable us to refer our M1 to *Myotis* without doubt. The morphology of this tooth as we described is well identical to that of M1 of some species Sevilla studied, for example *M. myotis*, *M. blythi*, *M. nattereri* from Quaternary of Spain.

The specimen is the first record of *Myotis* from the Miocene of China. The earliest record of this genus is from the Early Oligocene (MP21) of Hoogbutsel of Belgium. It has also been recovered from the Miocene of Europe (MN3–8; Wintershof-West, Sansan, La Grive, Lissieu, Oberdorf) (Baudelot, 1972; Ziegler, 1993, 1998; Storch, 1999).

Lagomorpha Brandt, 1855

Ochotonidae Thomas, 1897

Alloptox gobiensis (Young, 1932)

(Fig. 2A–C)

Referred specimens XJ 200613: 1I1, 1I2, 1DP2, 4P2, 2 well preserved P3, 1i2, 4 well preserved p3, a right mandible with p3–m3, 2 P4/M1 and 1 p4/m1/m2 (V 15597.1–18). XJ 200617: a fragmentary right upper jaw with P4–M2, 1I1, 2P2, 2 damaged P2, 1DP4, 2P4/M1; 1i2, 1dp3, 1p3, 8p4/m1/m2 (V 15598.1–20).

Measurements See Table 2.

Description The P2s and p3s are morphologically and metrically identical with those of *Alloptox gobiensis* from the Miocene of Tunggur (Qiu, 1996) and Tongxin (Wu et al., 1991). P2 has two distinct anterior reentrants which divide the tooth shaft into three lobes, the internal anterior reentrant is much deeper than the external one. The internal lobe is the largest one that again has a shallow reentrant on the anterolingual wall, forming an acute hook-like internal lobe of the tooth. The middle and external lobes are smaller and approximately equal. The p3 has the transversely extended rhomboid-shaped metaconid with anterior angle and two anteroexternal reentrants, and the anterointernal reentrant extending posteroexternally at first, then bending posterointernally. All teeth are well embedded in the cement.

Table 2 Measurements of *Alloptox gobiensis* from the Dingshanyanchi Formation (mm)

Loc.	DP2	P2	P3	DP4	dp3	p3
XJ 200613	0.68×1.12	0.93×1.45	1.61×2.74			1.70×1.66
		1.07×1.66	1.71×3.07			2.05×2.20
		0.98×1.82				2.15×2.29
		1.07×2.05				2.10×2.20
						1.86×1.96
XJ 200617		1.08×1.86		0.90×1.95	1.85×1.17	1.76×1.86
		0.88×1.66				

Desmatolagus sp.

(Fig. 2D–E)

Referred specimens XJ 200613: 1 right P4 and 2 fragmentary upper incisors (V 15599.1–3). XJ 200617: a middle part of a right mandible with p4–m3 and 3 fragmentary upper incisors (V 15600.1–4).

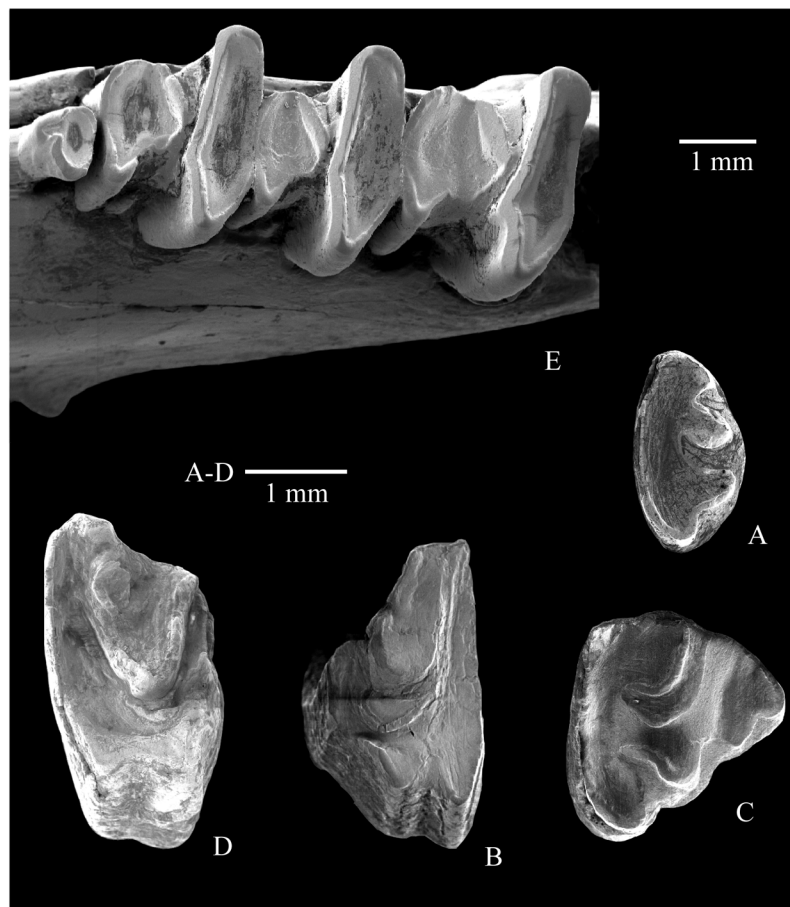


Fig. 2 Occlusal view of cheek teeth of *Alloptox gobiensis* (A–C) and *Desmatolagus* sp. (D–E)
 A. r P2 (V 15597.4); B. l P3 (V 15597.8); C. r p3 (V 15597.11); D. r P4 (V 15599.1);
 E. right mandible with p4–m3 (V 15600.1)

Description The P4 (V 15599.1) measures 1.71 (length) \times 2.30 (width of anterior lobe), 2.74 (width of posterior lobe); 4.4 mm high lingually and 2.45 labially. The tooth row length (p4–m3, measured along the tooth surface) of V 15600.1 is 7.04; other measurements of the specimen are listed in Table 3.

Table 3 Measurements of the lower cheek teeth of *Desmatolagus* sp. (mm)

V 15600.1	p4	m1	m2	m3
Length of tooth	2.35	1.96	1.96	
Trigonid (length \times width)	0.98 \times 2.64	0.98 \times 2.58	0.83 \times 2.45	0.78 \times 0.88
Talonid (length \times width)	1.27 \times 1.76	0.98 \times 1.66	0.98 \times 1.66	unmeasurable

The moderately worn P4 is unihypsodont, curved lingually, and posteriorly slightly wider than anteriorly. Its labial edge is slightly damaged, but the two small labial roots are visible. The main root is a circular cone in shape, and opens at the end. The hypostria is shallow and extends down to two thirds of the lingual height of the tooth. The crescentic valley is nearly of symmetrically acute V-shape. The general tooth pattern is similar to that of *Desmatolagus gobi-*

ensis from Hsanda Gol (Bohlin, 1937, textfigure 11, p. 18).

The p4, m1 and m2 on the mandible consist of wide trigonid and much narrower talonid respectively. The trigonid of m3 is very narrow and its talonid is greatly reduced, becoming a posterior process of the trigonid after wear. The single root of the m3 is visible.

Both upper and lower cheek teeth described here are characteristic of *Desmatolagus*. *Desmatolagus* (*Desmatolagus?* *moergenensis*) occurs in the Moergen fauna, Nei Mongol (Qiu, 1996). The Xinjiang and Nei Mongol forms represent by far the biostratigraphically youngest occurrences of the genus. No lower cheek tooth was collected from the Moergen fauna, and P4 from the Dingshanyanchi Fm. is different from that of Moergen fauna. A conclusive relationship between these forms remains unclear until more material is recovered.

Rodentia Bowdich, 1821

Sciuridae Gray, 1821

Sciuridae gen. et sp. indet.

(Fig. 3E–G)

Referred specimens XJ 200613: 2 damaged right m1/2 (ca. $1.66 \times -$; $- \times 1.76$), and a fragmentary left M1/2 with only anteroloph and protoloph remained; V 15601. 1–3. XJ 200617: a well worn left p4 (ca. 1.20×1.17) and a left M3 (1.65×1.63); V 15602. 1–2.

Description The protoloph of M1/2 is low and extends transversely to the robust and blunt protocone, it constricts midway and then slightly swells before it joins the protocone. The paracone is well developed. The anteroloph is parallel to the protoloph and lower than the latter. M3 is of a rounded-triangle in shape, its anteroloph is much lower than the protoloph. The mesostyle and metaloph are absent. The p4 is anteriorly narrower than posteriorly, and the mesoconid and entoconid are absent. The m1/2 is antero-posteriorly compressed, bearing a rhomboid-like tooth contour. The metaconid is the highest cusp. The anteroconid is weak and connected with the nearly complete metalophid through a short crest. The anterolophid is slightly lower than the metalophid, and the anterior cingulum is well developed. The entoconid is weak or absent, merged into the posterolophid. A shallow notch is present on the lingual crest between the metaconid and entoconid. The ectolophid is complete, slightly convex inwards, and the mesoconid is absent. The sinusid is wide. The enamel surface is smooth on the occlusal plane.

Judging from the size and morphology we regard the described specimens as from the same species. This species is characterized by the following dental features: small size; upper molar protoloph extending from the paracone to the protocone; the protoconule weak and the mesostyle absent; lower molars anteroposteriorly compressed, possessing the anterior cingulum, a weak anteroconid and a nearly complete metalophid but lacking the mesoconid and mesostylid; the entoconid merged into the posterolophid. This species appears similar in morphology and size to *Eutamias* aff. *E. ertemtensis* from Tunggur. Given the small sample size and fragmentary specimens, it is premature to identify it with certainty.

Dipodidae Waterhouse, 1842

***Protalactaga major* Qiu, 1996**

(Fig. 4A–F)

Referred specimens XJ 200613: 1 left m2 (2.31×1.68), 1 right m3 (1.73×1.42), 1 left M3 (1.35×1.44) and three fragmentary M1/2 (one M1/2 measured 2.31 mm in length); V 15603. 1–6. XJ 200617: 1 left P4 (0.88×0.90); 1 right M1 (2.15×1.76); 1 left M1 (2.31×1.95); 1 right m1 (2.49×1.74); 1 left m2 (ca. 2.25×1.56); 1 right m2 (2.41×1.76); V 15604. 1–6.

Description Similar to *P. major* from the Quantougou fauna (Qiu, 2000), the specimens from the Dingshanyanchi Formation are morphologically identical to *P. major* from its type

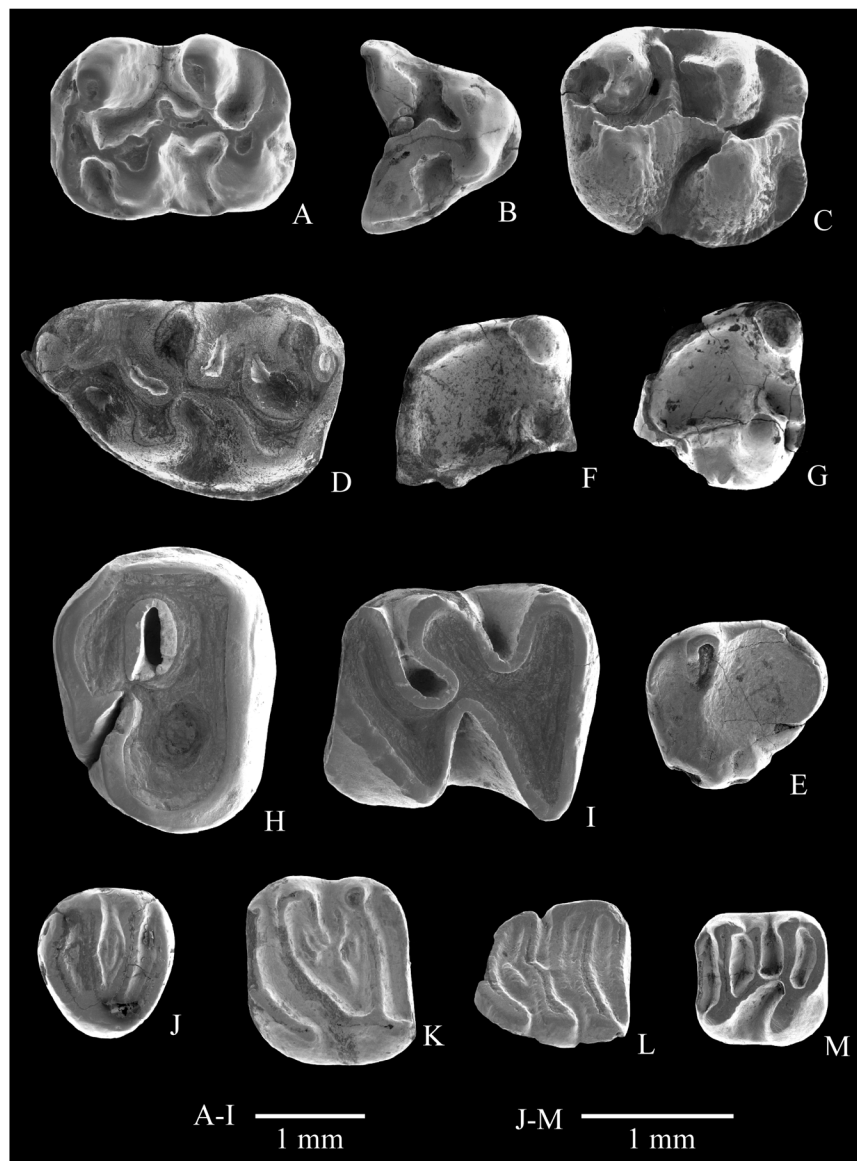


Fig. 3 Occlusal view of *Cricetodon volkeri* sp. nov. (A–D), Siuridae gen. et sp. indet. (E–G), Rodentia incertae familiae (H), *Sayimys* sp. (I), *Miodyromys* sp. (J–L) and *Keramidomys fahlbuschi* (M)

A. l m2 (V 15622); B. anterior fragment of right M1 (V 15621.2), paratype; C. r M2 (V 15621.3), paratype; D. l M1 (V 15621.1), holotype; E. l M3 (V 15602.1); F. r m1/2 (V 15601.2); G. r m1/2 (V 15601.3); H. r M3 (V 15626); I. r m2 (V 15612); J. l P4 (V 15611.3); K. l M1/2 (V 15610.1); L. r m2 (V 15611.1); M. l m1/2 (V 15609)

locality (Moergen II of Nei Mongol). However, the size of the new material metrically falls into the lower variation range of *P. major* from Moergen II. Of the Dingshanyanchi specimens the m2 mesolophid is slightly convergent to the hypolophid (almost parallel), but is absent on m3.

P. major is more primitive than *P. lantianensis* from the early Late Miocene of Lantian (Li and Zheng, 2005), and species of the genus are distributed westwards to Turkey in the late

Middle Miocene (Ünay et al., 2006). Presence of the *P. major* in the middle Middle Miocene of northern Xinjiang fills a gap in the biogeographic distributions of the genus.

***Protalactaga grabau* Young, 1927**

(Fig. 4G–H)

Referred specimens XJ 200613: a right M1/2 (1.78×ca. 1.47) and a left incomplete M1/2, V 15605.1–2. XJ 200617: 1 left m2 (1.93×1.52), 1 right m2 (1.76×1.47), 2 right m3 (1.56×1.29, 1.61×ca. 1.24), V 15606.1–4.

Description The specimens from these two localities are metrically smaller than those from Tunggur fauna but within the variation area of Quantougou population. The protoloph of

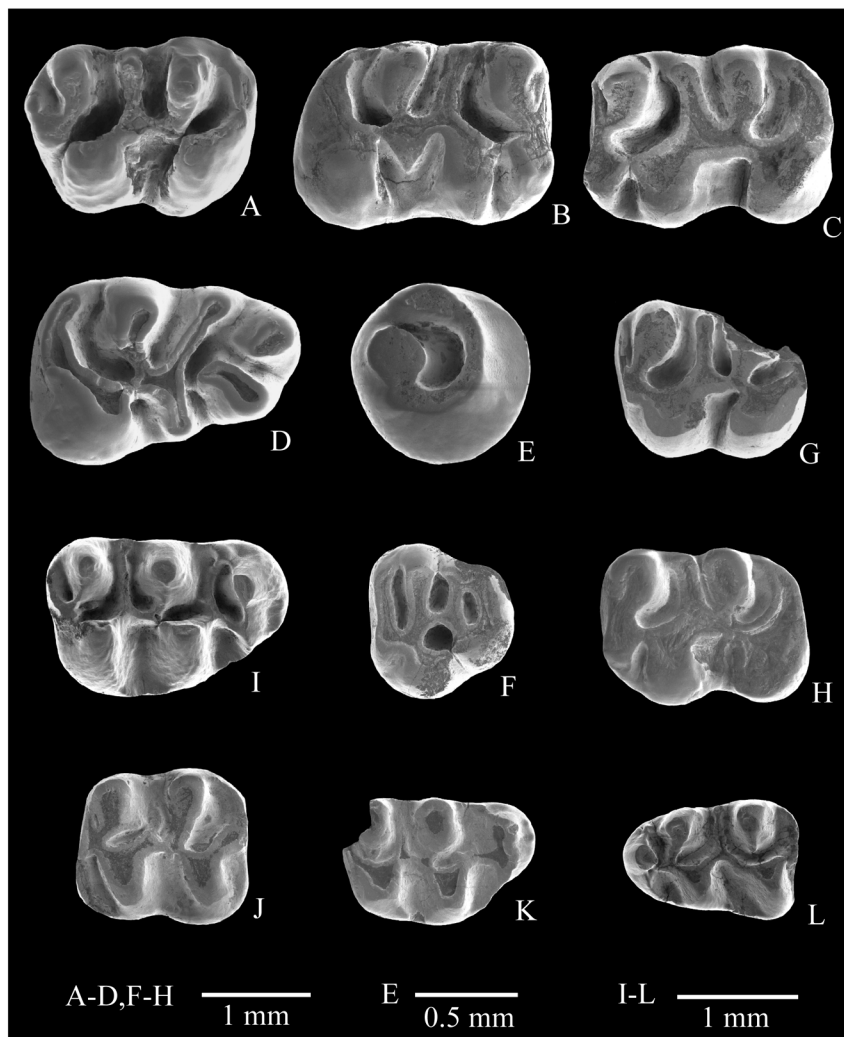


Fig. 4 Occlusal view of *Protalactaga major* (A–F), *Protalactaga grabau* (G–H), *Democricetodon lindsayi* (I–J) and *Democricetodon tongi* (K–L)

A. r M1, V 15604.2; B. r m2, V 15604.6; C. l m2, V 15603.1; D. r m1, V 15604.4; E. l P4, V 15604.1; F. l M3, V 15603.3; G. r M1/2, V 15605.1; H. l m2, V 15606.2; I. r M1, V 15616.1; J. l m2, V 15615.4; K. r M1, V 15613.1; L. l m1, V 15614.1

M1/2 is lingually connected with the endoloph, and the metaloph bends posteriorly.

Zapodidae Caues, 1875

***Heterosminthus orientalis* Schaub, 1930**

(Fig. 5M–N)

Referred specimens XJ 200613: 1 right P4, 1 damaged right M2, 1 left m1 and 1 right m3 (V 15607.1–4). XJ 200617: 1 right P4, 1 left M2, 1 damaged left M2 and 1 damaged right m1 (V 15608.1–4).

Measurements P4 (V 15607.1), 0.54×0.55 ; P4 (V 15608.1), 0.56×0.59 ; M2 (V 15607.2), $- \times 0.98$; M2 (V 15608.2), 1.34×0.93 ; M2 (V 15608.3), $- \times 0.95$; m1 (V 15607.3), $- \times ca. 0.93$; m1 (V 15608.4), $- \times 0.93$; m3 (V 15607.4), 1.02×0.78 .

Description Though most teeth are damaged but they are morphologically identical to and metrically within the variation range of *Heterosminthus orientalis*.

Heterosminthus orientalis is known from the middle Middle Miocene Tunggurian of Nei Mongol, Gansu and Qinghai, China, and the equivalent strata from the People's Republic of Mongolia. *Heterosminthus* cf. *H. orientalis* has been reported from the earliest Late Miocene of Amuwusu of Nei Mongol (Qiu, 1996; Qiu et al., 2006; Zazhigin and Lopatin, 2000).

Eomyidae Deperet & Douxami, 1902

***Keramidomys fahlbuschi* Qiu, 1996**

(Fig. 3M)

Referred specimen XJ 200617: a left m1/2 (V 15609).

Description The tooth measures 0.88×0.93 and has 4 roots. Except for its slightly larger size the tooth is identical to that of *Keramidomys fahlbuschi* Qiu (1996) from the Tunggur fauna.

Gliridae Thomas, 1897

***Miodiromys* sp.**

(Fig. 3J–L)

Referred specimens XJ 200613: left M1/2 (V 15610.1), 1.17×1.38 mm; left M1/2 (V 15610.2), ca. 1.19×1.37 mm, slightly damaged anteriorly. XJ 200617: 1 right m2 (V 15611.1), ca. 1.09×1.13 , slightly damaged posteriorly; 1 left m3 (V 15611.2), 1.03×1.06 ; and left P4 (V 15611.3), 0.89×1.05 .

Description and discussion M1/2 (V 15610.1, Fig. 3K) is rectangle in shape, wider than long, with concave occlusal surface. The paracone and metacone are somewhat swollen; the latter is obviously isolated from the posterior centroloph and the former is labially slightly isolated from the protoloph. The anteroloph is lingually not connected to the endoloph, and both anteroloph and posteroloph are labially free-ended. The anterior and posterior centrolophs are connected with each other to form a Y-shape. Two accessory ridges are present: one between the protoloph and anterior centroloph, the other between the posterior centroloph and metaloph. No accessory ridge is present either between the antero-loph and protoloph or between the metaloph and posteroloph. The inner wall of the endoloph is lightly ornamented. The other M1/2 (V 15610.2) is similar to V 15610.1 in tooth pattern, but possesses only one accessory ridge that is between the protoloph and anterior centroloph. In addition, the centrolophs are not connected with each other.

The P4 (Fig. 3J) is oval-shaped and three-rooted, with the anterolabial and lingual roots being more robust than the posterolabial one. Five transversal main ridges, including anteroloph, protoloph, metaloph, posteroloph and one centroloph, and an endoloph are present. The centroloph is short and low, located in the middle of the trigon and isolated from all other lo-

phs. The other four transversal ridges are all labially free and their lingual ends are connected with a smooth endoloph. The protoloph and metaloph converge to the protocone in a V-shape. The paracone and metacone are swollen, with the latter being more so. Because they all have the swollen and usually isolated paracone or metacone, the P4 and M1/2 are considered from the same species.

The m2 (Fig. 3L) has a weak accessory ridge between the anterolophid and metalophid, otherwise only one accessory ridge is between the mesolophid and posterolophid on m2 and m3. The centrolophid is three fourths of the tooth width. The labial ends of metalophid, mesolophid and posterolophid are inflated. The lingual ends of the lophids are often freely ended. The m2 retains a stump of the anterior root that is wide and bears a perpendicular groove on its anterior surface.

The upper and lower molars of this form are comparable in both morphology and size with those of *Miodiromys* sp. from Moergen II of Nei Mongol (Qiu, 1996). This form is characterized by its simple tooth pattern, slender lophs and somewhat smooth enamel surface, as well as by the P4 which possesses a slender, low and isolated centroloph and an endoloph. It is different from the European species in having relatively slender lophs and smooth enamel surface and in the pattern of P4. These specimens probably represent a new species as additional material becomes available in the future.

Species of *Miodiromys* with simple tooth pattern, such as *M. biradiculus*, occurs from MN2 to MN3 in Germany (Mayr, 1979). It is much earlier than Tuggurian in age. However, the Dingshanyanchi specimens are insufficient to explore the taxonomic relationship with their European relatives.

Ctenodactylidae Zittel, 1893

Sayimys sp.

(Fig. 3I)

Referred specimen XJ 200617: a right m2 (V 15612).

Description and comment The m2 measures 2.45×2.15, and 2.15 wide anteriorly and 2.05 posteriorly. The tooth is undoubtedly an m2 because of presence of anterior and posterior contact facets. On the occlusal surface the mesoflexid is shorter, wider and deeper than the metaflexid. The hypoflexid is further deeper than the mesoflexid. No metalophulid is present. The hypolophid extends obliquely and is almost aligned with the posterior arm of the protoconid. The posterolophid is not constricted, and the postero-labial ledge is developed. This tooth is identical to, but slightly larger than, *Sayimys* cf. *S. minor* from Y721 and Y747 of Kamliar Formation, Potwar Plateau, Pakistan (Baskin, 1996). López-Antoñanzas and Sen (2003) restudied the material of *S. cf. S. minor* from Y721 and Y747 and named a different species *Sayimys baskini*. The Xinjiang form probably belongs to the same lineage of *S. baskini*.

Bohlin (1946) described the first *Sayimys* from China: *Sayimys obliquidens* from Tabenbuluk of Gansu (Tieh-Chiang-ku, Yindirte valley). More specimens of *Sayimys* have been collected from China since 1980s (Li et al., 1983; Wu et al., 1998; Qiu and Wang, 1999; Ye et al., 2001a,b) but none of them has been fully described. The m2 from the Dingshanyanchi Fm. is similar to that of *Sayimys obliquidens* in having the mesoflexid shorter and wider than metaflexid, the mesoflexid deeper than metaflexid, an obliquely extended hypolophid, the posterolophid not constricted and a well-developed posterolabial ledge, however differs from the latter in absence of the metalophulid II on m2. It is most likely that the specimen from the Dingshanyanchi Fm. is a species different from *Sayimys obliquidens*. A systematic study of all *Sayimys* specimens from various localities of different ages from North Junggar Basin of Xinjiang is under way.

Cricetidae Rochebrune, 1883***Democricetodon lindsayi* Qiu, 1996**

(Fig. 4I–J)

Referred specimens XJ 200613: 1 right m1 (1.71×1.20), 3 m2 (2 left m2 1.44×1.30 ; ca. $1.52 \times \text{ca. } 1.27$; a damaged right m2 ~ 1.37), V 15615.1–4. XJ 200617: 1 right M1 (2.00×1.37), 2 left M3 (1.00×1.09 ; 1.00×1.10), 1 fragmentary left m1 (~ 1.02) and 1 fragmentary right m2 (~ 1.22), V 15616.1–5.

Description The anterior tip of the m1 anteroconid (V 15615.3) is eroded. It has a long mesolophid and distinct ectomesolophid. Three of the four m2s are damaged. The mesolophid on m2 varies from short to long and a distinct ectomesolophid is present on one m2.

The anterocone of M1 is slightly bifid, with a small enamel tubercle being present on the lingual base of the anterior wall of the anterocone. The labial spur of the anterolophule extends to the labial border of the tooth. The protolophule is doubled, with the protolophule I being very low. The metaloph extends backward and connects to the posterior arm of the hypocone. The M1 mesoloph is long and ends at the labial border of the tooth. The subtriangular M3 is wider than long; its posterior half is strongly reduced so that the hypocone is very small, the metacone is absent, and the sinus is almost absent. The mesoloph is present on one tooth as a remnant but absent on the other.

In general, the Dingshangyanchi specimens are similar in both morphology and size to those from Moergen II except that some teeth show a slightly larger width and occasional presence of the ectomesolophid on m1 and m2.

***Democricetodon tongi* Qiu, 1996**

(Fig. 4K–L)

Referred specimens XJ 200613: 2 M1 (right M1 ca. $1.61 \times \text{ca. } 1.10$; left M1 ~ 1.05), one of which lacks the anterocone, the other one is damaged posterolabially; left m3 (1.01×0.81), V 15613.1–3. XJ 200617: 2 left m1 (1.42×1.02 ; 1.46×1.02), 1 left m3 (1.05×0.88); V 15614.1–3.

These specimens are basically identical to those of *Democricetodon tongi* from Moergen II in size, but M1s are slightly larger, and one m1 and the m3s are slightly smaller than those of *D. tongi* from the type locality. The following features are observed, which fall into the morphological variation of *D. tongi* from Moergen II: M1s possess doubled protolophule and the metalophule II that connects to the posterior arm of hypocone; the metalophule I is absent; the mesoloph is of half length; one M1 displays a short labial spur of anterolophule; the m1 has a long mesolophid that extends to the lingual border of the tooth. The m3s demonstrate both labial and lingual anterolophid; one specimen has a short mesolophid and the other lacks it.

***Megacricetodon sinensis* Qiu et al. 1981**

(Fig. 5B–I)

Referred specimens XJ 200613: 3 right and 3 left M1 (four out of six M1 are damaged or eroded), 2 right and 1 left M2, 2 right M3, 3 left m1, 2 left and 1 right m2, 1 left m3; V 15617.1–18. XJ 200617: 2 left M1, 1 left and 1 right M2; 3 right m2 (one fragmentary); V 15618.1–7.

Measurements See Table 4.

Description A cingulum is present at the base of the anterior wall of the anterocone of M1. The posterior spur of the paracone is more or less developed on all M1 and M2. The protolophule I is present on only one M1 as a low ridge, and the protolophule II connects to the posterior arm of the protocone. The metaloph is connected to the posterior arm of the hypocone

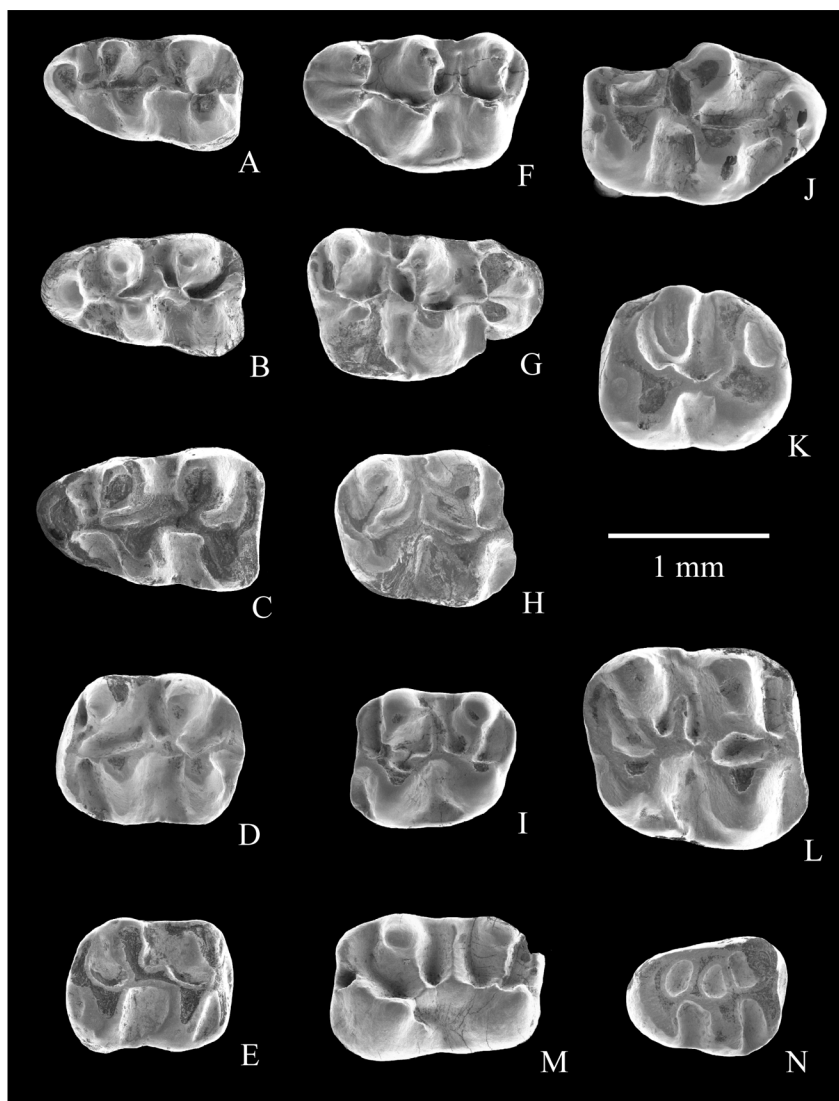


Fig. 5 Occlusal view of molars of *Megacricetodon pusillus* (A), *Megacricetodon sinensis* (B-I), *Paracricetulus schaubi* (J), *Myocricetodontinae* gen. et sp. indet. (K), *Ganocricetodon cheni* (L) and *Heterosminthus orientalis* (M-N)

A. 1 ml (V 15721); B. 1 ml (V 15617.12); C. 1 ml (V 15617.13); D. 1 m2 (V 15617.15); E. r m2 (V 15618.5); F. 1 M1 (V 15618.1); G. r M1 (V 15617.1); H. r M2 (V 15617.7); I. 1 M2 (V 15618.3); J. r M1 (V 15620); K. 1 M2 (V 15625.1); L. r M2 (V 15619.1); M. 1 M2 (V 15608.2); N. r m3 (V 15607.4)

or the posteroloph on M1. The mesoloph is long on M1 and M2, reaching or almost reaching the labial margin of the tooth. All M2s have developed protolophule I, and the protolophule II is present on only one M2 (Fig. 5I). Three M2s have their metaloph connected to the anterior arm of the hypocone (Fig. 5I) as in the population from Moergen II of Nei Mongol. There are two M2s from XJ 200613 with their metalophs connected posteriorly to the posterior arm of the hypocone (Fig. 5H), they are much wider (1.10×1.08, 1.12×1.08) than those from Moergen II. However we have noticed that from the Quantougou population one M2 also has its metaloph

connected to the posterior arm of the hypocone (Qiu, 2001a:208), therefore we tentatively refer these two M2s from the Dingshanyanchi Fm. to *M. sinensis*. The M3 is slightly narrower than those from Moergen II and Quantougou, otherwise it is similar to the Moergen II form in morphology. The m1 is long and narrow with a single anteroconid. The mesolophid on m1 and m2 varies from absent to long (it is long on one m1, absent on another m1, and half-long on the third one), it is usually short in m2. The lingual anterolophid of m2 is much weaker than the labial one. The m3 lacks the mesolophid. The M1 and M2 are three-rooted.

The type locality of *Megacricetodon sinensis* is Danshuilu, Huzhu County of Qinghai Province (Qiu et al., 1981), where only one m1 and m2–m3 are recovered. More specimens of the species have also been found from Tunggur (Qiu, 1996) and Quantougou (Qiu, 2001a) faunas. The specimens from Dingshanyanchi fauna are morphologically and metrically similar to *M. sinensis*.

Table 4 Measurements of the cheek teeth of *Megacricetodon sinensis* (mm)

Specimens	Length			Width		
	N	mean	range	N	mean	range
XJ 200613						
M1	4	1.41	1.33 ~ 1.48	5	0.91	0.83 ~ 0.98
M2	3	1.09	1.05 ~ 1.12	3	1.02	0.89 ~ 1.08
M3	2	0.68	0.66 ~ 0.71	2	0.67	0.66 ~ 0.68
m1	3	1.38	1.29 ~ 1.44	3	0.89	0.78 ~ 0.98
m2	3	1.16	1.10 ~ 1.22	3	0.95	0.83 ~ 1.05
m3	1		0.84	1		0.66
XJ 200617						
M1	2	1.33	1.30 ~ 1.37	2	0.87	0.86 ~ 0.89
M2	2	1.02	1.00 ~ 1.05	2	0.89	0.86 ~ 0.91
m2	2	1.04	1.03 ~ 1.06	2	0.86	0.86

Megacricetodon pusillus Qiu, 1996

(Fig. 5A)

Referred specimens XJ 200613: a right m1 (V 15720). XJ 200617: a left m1 (V 15721).

Description The two m1s measure $1.23 \times ca. 0.73$ (V 15720) and 1.24×0.73 (V 15721) respectively. These teeth are identified as *Megacricetodon pusillus* based on their morphology and size. Both are as long as the smallest teeth of *Megacricetodon sinensis* of Tunggur fauna but quite narrower than the minimum width of the latter. *Megacricetodon pusillus* has been recovered only from Tunggur fauna (Moergen II and V), which is represented by only a few specimens. After studying *Megacricetodon pusillus* and *M. sinensis* from all localities we regard *M. pusillus* as a valid species for the time being.

Ganocricetodon cheni Qiu, 2001

(Fig. 5L)

Two M2s (V 15619.1–2) from XJ 200613 are measured 1.37×1.32 (figured) and 1.27×1.12 respectively. They are morphologically different from all other cricetids from the basal Dingshanyanchi fauna in having the doubled protolophule, the developed labial and lingual anterolophs and the anteriorly directed metaloph that is connected with the anterior arm of the hypocone. Moreover both protolophule I and II are almost equally developed and symmetrically positioned. These structures and size are undoubtedly characteristic of *Ganocricetodon cheni*, a

species named by Qiu (2001a) from the Quantougou faunas. It is noted that the lingual root of the specimen V 15619.1 is strong and anteroposteriorly expended with a shallow perpendicular groove on the inner surface.

***Paracricetulus schaubi* Young, 1927**

(Fig. 5J)

Only one specimen from locality XJ 200617 (a damaged right M1, V 15620) has been recovered. This tooth has lost its posterolabial part, and measured $1.52 \times ca. 1.03$. It is characterized by the following features: conical cusps, short and unilobed anterocone, presence of lingual anteroloph and distinct posterior spur of the paracone, the posterolingually extended protoloph that joins the posterior arm of the protocone, well-developed mesoloph, posteriorly extended metaloph that connects the posteroloph, wide and transversely extended sinus, presence of the cingulum blocking the sinus and the antero-ectosinus, and presence of four roots. With these features the tooth can be assigned to *Paracricetulus schaubi*. This species was known only in the Middle Miocene Quantougou fauna of Gansu (Qiu, 2001a).

***Cricetodon volkeri* sp. nov.**

(Fig. 3A–D)

Derivatio nominis This species is dedicated to the late German paleontologist, Prof. Dr. Volker Fahlbusch who has made a great contribution to the study of hamsters.

Holotype A left M1 (V 15621.1), ca. 2.93×1.98 .

Paratypes An incomplete right M1 (V 15621.2); and an unworn right M2 (V 15621.3), 2.25×2.05 .

Type locality XJ 200613, northwest of the Dingshan Salt Lake of North Junggar Basin, Xinjiang.

Age Middle Middle Miocene (middle Tunggurian).

Referred specimens A left m2 (V 15622) from XJ 200617, measured 2.27×1.73 , the greatest height (at the metaconid) of the tooth crown is 1.32 mm.

Diagnosis Anterocone of M1 slightly bilobed; presence of a short labial spur of anterolophule; posterior spur of paracone present or absent on M1 and present on M2; posteroloph of M1 and M2 extending beyond the junction of metaloph and posteroloph; M1 probably three-rooted; main loph(id)s of cheek teeth oriented almost transversely; endoloph and ectolophid extending almost anteroposteriorly.

Description Cheek teeth are low-crowned. The holotype M1 is slightly eroded so that some features are not clear; however the paratype provides a complement to the holotype. The anterocone is slightly bilobed. A short labial spur of the anterolophule is present. The posterior spur of the paracone is absent on the holotype but present on the paratype. The protoloph extends slightly posterolingually and connects the posterior arm of the protocone. The metaloph joins the posteroloph. The mesoloph is at least half as long as the mesosinus length. The sinus is anterolabially extended. A perpendicular groove is present on the inner surface of the lingual root. M2 is similar to the posterior part of M1 in morphology but has a developed posterior spur of the paracone. The mesoloph is long and bends backwards on the labial border of the tooth, it tapers and becomes lower labialwards. Both labial and lingual anterolophs are well developed with the lingual one being lower. The mesosinus is enclosed by a distinct cingulum on the labial border, and the sinus is probably blocked by a lingual cingulum that is damaged in part. The endoloph on M1 and M2 is almost anteroposteriorly extended. The m2 is slightly worn. The anteroconid and labial anterolophid are developed but the lingual anterolophid is absent (merged into the metalophid). The ectolophid is parallel to the labial and lingual borders of the tooth. The mesolophid is short and a very weak ectomesolophid is observable. The metalophid and hy-

polophid are transversely directed.

Comparison and discussion de Bruijn et al. (1993) diagnosed *Cricetodon* as “...low-crowned cheek teeth. Cusps of cheek teeth ‘inflated’. Anterocone of M1 single or double. Labial branch of the antrolophid of the m2 incorporated in the metalophulid I. M1 and M2 with three or four roots. Free posterior arm of the hypoconid absent in all lower molars...”. The new species, although represented by only a few molars, belongs distinctively to *Cricetodon*. It is characterized mainly by the slightly bilobed anterocone of M1, absence or presence of the posterior spur of the paracone on M1 and M2, nearly anteroposteriorly extended endoloph and ectolophid, almost transversely directed main loph(id)s on cheek teeth, and the metaloph not merged into the posteroloph on upper cheek teeth.

New species is obviously different from *Cricetodon orientalis*, the first described species of *Cricetodon* from China (Bi, 2005). *C. orientalis* is in contrast characterized by well bilobed anterocone on M1, the endoloph and ectolophid more diagonally extended, the metaloph on M1 and M2 more obliquely extended and almost merged into the posteroloph, and the well developed posterior spur of the paracone on M1 and M2. *Cricetodon volkeri* seems more primitive than *C. orientalis* from the Halamagai Formation of early Middle Miocene (Bi, 2005) although the Dingshanyanchi Fm. is younger than the Halamagai Fm. as their superpositional relationship unquestionably indicates.

There are at least 18 known species of *Cricetodon* that are distributed in Europe and Asia. Among them *Cricetodon volkeri* is more similar to *Cricetodon tobieni* from Turkey (de Bruijn et al., 1993; upper MN3–lower MN4) than to any other species in that the posteroloph on M1 and M2 extends beyond the junction of the metaloph and posteroloph. However, *C. tobieni* is smaller; it has the well bilobed anterocone, a more developed posterior spur of the paracone on M1 and M2, M2 four-rooted and tooth enamel more wrinkled.

Cricetodon aliveriensis from Aliveri (MN4) of Greece (Klein Hofmeijer and de Bruijn, 1988) is also similar to *Cricetodon volkeri* but differs in having a much smaller size, well bilobed M1 anterocone, and four-rooted M1 and M2.

Another species similar to *Cricetodon volkeri* is *C. kasapligili* from locality Keseköy (MN3) of Turkey (de Bruijn et al. 1993), which is characterized in having a ill-bilobed or unilobed M1 anterocone, M1 three-rooted with a broad and grooved lingual root, the metaloph not merged into the posteroloph, and the posterior spur of the paracone on M1 and M2 undeveloped. *Cricetodon kasapligili* differs from *Cricetodon volkeri* in having short mesoloph(id) on cheek teeth, and possibly four-rooted M2(the M2 root-number of *C. volkeri* is unknown).

Cricetodon versteegi from locality Kilçak 3a (MN1) of Turkey differs from *Cricetodon volkeri* in having a smaller size, the M1 anterocone well bilobed, and the M2 metaloph anterolingually directed.

Other species of *Cricetodon* include *C. caucasicus* (Argyropulo, 1938), *C. meini* (Freudenthal, 1963), *C. lavocati* (Freudenthal, 1966), *C. joeti* and *C. aureus* (Mein and Freudenthal, 1971), *C. aguirrei*, *C. sansaniensis*, *C. albanensis*, *C. pasalarensis* and *C. candirensis* (Tobien, 1978; Sen and Ünay, 1979), *C. cariensis* (Sen and Ünay, 1979), *C. hungaricus* (Kordos, 1986) and *C. bolligeri* (Rummel, 1995). All these species have the anterocone well-bilobed, the labial spur of the labial anterocone on M1 well developed, the posterior spur of the paracone developed, the metaloph strongly extended backwards and merged into the posteroloph on the upper cheek teeth, and M1 and M2 usually four-rooted. *Cricetodon volkeri* is clearly different from all of them.

Cricetodon is a group of cricetodontines with high diversity and complicated phylogeny. *C. volkeri* and *C. orientalis* most likely belong to different lineages of the genus. *C. volkeri* retains some more primitive characters although it has a younger temporal distribution than *C. orientalis*. The stratigraphically older but morphologically more derived *C. orientalis* probably leads to a

lineage that gives rise to *Gobicricetodon* and *Plesiodipus*. This scenario implies that *Cricetodon* is possibly a non-monophyletic group, an issue beyond the scope of this study.

Plesiodipus leei Young, 1927

(Fig. 6)

Referred specimens XJ 200617: an unworn left M2, an incomplete right lower jaw with m1–m3, 1 right m1 and a left m3; V 15623.1–4. XJ 200613: two heavily damaged m2 and one incomplete m3; V 15624.1–3.

The M2 measures 2.22×1.71 , lingual crown height at the level of the protocone 1.71, labial height at the level of paracone 1.38. The transverse lophs extend diagonally. The lingual anteroloph and the mesoloph are almost absent. The posterior spur of the paracone strongly bends lingually, even more so than in *Gobicricetodon flynni* (Qiu, 1996) and it will disappear soon after the initial stage of wear. The metaloph completely merges into the posteroloph. The sinus extends anterolabially.

The vertical ramus of the right lower jaw (V 15623.2) is broken. The m3 (Fig. 6B) is detached but definitely belongs to the same individual (the lower dentition on Fig. 6A is reconstructed). The teeth measurements are: length of m1–m2 = 4.35, m1: 2.20×1.48 ; m2: 2.13×1.70 ; m3: 2.05×1.54 .

The lower jaw is distinctly slender than that of *Gobicricetodon flynni*. The mental foramen is located below the diastema, anterior to the anterior end of the masseteric ridge, as in *Gobicricetodon flynni*. On the anterior surface of the lower incisor there are two distinct thin parallel longitudinal ridges. The ectolophid of m1 extends anterolabially. The mesolophid is absent on m1–m2 and weak on m3. The m1 possesses short ectomesolophid and extremely short metalophulid I and II. The labial anterolophid on m2 and m3 is short and connected labially to the base of the protoconid, the lingual anterolophid is absent on m2 and m3.

The isolated m1 (V 15623.3) is strongly rounded in preservation but is similar to the m1 on the lower jaw. The isolated left m3 (V 15623.4, Fig. 6D) measures 1.93×1.52 ; it has a very weak mesolophid.

Plesiodipus leei from the basal Dingshanyanchi fauna is metrically within the variation range of the Moergen II population but slightly smaller than that of Quantougou population.

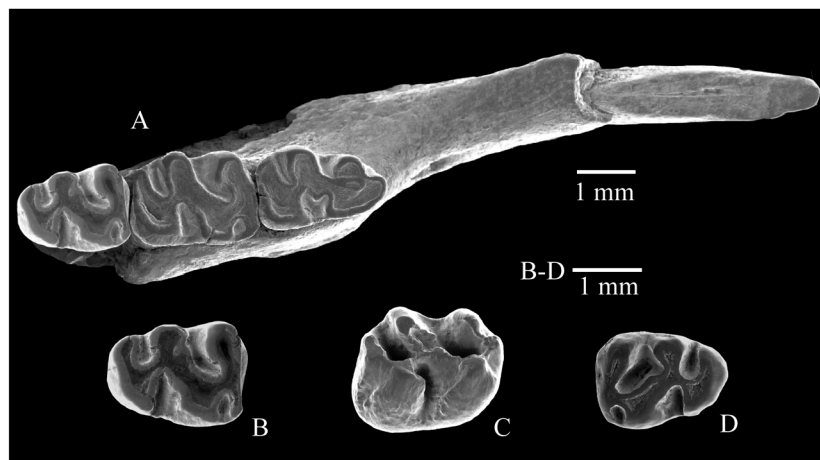


Fig. 6 Occlusal view of *Plesiodipus leei*

A. Right mandible with m1–m3, the m3 is detached from the mandible, the picture of m3 was taken separately and then put back to the original position (V 15623.2); B. r m3 (V 15623.2); C. l M2 (V 15623.1); D. l m3 (V 15623.4)

Myocricetodontinae gen. et sp. indet.

(Fig. 5K)

Two teeth are present from XJ 200617: one left M2(1.20×1.07) and one right m3(0.98×0.83); V 15625.1–2. These two teeth are characterized by their small sizes, absence of the mesoloph and mesolophid, straight and very thin and short longitudinal crests (endoloph and ectolophid) that are parallel to the longitudinal axis of the tooth. The M2 longitudinal crest (endoloph) is positioned more lingually. The robust protoloph and metaloph extend slightly anterolabial-posterolingually. The protoloph is directed to the anterior part of the protocone but constricts before reaching the latter. The metaloph connects the center of the hypocone, so that the posterior sinus is wide. The m3 lingual anterolophid is absent, the metalophid merges into the labial antorolophid; the entoconid and hypoconid are transversely elongated, connected with each other, formig a transverse row, the posterolophid is absent.

Myocricetodontinae are distributed in Africa, south Europe, south and west Asia. There is no record of Myocricetodontinae in the Tunggur fauna but two genera and two species (*Mellalomys gansus* and *Myocricetodon plebius*) were known from the Quantougou fauna. The Dingshanyan-chi specimens are similar to *Mellalomys gansus* but the M2 differs from the latter in development of the posterior sinus and the endoloph being lingually positioned. We do not think the available specimens warrant a more precise taxonomic allocation and tentatively assign them to Myocricetodontinae gen. et sp. indet. Presence of Myocricetodontinae in the basal Dingshanyan-chi Fm. indicates probably dry and open environment (ref. Qiu, 2001b).

Rodentia incertae familiae

(Fig. 3H)

Referred specimen XJ 200617: a right M3(V 15626).

Description The tooth is high-crowned and antero-posteriorly compressed, with its labial side being longer than its lingual one. The enamel is thick and smooth. The tooth is well-worn and an enamel pit on the labial part of the occlusal surface remains. Opposite to the pit is the posterolingually extended flexus. The lingual part of the occlusal surface is excavated by a deep hollow. A wear facet is present on the anterior wall of the tooth, but absent on the posterior. Three roots are present. The large anterior labial root is anteroposteriorly expanded to such an extent that its antero-posterior length is almost equal to the tooth length, and a shallow vertical groove is present on its labial surface. The posterior labial root is very small and is located posterolingually to the large labial root. The lingual root is anterolingually situated. The tooth crown measures 2.01×2.64, 1.80 mm high labially and a minimum height of 0.98 mm lingually. This tooth has an unusual morphology, but it most likely belongs to a rodent.

Carnivora Bowdich, 1821**Ursidae Gray, 1825****Subfamily Hemicyoninae Frick, 1926*****Hemicyon* cf. *H. stehlini* Hürzeler, 1944**

(Fig. 7)

Referred specimen XJ 200617: a left P4(V 15627).

Description The P4 is small, measured 18.8×11.38 mm (width at the level of the protocone), with the protocone being about 8.3 mm long. The paracone is swollen anterolabially and the parastyle is absent. The anterolabial cingulum is absent but the lingual and posterolabial cingula are well developed. Two crests stretch out from the tip of the paracone and run down to the base of the tooth, one along the anterior slope of the paracone and the other to the anterolabial side of the protocone. The protocone is low, ridge like, merging posteriorly into the

lingual cingulum. The specimen is identical to that of *Hemicyon*, characterized by the anterolabially inflated paracone and the absence of a parastyle.

Two species of *Hemicyon* have been described from China: *H. teilhardi* from the Middle Miocene of Tung Gur, Nei Mongol (Colbert, 1939a) and *Hemicyon* (*Phoberocyon*) *youngi* from the Middle Miocene of Zhongxiang, Hubei (Chen, 1981) and the early Miocene of Shanyang, Shandong (Qiu et al., 1986). The P4 from the basal Dingshanyanchi Fm. is clearly smaller than that of both species. It is similar to the P4 of European *Hemicyon stehlini* which has the biostratigraphic range from MN3 to MN5 in Europe. The Dingshanyanchi specimen is more similar to that of *H. stehlini* from Faluns d'Anjou of France (Ginsburg and Morales, 1998) in morphology and size and smaller than the P4 of *H. stehlini* from North Bohemia, Czech (MN3a; Fejfar et al., 2003). We tentatively assign the Dingshanyanchi specimen to *Hemicyon* cf. *H. stehlini*.

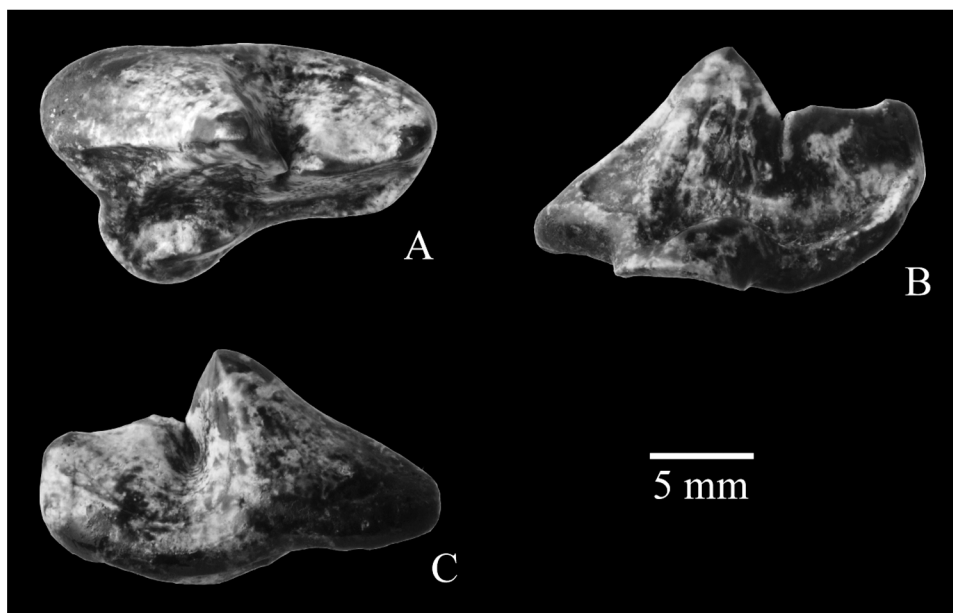


Fig. 7 Left P4 of *Hemicyon* cf. *H. stehlini* Hürzeler, 1944 from XJ 200617, V 15627
A. occlusal view; B. lingual view; C. labial view

Perissodactyla Owen, 1848

Anchitherium sp.

Referred specimen XJ 200613: fragments of probable two left upper cheek teeth (V 15628.1–2). The paracone, protocone, metacone, hypocone, hypoconule and protoloph are recognizable. The incomplete specimens are identifiable but not measurable.

Artiodactyla Owen, 1848

Cervoidea gen. et sp. large and small

Referred specimen XJ 200613: two fragments of artiodactyl teeth, representing a large and a small species respectively (V 15629 and V 15630). A more precise identification for either is impossible.

1.2 Mammals from the upper part of Dingshanyanchi Formation

Perissodactyla Owen, 1848

Hipparion (*Plesiohipparion*) *houfenense* Teilhard de Chardin & Young, 1931

Referred specimen XJ 200614: an incomplete molar (probably m2), V 15631.

Description and comment The tooth measures about 70 mm high, longer than 29 mm, and ca. 14 mm in width. Though the hipparionine molar lacks hypoconid it is best identified as *Hipparion* (*Plesiohipparion*) *houfenense*, judging by the symmetrically triangular metaconid and metastylid (double-knot), and the relatively narrow and deep U-shaped lingualflexid. Qiu et al. (1987:207) pointed out that it is difficult to distinguish the lower cheek teeth of *H. houfenense* from *H. pater* ...“The most clearly expressed difference is the form of the ectoflexid. In *H. houfenense* it is shallow, widened lingually and blocked by a pli antecaballinid at its outlet. The ectoflexid in *P. pater* is generally normally developed.” However, because of the incompleteness of the Dingshanyanchi specimen, whether or not the pli anticaballinid is present at the posterior end of protoconid cannot be certain. For the better preserved portion of the tooth, the ectoflexid seems narrow and deeply intrudes into the neck of the double-knot, probably resulting from certain degree of tooth wear. Nevertheless, the shapes of the double-knot and ectoflexid are similar to those on the specimen of *H. (P.) houfenense* from Yushe (THP10733). *Hipparion* (*Plesiohipparion*) *houfenense* spans geologically from Late Miocene (late Baodean) to Pliocene (Youhean) and is geographically distributed from northwest Mongolia to southeast Shanxi. The occurrence of *Hipparion* (*Plesiohipparion*) *houfenense* in Junggar Basin, if our identification proves to be correct, expands its distribution further westward.

In addition to the *Hipparion* tooth, tooth fragments of rhinocerotids, proboscideans and egg shells of ostrich (*Struthio*) are also found from the upper beds of Dingshanyanchi Formation.

2 Discussion

From the lower beds of Dingshanyanchi Formation 26 mammalian taxa have been recognized, which belong to 7 orders (Insectivora, Chiroptera, Lagomorpha, Rodentia, Carnivora, Perissodactyla and Artiodactyla), 16 families (Soricidae, Talpidae, Vespertilionidae, Ochotonidae, Gerbillidae, Cricetidae, Gliridae, Eomyidae, Dipodidae, Zapodidae, Sciuridae, Ctenodactylidae, Rodentia Familia incerti, Cervidae, Equidae and Ursidae). Among them 22 are small mammals (See Table 5).

Of the 22 small mammals, 12 are in common with the Tunggur fauna (Moergen II) of Nei Mongol (Qiu, 1996), including *Alloptox gobiensis*, *Desmatolagus* sp., *Heterosminthus orientalis*, *Protalactaga major*, *P. grabaui*, *Democricetodon lindsayi*, *D. tongi*, *Megacricetodon sinensis*, *M. pusillus*, *Plesiodipus leei*, *Miodymys* sp., *Keramidomys fahlbuschi*. Among identifiable larger mammals, *Anchitherium* (Colbert, 1939b) and *Hemicyon* are also present in Tunggur fauna (Colbert, 1939a).

In the recent study of the Neogene mammalian faunas from Nei Mongol, Qiu et al. (2006) suggested a new tri-division of the Tunggur fauna, the Tairum Nor fauna, Moergen fauna (= Moergen II) and Tamuqin fauna (= Moergen V), ranging from the oldest to youngest. The youngest Tamuqin fauna possesses *Plesiodipus progressus* that is more derived than *Plesiodipus leei* from the Moergen fauna. The oldest Tairum fauna includes *Distylomys* and *Tachyoryctoides* which are already present in the Oligocene and early Miocene faunas in North China, as well as species with more primitive morphologies than those from younger faunas. The Moergen fauna was defined as Tunggur fauna s. s. (Qiu et al., 2006). The fauna from the basal bed of the Dingshanyanchi Formation is best correlative to the Moergen fauna.

Table 5 Fauna list from XJ 200613 and XJ 200617 of the basal Dingshanyanchi Formation in comparison with those from Moergen and Quantougou faunas

	XJ 200613	XJ 200617	Moergen fauna	Quantougou fauna
Soricidae gen. et sp. indet. large	×	×		
Soricidae gen. et sp. indet. small	×			
Talpidae gen. et sp. indet.	×			
<i>Myotis</i> sp.		×		
<i>Desmatolagus</i> sp.	×	×	×	
<i>Alloptox gobiensis</i>	×	×	×	
Sciuridae gen. et sp. indet.	×	×		
<i>Keramidomys fahlbuschi</i>		×	×	
<i>Miodiromys</i> sp.	×	×	×	
<i>Megacricetodon sinensis</i>	×	×	×	×
<i>M. pusillus</i>		×	×	
<i>Democricetodon lindsayi</i>	×	×	×	
<i>D. tongi</i>	×	×	×	
<i>Ganocricetodon cheni</i>	×			×
<i>Paracricetulus schaubi</i>		×		×
<i>Cricetodon volkeri</i>	×	×		
<i>Plesiodipus leei</i>	×	×	×	×
Myocricetodontinae		×		×
<i>Heterosminthus orientalis</i>	×	×	×	×
<i>Protalactaga major</i>	×	×	×	×
<i>Protalactaga grabau</i>	×	×	×	×
<i>Sayimys</i> sp.		×		
<i>Hemicyon</i> cf. <i>H. stehlini</i> .		×		
<i>Anchitherium</i> sp.	×		×	
Cervoidea gen. et sp. large	×			
Cervoidea gen. et sp. small	×			

The Quantougou fauna from the upper part of Xianshuihe Formation in Gansu, the assemblages from the Chetougou and Xianshuihe formations of Qinghai, and the Kekemaideng fauna from the Kekemaideng Formation of Xinjiang are also correlative to the Moergen fauna; these faunas are considered to be middle Middle Miocene (middle Tunggurian) in age (Qiu, 2000, 2001a,b; Qiu et al., 1981, 2006).

Among the 12 small mammal species of 11 genera from the Quantougou fauna 7 species are in common with the basal Dingshanyanchi fauna, including *Heterosminthus orientalis*, *Protalactaga major*, *P. grabau*, *Megacricetodon sinensis*, *Plesiodipus leei*, *Ganocricetodon cheni* and *Paracricetulus schaubi*. Of these 7 species the former 5 are further in common with the Moergen fauna, two species, *Ganocricetodon cheni* and *Paracricetulus schaubi*, are shared only by Quantougou and the basal Dingshanyanchi fauna.

The mammal assemblage from Xianshuihe Formation of Qinghai (Qijia, Lierpu of Minhe County) consists of *Plesiodipus leei*, *Alloptox chinghaiensis*, *Megacricetodon* cf. *M. sinensis*. As we know, in Nei Mongol *Plesiodipus leei* exists only in the Moergen fauna. From the Chetougou Formation of Danshuilu two species are presented: *Heterosminthus orientalis* and *Megacricetodon sinensis*.

Given the shared species in these faunas, the basal Dingshanyanchi fauna can also correlate with the faunas from Quantougou of Gansu, Xianshuihe Fm. and probably Chetougou Fm. of Qinghai. Faunal correlation suggests that the basal Dingshanyanchi Fm. is also middle Mid-

dle Miocene (middle Tunggurian) in age.

In addition, the basal Dingshanyanchi fauna is comparable with the mammal assemblage A4 at level 148 m of Qin'an section, Gansu (Guo et al., 2002). As is listed in the original paper, assemblage A4 of Qin'an consists of *Desmatolagus* sp., *Alloptox gobiensis*, *Mioechinus* sp., *Ansomys* sp., *Gobicricetodon* sp., *Cricetodon* sp., and Talpidae gen. et sp. indet. Based on our reexamination of Qin'an specimens, we identify *Gobicricetodon* sp. as *Plesiodipus leei*, and *Cricetodon* sp. probably *Cricetodon volkeri*. Assemblage A4 has been considered comparable with Tunggur fauna (Guo et al., 2002) and apparently younger than the Suosuoquan zone III fauna (Meng et al., 2006).

The fact that *Ganocricetodon cheni*, *Paracricetulus schaubi*, and the characterized myocricetodontine are shared by the basal Dingshanyanchi and Quantougou faunas but absent in Moergen fauna probably indicates that the biotope of the Dingshanyanchi fauna is similar to the Quantougou fauna in having a more open and drier environment (ref. Qiu, 2001b).

In addition to mammal fossils, 8 gastropod species were collected from the same beds, of which 6 are terrestrial species and are common taxa in Chinese loess. The lithology and faunas indicate aeolian origin of these red beds, or at least some of the beds (Meng et al., 2008).

The only identifiable mammal specimens from the upper beds of Dingshanyanchi Formation belong to *Hipparion* (*Plesiohipparion*) *houfenense*. This species, along with tooth fragments of rhinocerotids, proboscidean and egg shells of ostrich from the same level, suggests a *Hipparion* fauna with the age of Late Miocene Baodean or Early Pliocene. Fossils from the two levels indicate that the Dingshanyanchi Formation spans a time interval from the middle Middle Miocene to Late Miocene, or even early Pliocene. However a preliminary identification of the small mammals newly collected in 2008 field season, demonstrates an age of late Late Miocene for the top level of the formation.

Acknowledgments We thank Prof. Qiu Zhanxiang for directing to identify *Hipparion*; Profs. Li Chuankui, Qiu Zhuding and Associate Prof. Li Qiang for providing relevant references and instructive discussions; Zheng Xinwei and Yang Yongchun for field assistance; the farm workers of Xinjiang Production and Construction Corp for collecting earth sample and screenwashing; Yue Qiwan for sorting microfossils; Zhang Wending for taking SEM pictures and Gao Wei for making digital pictures of *Hemicyon*. This research has been supported by grants from the Knowledge Innovation Program of the Chinese Academy of Sciences (KZCX2-YW-120) and the Chinese National Natural Science Foundation (40472022).

References

- Argyropulo A I, 1938. On the fauna of Tertiary Cricetidae of the USSR. *Comp Rend Acad Sci URSS*, **20**(2-3): 223-226
- Baskin J A, 1996. Systematic revision of Ctenodactylidae (Mammalia, Rodentia) from the Miocene of Pakistan. *Palaeovertebrata*, **25**(1): 1-49
- Baudelot S, 1972. Etudes des Chiroptères, Insectivores et Rongeurs du Miocène de Sansan (Gers). Toulouse: Thèse Université Toulouse, **496**: 1-364
- Bi S D, 2005. Evolution, systematics and functional anatomy of a new species of Cricetodontini (Cricetidae, Rodentia, Mammalia) from the northern Junggar Basin, northwestern China. Ph D Dissertation, Washington D C: Howard University. 1-183
- Bohlin B, 1937. Oberoligozäne Säugetiere aus dem Shargaltein-Tal (Western Kansu). *Palaeont Sin, New Ser C*, **3**: 1-66
- Bohlin B, 1946. The fossil mammals from the Tertiary deposits of Taben-buluk, western Kansu, Part II: Simplicidentata, Carnivora, Artiodactyla, Perissodactyla, and Primates. *Palaeont Sin, New Ser C*, **8b**: 1-259
- Bruijn H de, Fahlbusch V, Saraç G et al., 1993. Early Miocene rodent faunas from the eastern Mediterranean area. Part III. The genera *Deperetomys* and *Cricetodon* with a discussion of the evolutionary history of the Cricetodontini. *Proc K Ned Akad*

- Wet, Ser B, **96**(2): 152–216
- Chen G F(陈冠芳), 1981. A new species of *Amphicyon* from the Pliocene of Zhong Xiang, Hubei. Vert PalAsiat(古脊椎动物学报), **19**(1): 21–34(in Chinese with English summary)
- Colbert E H, 1939a. Carnivora of the Tung Gur Formation of Mongolia. Bull Am Mus Nat Hist, **76**(2): 47–81
- Colbert E H, 1939b. A new anchitheriine horse from the Tung Gur Formation of Mongolia. Am Mus Novit, (1019): 1–9
- Fejfar O, Dvorák Z, Kadlecová E, 2003. New record of Early Miocene (MN3a) mammals in the open brown coal pit Merkur, North Bohemia, Czech Republic. In: Reumer J W F, Wessels W eds. Distribution and Migration of Tertiary Mammals in Eurasia. A volume in honour of Hans de Bruijn. Deinsea, **10**: 163–182
- Freudenthal M, 1963. Entwicklungsstufen der miozänen Cricetodontinae (Mammalia, Rodentia) Mittelspaniens und ihre stratigraphische Bedeutung. Ph D Thesis. Wageningen; Utrecht. 1–107
- Freudenthal M, 1966. On the mammalian fauna of the *Hipparion*-beds in the Calatayud-Teruel basin. Part 1, the genera *Crictodon* and *Rotundomys* (Rodentia). Proc K Ned Akad Wet, Ser B, **69**(2): 296–317
- Ginsburg L, Morales J, 1998. Les Hemicyoninae (Ursidae, Carnivora, Mammalia) et les formes apparentées du Miocène inférieur et moyen d'Europe occidentale. Ann Paléont, **84**(1): 71–123
- Guo Z T, Ruddiman W F, Hao Q Z et al., 2002. Onset of Asian desertification by 22 Myr ago inferred from loess deposits in China. Nature, **416**: 159–163
- Klein Hofmeijer G, Bruijn H de, 1988. The mammals from the Lower Miocene of Aliveri (Island of Evia, Greece). Part 8: the Cricetidae. Proc K Ned Akad Wet, Ser B, **91**(2): 185–204
- Kordos M, 1986. Upper Miocene hamsters (Cricetidae, Mammalia) of Hasznos and Szentendre; a taxonomic and stratigraphic study. Földt Int Évi Jel, **1986**: 523–553
- Li C K(李传夔), Lin Y P(林一璞), Gu Y M(顾玉珉) et al., 1983. The Aragonian vertebrate fauna of Xiaocowan, Jiangsu—1. A brief introduction to the fossil localities and preliminary report on the new material. Vert PalAsiat(古脊椎动物学报), **21**(4): 313–317(in Chinese with English summary)
- Li C K(李传夔), Qiu Z D(邱铸鼎), Wang S J(王世阶), 1981. Discussion on Miocene stratigraphy and mammals from Xining Basin, Qinghai. Vert PalAsiat(古脊椎动物学报), **19**(4): 313–320(in Chinese with English abstract)
- Li Q(李强), Zheng S H(郑绍华), 2005. Note on four species of dipodids (Dipodidae, Rodentia) from the Late Miocene Bahe Formation, Lantian, Shaanxi. Vert PalAsiat(古脊椎动物学报), **43**(4): 283–296(in Chinese with English summary)
- López-Antoñanzas R, Sen S, 2003. Systematic revision of Mio-Pliocene Ctenodactylidae (Mammalia, Rodentia) from the Indian subcontinent. Eclogae Geol Helv, **96**: 521–529
- Mayr H, 1979. Gebissmorphologische Untersuchungen an Miozänen Gliriden (Mammalia, Rodentia) Süddeutschlands. Ph D Thesis. München; University of München. 1–380
- Mein P, Freudenthal M, 1971. Les Cricetidae (Mammalia, Rodentia) du Néogène Moyen de Vieux-Collonges. Partie 1: Le genre *Crictodon* Lartet 1851. Scripta Geol, **5**: 1–51
- Meng J(孟津), Ye J(叶捷), Wu W Y(吴文裕) et al., 2006. A recommended boundary stratotype section for Xiejia Stage from northern Junggar Basin: implications to related bio-chronostratigraphy and environmental changes. Vert PalAsiat(古脊椎动物学报), **44**(3): 205–236(in Chinese with English summary)
- Meng J(孟津), Ye J(叶捷), Wu W Y(吴文裕) et al., 2008. The Neogene Dingshanyanchi Formation in northern Junggar Basin of Xinjiang and its stratigraphic implication. Vert PalAsiat(古脊椎动物学报), **46**(2): 90–110(in Chinese with English summary)
- Qiu Z D(邱铸鼎), 1996. Middle Miocene micromammalian fauna from Tunggur, Nei Mongol. Beijing: Science Press. 1–216 (in Chinese with English summary)
- Qiu Z D(邱铸鼎), 2000. Insectivore, dipodoidean and lagomorph from the Middle Miocene Quantougou fauna of Lanzhou, Gansu. Vert PalAsiat(古脊椎动物学报), **38**(4): 287–302(in Chinese with English summary)
- Qiu Z D(邱铸鼎), 2001a. Cricetid rodents from the Middle Miocene Quantougou fauna of Lanzhou, Gansu. Vert PalAsiat(古

- 脊椎动物学报), **39**(3): 204–214
- Qiu Z D(邱铸鼎), 2001b. Glirid and gerbillid rodents from the Middle Miocene Quantougou fauna of Lanzhou, Gansu. Vert PalAsiat(古脊椎动物学报), **39**(4): 297–305
- Qiu Z D(邱铸鼎), Li C K(李传夔), Wang S J(王世阶), 1981. Miocene mammalian fossils from Xining Basin, Qinghai. Vert PalAsiat(古脊椎动物学报), **19**(2): 156–173 (in Chinese with English summary)
- Qiu Z D(邱铸鼎), Wang X M(王晓鸣), 1999. Small mammal faunas and their ages in Miocene of central Nei Mongol (Inner Mongolia). Vert PalAsiat(古脊椎动物学报), **37**(2): 120–139 (in Chinese with English summary)
- Qiu Z D(邱铸鼎), Wang X M(王晓鸣), Li Q(李强), 2006. Fauna succession and biochronology of the Miocene through Pliocene in Nei Mongol (Inner Mongolia). Vert PalAsiat(古脊椎动物学报), **44**(2): 164–181
- Qiu Z X(邱占祥), Huang W L(黄为龙), Guo Z H(郭志慧), 1987. The Chinese Hipparionine fossils. Palaeont Sin(中国古生物志), New Ser C, **25**: 1–250 (in Chinese with English summary)
- Qiu Z X(邱占祥), Yan D F(阎德发), Jia H(贾航) et al., 1986. The large-sized ursid fossils from Shanwang, Shandong. Vert PalAsiat(古脊椎动物学报), **24**(3): 182–194 (in Chinese with English summary)
- Reumer J W F, 1984. Ruscinian and early Pleistocene Soricidae (Insectivora, Mammalia) from Tegelen (the Netherlands) and Hungary. Scripta Geol, **73**: 1–173
- Rummel M, 1995. *Cricetodon bolligeri* n. sp. ein neuer Cricetide aus dem Obermiozän von Petersbuch bei Eichstätt. Mitt Bayer Staatsslg Paläontol hist Geol, **35**: 109–123
- Sen S, Ünay E, 1979. Sur quelque Cricetodontini (Rodentia) du Miocène moyen d'Anatolie. Proc K Ned Akad Wet, Ser B, **82**(3): 293–301
- Sevilla P, 1988. Estudio paleontológico de los Quirópteros del Cuaternario español. Paleont Evol, **22**: 113–233
- Storch G, 1999. Order Chiroptera. In: Rössner G, Heissig K eds. The Miocene Land Mammals of Europe. München: Verlag Dr. Friedrich Pfeil. 81–90
- Tobien H, 1978. New species of Cricetodontini (Rodentia, Mammalia) from the Miocene of Turkey. Mainzer geowiss Mitt, **6**: 209–219
- Ünay E, Bruijn H de, Suata-Alpaslan F, 2006. Rodents from the Upper Miocene hominoid locality Çorakyerler (Anatolia). Beitr Paläont, **30**: 453–467
- Wu W Y(吴文裕), Ye J(叶捷), Meng J(孟津) et al., 1998. Progress of the study of Tertiary biostratigraphy in North Junggar Basin. Vert PalAsiat(古脊椎动物学报), **36**(1): 24–31 (in Chinese with English summary)
- Wu W Y(吴文裕), Ye J(叶捷), Zhu B C(朱宝成), 1991. On *Alloptox* (Lagomorpha, Ochotonidae) from the Middle Miocene of Tongxin, Ningxia Hui Autonomous Region, China. Vert PalAsiat(古脊椎动物学报), **29**(3): 204–229 (in Chinese with English summary)
- Ye J(叶捷), Wu W Y(吴文裕), Meng J(孟津), 2001a. Tertiary stratigraphy in the Ulungur River Area of the northern Junggar Basin of Xinjiang. J Stratigr(地层学杂志), **25**(3): 193–200 (in Chinese with English abstract)
- Ye J(叶捷), Wu W Y(吴文裕), Meng J(孟津), 2001b. The age of Tertiary strata and mammal faunas in Ulungur River Area of Xinjiang. J Stratigr(地层学杂志), **25**(4): 283–287 (in Chinese with English abstract)
- Zazhigin V S, Lopatin A V, 2000. The history of the Dipodoidea (Rodentia, Mammalia) in the Miocene of Asia: 3. Allactaginae. Paleont J, **34**(5): 553–565 (English translation from Russian)
- Ziegler R, 1993. Die Chiroptera (Mammalia) aus dem Untermiozän von Wintershof-West bei Eichstätt (Bayern). Mitt Bayer Staatsslg Paläont hist Geol, **33**: 119–154
- Ziegler R, 1998. Wirbeltiere aus dem Unter-Miozän des Lignit-Tagebaues Oberdorf (Weststeirisches Becken, Österreich): 5. Marsupialia, Insectivora und Chiroptera (Mammalia). Ann Naturhist Mus Wien, **99A**: 43–97