

蒙古新发现的渐新世山河狸和松鼠类化石¹⁾

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摘要: 蒙古中部地区的三达河组(Hsanda Göl Formation)是亚洲渐新世陆相地层的经典地层之一。三达河组的沉积岩层现被分成两个岩性段:上部早渐新世晚期-?晚渐新世山地段(Shand Member)和下部早渐新世早期塔塔尔段(Tatal Member);两段间有时夹有 Khar Khoroo 玄武岩层(Bryant and McKenna, 1995; Meng and McKenna, 1998)。该玄武岩层的时代用⁴⁰Ar/³⁹Ar法被确定为距今 31.5 Ma(Höck et al., 1999, 他们称其为 Basalt D)。三达河组中产有丰富的哺乳动物化石,特别是啮齿类化石(Matthew and Granger, 1923; Kowalski, 1974; Russell and Zhai, 1987; Höck et al., 1999)。近年来,本文的后一作者在三达河组中又采集到一批啮齿类化石,其中包括松鼠和山河狸 2 科的化石。本文是对这两类化石新材料的记述。

现生的松鼠科分异很大,而且大多数都分布在亚洲。然而,松鼠科化石在古近纪时在北美和欧洲却很丰富。在北美出现于晚始新世,在渐新世时已明显分异;在欧洲出现于早渐新世,在中新世时分异很大。相反,亚洲古近纪的松鼠化石却发现得很少,标本也很破碎。已报道的只有 3 件标本。2 件产自党河下游地区:Bohlin (1946)报道的晚渐新世的 *Sciurus* sp., 标本只是 2 枚单个臼齿(M3 和 m2);王伴月、邱占祥(2004)报道的早渐新世的党河鲜松鼠(*Oligosciurus dangheensis*),标本只是一段带 m1~2 的下颌骨。还有一件是 Minjin (2004)报道的蒙古渐新世的三达河克热姆鼠(*Kherem hsandgoliensis*),标本也只是一段带 m1~3 的下颌骨。本文报道的松鼠化石产自蒙古国的巴彦洪戈尔省的塔石盖贝(Tashgain Bel)地点的三达河组上部山地段,时代为早渐新世晚期-?晚渐新世。这批松鼠化石标本包括 1 件具 P3~M3 的上颌骨(PC 36-9)和 2 段下颌骨(PC 36-10 和 PC 36-11)。这是亚洲古近纪目前已知的最好的一批松鼠化石标本,代表松鼠科 *Kherem* 属的一新种:亚洲克热姆鼠(*Kherem asiatica* sp. nov.)。其主要特征是颊齿较大,较宽;下内尖的高度和下次尖的大小从 m1 到 m3 变化不大,彼此相近;下内脊较明显;下内尖较明显,与下后边脊间有浅沟分开等。

K. asiatica 的形态特征表明,*Kherem* 属应归入北美的 Cedromurinae 亚科。新的发现表明,亚洲渐新世的松鼠已发生了分异,至少可分为 3 支。以 *Kherem* 为代表的一支,与北美早期的 cedromurines 有较近的系统关系。它可能是由类似于北美 *Oligospermophilus* 的种类演化并迁徙到亚洲来的。

现生的山河狸只有一种(*Aplodontia rufa*),仅生活在北美西部沿海地区。但从始新世到中新世,山河狸却遍布全北区。它们在北美较繁盛,分异大,但在亚洲发现得很少。在亚洲渐新世地层中虽曾报道过 3 属 4 种山河狸化石,但材料都很少(*Prosciurus ordosicus* 和 *P. ? shantungensis* 均只有一枚单个的牙)。山河狸化石在蒙古渐新世地层的新发现表明,亚洲渐新世的山河狸化石比已知的要丰富。

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本文描述的山河狸化石分别采自蒙古南戈壁省 Shunkt 地点的山地段和前杭爱省 Ulaan Khongil (= Tatal Göl) 地点的塔塔尔段。它们代表原松鼠属的 3 类: 蒙古原松鼠(新种) (*Prosciurus mongoliensis* sp. nov.)、蒙古原松鼠(相似种) (*P. cf. P. mongoliensis*) 和小原松鼠(新种) (*P. pisinnus* sp. nov.)。蒙古原松鼠的主要特征是下颊齿的下中附尖与下后附尖脊连, 下中尖发育较弱, 下外中脊弱或无; p4 无下前边尖和下前齿带; m1 具从下外脊伸向下次脊的小刺; m2 和 m3 的下后脊 II 较发育; 下次脊在 p4 和 m1 后弯, 与下后边脊连, 在 m2 和 m3 横向, 伸达下外脊等。蒙古原松鼠(相似种) 与蒙古原松鼠的区别是: 颊齿尺寸较小, p4 具明显的下外中脊, p4 和 m1 的下次脊弯曲度较缓, m1 缺从下外脊伸向下次脊的小刺, m2~3 的下后脊 II 较短等。小原松鼠的主要特征是: 个体较小; 齿冠较低; 下臼齿的下中附尖孤立; 下颊齿的下次脊横向、较低, 与下外脊连, 下中尖和下外中脊均较明显, 下次尖明显向前颊侧延伸, 具明显的齿带等。

蒙古渐新世啮齿类化石的新发现表明, 亚洲渐新世的松鼠和山河狸与北美的关系要比与欧洲的近。

关键词: 蒙古, 渐新世, 松鼠科, 山河狸科

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NEW OLIGOCENE SCIURIDS AND APLDONTIDS (RODENTIA, MAMMALIA) FROM MONGOLIA

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Abstract A new species of *Kherem*, *K. asiatica*, and three new forms of *Prosciurus* (*P. mongoliensis* sp. nov., *P. cf. P. mongoliensis* and *P. pisinnus* sp. nov.) from Oligocene of Mongolia are described here.

Kherem asiatica, known from Shand Member (late early Oligocene - ?late Oligocene) of Mongolia, is characterized by: cheek teeth larger and wider than those of *K. hsandgoliensis*; m1~3 with subequally high metaconid and large hypoconid, with more distinct entolophid and entoconid separated from posterolophid by shallow groove.

Kherem is referred to the North American subfamily Cedromurinae. It might be derived from an *Oligospermophilus*-like form. The three genera so far described from Asia (*Sciurus*, *Oligosciurus* and *Kherem*) may represent three different lineages, indicating the Oligocene diversity of the sciurids in Asia.

Prosciurus mongoliensis is known from Shand and Tatal Members of the Hsanda Göl Formation, Oligocene, in Mongolia. Its main features are: brachydont cheek teeth have mesostylid connected with metastylid crest, weak mesoconid, and weak or no ectomesolophid; anteroconid and anterior cingulum are absent on p4; an accessory crest extends from ectolophid to hypolophid on m1; metalophid II is well developed on m2~3; hypolophid bends posteriorly to join with posterolophid on p4~m1, but straight to join with ectolophid on m2~3. *Prosciurus cf. P. mongoliensis* from Shand Member is different from *P. mongoliensis* in having smaller cheek teeth in size, p4 having distinct ectomesolophid, p4 and m1 having gently curved hypolophid, m1 lacking accessory crest from ectolophid to hypolophid, and m2~3 having shorter metalophid II. *Prosciurus pisinnus*, collected from Tatal Member, is small in size. Its cheek teeth are brachydont with distinct cingulum. The metalophid II is short, and the hypolophid is transverse, low, and joins with ectolophid. The mesoconid and ectomesolophid are well developed, and the hypoconid extends more anterobuccally. The protoconid of p4 has more developed anterior arm.

The new material of the Mongolian Aplodontidae not only has confirmed the early existence of *Prosciurus* in Asia, but also shows that *Prosciurus* experienced considerable diversity during the Oligocene in Asia.

Both the sciurids and aplodontids found from Oligocene of Asia have closer relationships with those of North America than with Europe.

Key words Mongolia , Oligocene , Sciuridae , Aplodontidae

1 Introduction

The Oligocene continental deposits are well developed in Mongolia. The Oligocene Hsanda Göl Formation in Central Mongolia is one of the classic strata bearing rich mammalian fossils in Asia (Matthew and Granger, 1923; Kowalski, 1974; Russell and Zhai, 1987; Höck et al., 1999). Recently it has been subdivided into three parts (from top to bottom): late early Oligocene - ?late Oligocene Shand Member, Khar Khoroo Lava, and early early Oligocene Tatal Member (Bryant and McKenna, 1995; Meng and McKenna, 1998). Höck et al. (1999) reported a $^{40}\text{Ar}/^{39}\text{Ar}$ date of the Khar Khoroo lava (= their Basalt D) as 31.5 Ma. In recent years the latter author of the present paper collected some new rodent specimens from the Hsanda Göl Formation in Central Mongolia (Fig. 1). The new material of the Sciuridae and Aplodontidae are described in this paper.

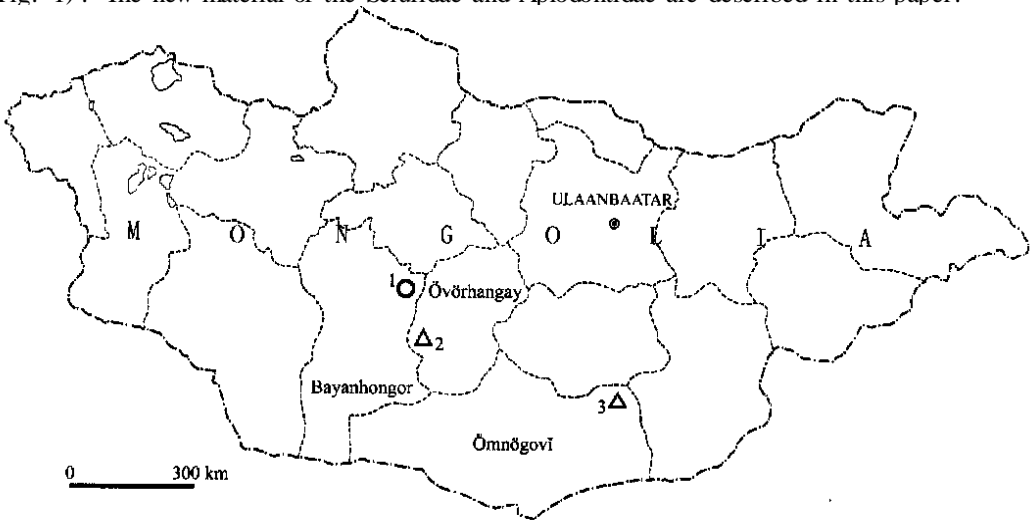


Fig. 1 Map of Mongolia showing the localities bearing the sciurid (○) and aplodontid (△) fossils
1. Tashgain Bel; 2. Ulaan Khongil; 3. Shunkt

The extant sciurids are abundant and widely diversified, mostly distributed in Asia. In Paleogene, however, they were rather diversified only in North America and Europe, but little has been known in Asia. Very fragmentary specimens of three forms have so far been reported from Asian Paleogene. They are *Sciurus* sp. from late Oligocene and *Oligosciurus dangheensis* from early Oligocene in Danghe area of Gansu, China (Bohlin, 1946; Wang and Qiu, 2004), and *Kherem hsandgoliensis* from Oligocene in Mongolia (Minjin, 2004). The sciurid specimens described here include one upper jaw and two mandibles, representing the best material in Asian Oligocene up to now. The new find not only indicates that the sciurids were already somewhat diversified during Oligocene in Asia, but also throws new light on the relationship between Asian and North American sciurids.

The extant Aplodontidae is represented by a single species living in western coast area of North America. However, their fossils were widely distributed in the Holarctic Region from Eocene through Miocene. Similarly to the sciurids, they were considerably diversified during Oligocene in North America, but rare fossils were found in Asia. Up to now five species of four genera (*Plesispermophilus* sp., *Haplomys arboraptus*, *Promeniscomys sinensis*, *Prosciurus ordosicus*, and

P. ? shantungensis) have been reported from Oligocene in Asia (Argyropulo, 1939; Rensberger and Li, 1986; Wang, 1987). Most of them are represented by very poor material (e. g., both *Prosciurus ordosicus* and *P. ? shantungensis* are represented by a single isolated tooth). The new specimens from Mongolia represent three new taxa of the Aplodontidae, indicating that during the Oligocene in Asia the aplodontids were more diversified than hitherto thought.

The terminology for sciurids used here follows Qiu (1996), and that for aplodontids follows Wang (1987). Abbreviation: MAE, The joint Mongolian Academy of Sciences and American Museum of Natural History Paleontological Expedition; PC, Paleontological Center of Mongolian Academy of Sciences; SG, Shand Gbl.

2 Systematics

Sciuridae Fischer de Waldheim, 1817 Cedromurinae Korth et Emry, 1991 Kherem Minjin, 2004

Type species *Kherem hsandgoliensis* Minjin, 2004.

Included species *K. asiatica* sp. nov.

Range Oligocene of Mongolia.

Amended diagnosis Primitive sciurid. Cheek teeth brachyodont; P4 ~ M2 with incomplete ectoloph, single but well-developed metaconule joining with posteroloph, without distinct hypocone; lower cheek teeth with small trigonid basin, rather narrow mesostylid, poorly developed mesoconid, and entolophid bending backward to join posterolophid.

Kherem asiatica sp. nov.

(Fig. 2; Table 1)

Holotype A partial left mandibular ramus with i2, p4 ~ m3 (PC 36-10).

Paratype A fragmentary left upper jaw with P3 ~ M3 (PC 36-9).

Referred specimen A partial left mandibular ramus with i2, p4 ~ m2 (PC 36-11).

Locality and horizon Tashgain Bel (45°27'47" N, 101°12'11" E), Bayanhongor, Mongolia; Late early Oligocene - ?late Oligocene Shand Member of Hsanda Gbl Formation.

Diagnosis Cheek teeth larger in size and wider in proportion than those of *K. hsandgoliensis*; m1 ~ 3 with subequally high metaconid and large hypoconid, more distinct entolophid, and distinct entoconid separated from posterolophid by shallow groove.

Etymology Asiatica, Latin, Asian.

Description The anterior root of the zygomatic arch broadens and slightly inclines anterodorsally. Its posterior margin is opposite to the posterior part of P4. The anterior part of the maxillary-palatine suture is opposite to M2. The posterior palate foramen is within the palatine and located lingual to the protocone of the M3.

The horizontal ramus of lower jaw is robust. The diastema between i2 and p4 is shorter than the length of the cheek tooth series and has slightly concave upper margin. The prominent masseteric fossa has a more distinct lower crest than the upper one. The rounded anterior end of the masseteric fossa is below the posterior part of the m1. The large mental foramen is located anterior to the anterior root of the p4. The i2 extends posteriorly to the m3.

Dental formula is 1023/1013. The cheek teeth are brachyodont. The upper cheek teeth have higher lingual crowns than the buccal ones. The P3 is oval in occlusal view and located anterolingually to P4. The P3 possesses a high main cusp and a lingual cingulum. The main cusp sends a transverse crest from its anterior part to the lingual cingulum. P3 is single rooted.

The P4 is transversely wide trapezoid in occlusal view, with the buccal border longer than the

lingual one. The protocone is high and narrow anteroposteriorly. The anterior and posterior arms of the protocone extend to the anterior and posterior margins respectively. Neither distinct anterior protocone crest nor hypocone are visible. The paracone and metacone are subequal in size. The protoloph and metaloph converge lingually. Their lingual ends constrict and become low before joining the protocone. Both protoconule and metaconule are distinct. An accessory crest extends from the middle of the protoloph into the trigon basin. The distinct mesostyle is separated by a shallow groove into two cusps: a large anterior one and a tiny posterior one. The incomplete ectoloph extends from the paracone to mesostyle. The metacone is separated from the mesostyle by a distinct valley. The anteroloph is developed on the buccal part of the anterior margin of the P4 and separated from the anterior arm of the protocone by a distinct groove. The distinct parastyle extends anteriorly. The posteroloph is low and weak. The P4 has three roots, a large lingual and two small buccal ones.

The M1 is rectangular in occlusal view and similar to P4 in basic occlusal features. But the anterior and posterior arms of the protocone are more developed than in P4. The anteroloph joins with the anterior arm of the protocone. The parastyle does not extend anteriorly. The constricted lingual end of the protoloph is not low. No distinct accessory crest from the protoloph is visible. One of the prominent features in M1 is that the well-developed metaconule extends backwards to meet the posteroloph at the base. The M2 is similar to the M1 in occlusal features. But M2 is slightly larger than the M1 in size, and has a more developed metaconule than in M1.

The M3 is triangular in occlusal view, with a rounded posterobuccal corner. The anterior part is similar to that of M1 and M2. But the posterior part is lower and extends more posteriorly. The two mesostyles are distinct, but lower than in M1 and M2 and extend lingually. The low and small metacone connects with the low and curved posteroloph. A small cusp (= hypocone?) is present between the protocone and posteroloph. The basin surrounded by the protoloph, mesostyle, posteroloph and protocone is full of enamel wrinkles.

The lower incisor is compressed laterally. The cross-section is oval, with a flat medial and convex lateral side continuous with narrow anterior one. The enamel covers the anterior side and about half of the lateral side, with fine veins on the surface.

The p4 is trapezoid in occlusal view, longer than wide. The trigonid is much narrower than talonid. The metaconid is slightly higher and larger than the protoconid. The narrow and deep trigonid basin is closed posteriorly by a low but complete metalophid. The tiny anteroconid stands on the anterolingual side of the protoconid, and is separated from the metaconid by a groove to open the trigonid basin anteriorly. The hypoconid is subequal to the protoconid in size, located slightly posterobuccal to the latter and does not extend anterobuccally. Both the hypoconid and the entoconid are lower than the anterior two main cusps. The posterolophid is continuous with the hypoconid, but separated from the entoconid by a shallow groove. The distinct mesostylid is separated from the metaconid by a shallow groove and from the entoconid by a deep groove. The distinct entolophid bends posteriorly to join with the posterolophid. The straight, short ectolophid is located one-third buccally, without distinct mesoconid. The talonid basin is wide. The p4 has three roots.

The m1 is rhomboid in occlusal view, slightly wider than long. The trigonid is short anteroposteriorly, but subequal to the talonid in width. The metaconid is higher than the protoconid. Both the anterolophid and metalophid are complete, closing the small trigonid basin. The small anteroconid is present on the anterolophid. The talonid is similar to that of p4. The hypoconid does not extend anterobuccally. A hypoconulid is present on the posterolophid. The mesoconid may be weak or absent. The m2 is similar to m1. But the width of m2 is subequal to its length or slightly wider than long. The metalophid is complete on the holotype (PC 36-10), but incomplete on PC 36-11. The trigonid basin may be closed or open posteriorly. The hypoconulid is absent. Both m1 and m2 have four roots.

The trigonid of m3 is similar to that of m2, but its talonid is larger, with a rounded posterior

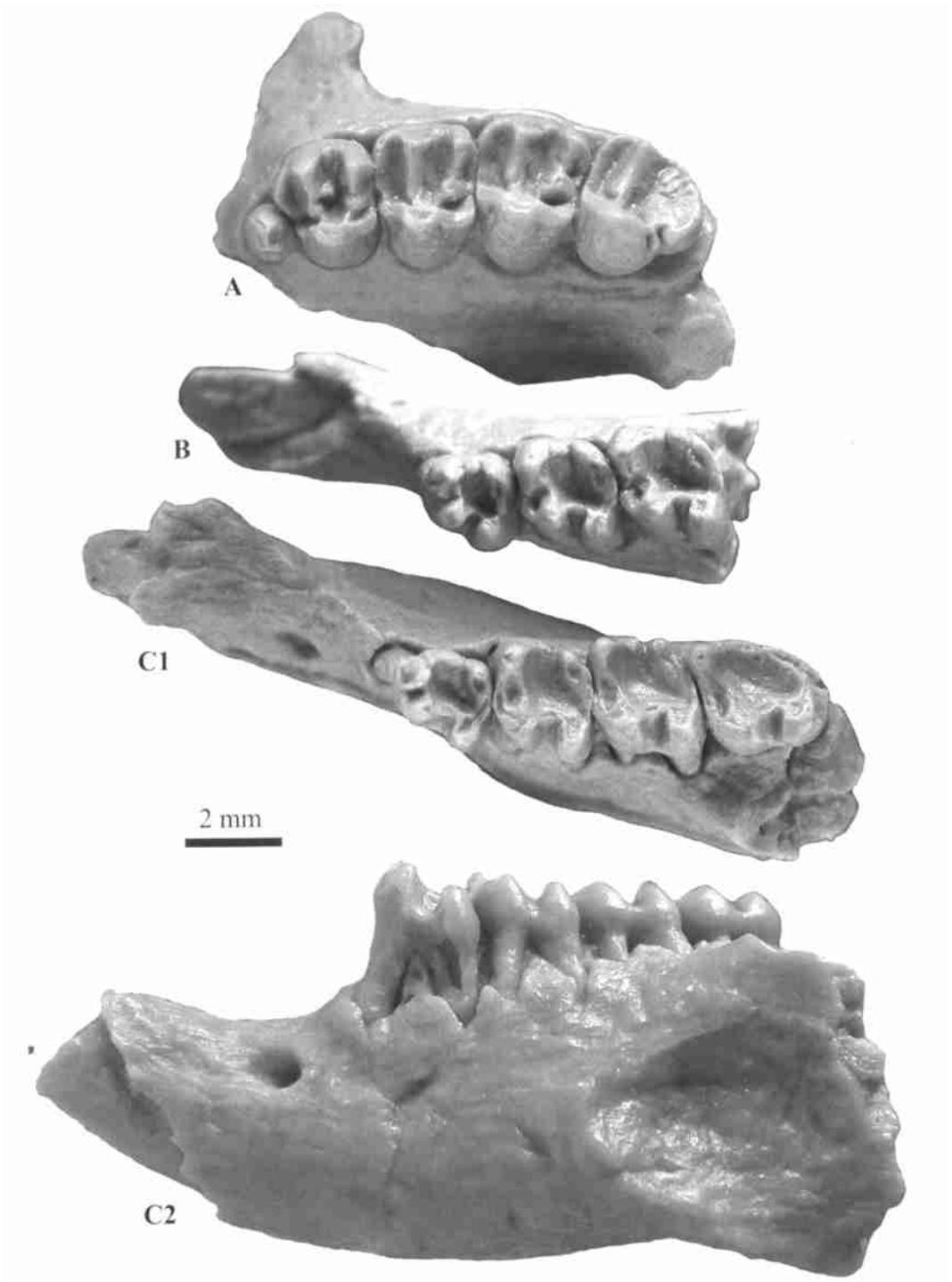


Fig. 2 *Kherem asiatica* sp. nov.

A. Occlusal view of a partial left upper jaw with P3~M3 (PC 36-9, paratype) ; B. Occlusal view of a partial left horizontal ramus with i2, p4~m2 (PC 36-11) ; C. A partial left horizontal ramus with i2, p4~m3 (PC 36-10, holotype) , C1. occlusal view ; C2. lateral view

border. The posterolophid is curved. No distinct entolophid can be seen. The hypoconulid part is broken, but may be present. The m3 has also four roots: two anterior, one large posterior, and a small one between the posterior one and anterolingual one.

Dimensions See Table 1.

Table 1 Measurements and comparison of cheek teeth of *Kherem* (mm)

	<i>K. asiatica</i> sp. nov.			<i>K. hsandgoliensis</i>
	PC 36-9 (Paratype)		PC 36-10 (Holotype)	PC 36-11 MAE-SG97-2110 (Holotype)
P3 ~ M3 L	9.4	p4 ~ m3 L	9.2	
P4 ~ M3 L	8.9	m1 ~ 3 L	7.2	6.45 *
M1 ~ 3 L	6.8	p4 L	2.4	2.1
P3 L	1	p4 Tr W (Ta W)	1.8 (2.1)	1.8 (2.2)
P3 W	1.3	p4 Tr W / L (Ta W / L)	0.75 (0.88)	0.86 (1.05)
P4 L	2.2	m1 L	2.1	2.1
P4 W	3	m1 Tr W (Ta W)	2.3 (2.4)	2.4 (2.5)
M1 L	2.2	m1 Tr W / L (Ta W / L)	1.1 (1.14)	1.14 (1.19)
M1 W	3.1	m2 L	2.5	2.3
M2 L	2.3	m2 Tr W (Ta W)	2.4 (2.5)	2.7 (2.8)
M2 W	3.1	m2 Tr W / L (Ta W / L)	0.96 (1)	1.17 (1.22)
M3 L	2.7	m3 L	3	
M3 W	2.9	m3 Tr W (Ta W)	2.4 (2.1)	
		m3 Tr W / L (Ta W / L)	0.8 (0.7)	
		i2 L (a-p)	2.6	2.8
		i2 W	1.6	1.7
		i2 W / L	0.62	0.61
				0.65 *

Abbreviations: L. length; L (a-p). length from anterior side to posterior side; W. width;

Tr W. width of trigonid; Ta W. width of talonid.

* After Minjin (2004); ** Calculated based on the measurements of Minjin (2004).

Comparison and discussion The major features of the new specimens (the position of the anterior border of masseteric fossa, the crown-height of the cheek teeth, the pattern of the entolophid and ectolophid in the lower molars, the absence of distinct mesoconid, and the presence of complete metalophid in m1) are identical with those of *Kherem hsandgoliensis* described by Minjin (2004) from the same locality, Tashgain Bel. However, the new specimens differ from *K. hsandgoliensis* in the following points: the lower molars are about 10% larger and proportionally wider than those of *K. hsandgoliensis* (see Table 1); the height of the metaconid and the size of the hypoconid do not increase from m1 to m3 as in *K. hsandgoliensis*; the m1 has a distinct hypoconulid; the entolophid is more distinct in the molars, and the entoconid is more distinct and separated from the posterolophid by a distinct shallow groove. Unfortunately, *K. hsandgoliensis* is based on a single lower jaw, and the figures given by Minjin (2004) are inadequate for a reliable judgment. We do not know whether there are differences between the upper cheek teeth of the two forms. Based on the above listed differences, with some reservations, we tentatively propose a new species for the new specimens, named as *K. asiatica* here.

As for the phylogenetic position of *Kherem* in the Sciuridae, Minjin (2004) mentioned: "The placement of *Kherem* within Sciuridae is quite ambiguous." Now, the better specimens of *K. asiatica* shed some new light on the phylogenetic position of *Kherem* in the Sciuridae.

Among the known sciurids, the North American cedromurines are the group most similar to *Kherem*. They share the following features in common: the anterior border of masseteric fossa is located below the posterior part of m1; the upper cheek teeth have an ectoloph, a minute protoconule, and a metaloph weakly connecting with the protocone; the lower cheek teeth have a

closed and bucco-lingually elongated trigonid basin and a complete entolophid. The presence of an ectoloph in upper molars has been considered synapomorphic of the cedromurines (Korth and Emry, 1991). *Kherem* possesses such a feature, as well. *Kherem* is to be referred to the subfamily Cedromurinae.

The Cedromurinae have been so far known to include only two genera of North America: *Cedromus* (early Oligocene) and *Oligospermophilus* (from late Eocene through early Oligocene) (Korth and Emry, 1991). *Kherem* is different from *Cedromus* in such features as: the ectoloph is incomplete; the metaconule is well developed joining with posteroloph; the entolophid bends backwards to join with posterolophid and the mesostylid is narrower transversely. Although *Kherem* is similar to *Oligospermophilus* in having incomplete ectoloph on upper cheek teeth and a shallow groove between entoconid and posterolophid, the former differs from the latter in having higher crowned cheek teeth; upper molars having larger metaconule joining the posteroloph, but lacking hypocone; lower cheek teeth having smaller trigonid basin. Taken as a whole, *Kherem* is more similar to *Oligospermophilus* than to *Cedromus*. Based on the evolutionary tendencies of the sciurids suggested by Korth (1994, p. 116), *Kherem* is more derived than *Oligospermophilus*. *Kherem* probably evolved from some *Oligospermophilus*-like form by increasing its tooth crown height, reducing the hypocone, but enlarging the metaconule. If this proves tenable, *Kherem* might have migrated from North America into Asia in Oligocene or even earlier. In this case the distribution of the Cedromurinae would not be limited to North America, but expand into Asia. As for the relationship between *Cedromus* and *Kherem*, they may represent different lineages as well. In *Cedromus* the ectoloph is complete and the mesostylid extends transversely, whereas in *Kherem* the metaconule is enlarged joining with the posteroloph.

Up to now three genera of sciurids (*Sciurus*, *Oligosciurus* and *Kherem*) are known to occur in Oligocene of Asia. *Kherem* differs from *Oligosciurus* in being larger in size, more anteriorly located masseteric fossa and mental foramen, having higher crowned cheek teeth, and not anterobuccally extended hypoconid. *Sciurus* sp. from Tabern-buluk is also different from *Kherem*, being smaller in size, lower in cheek tooth crown, and lacking entolophid in m2. *Sciurus* sp. from Tabern-buluk seems to be more advanced than *Kherem*, but *Oligosciurus* is the most primitive among them. Since every one of the three Asian taxa has its own autapomorphic features (*Oligosciurus* has more anterobuccally extending hypoconid; *Sciurus* sp. lacks entolophid; *Kherem* is larger in size, cheek teeth higher crowned, upper cheek teeth with ectoloph and well-developed metaconule joining with posteroloph etc.), the three forms may represent three different evolutionary lineages. This, in turn, indicates that the diversification of the sciurids occurred already in Asian Oligocene.

Aplodontidae Brandt, 1855

Prosciurinae Wilson, 1949

Prosciurus Matthew, 1903

Prosciurus mongoliensis sp. nov.

(Fig. 3; Table 2)

Holotype A segment of left mandibular ramus with posterior part of i2 and p4 ~ m3 (PC 29-53).

Locality and horizon of holotype Shunkt, Önnögov, Mongolia; late early Oligocene - ?late Oligocene Shand Member of Hsanda Göl Formation.

Referred specimens One segment of right mandibular ramus with posterior part of incisor and m1 ~ 3 (PC 29-55), and one segment of left mandibular ramus with p4 ~ m3 (PC 17-65).

Localities and horizons Shunkt, Önnögov, Mongolia, late early Oligocene - ?late Oligocene Shand Member of Hsanda Göl Formation (PC 29-55); Ulaan Khongil (= Tatal Göl, 45°17'50" N, 101°37'16" E), Övörhangay, Mongolia, early early Oligocene Tatal Member of Hsanda Göl Formation (PC 17-65).

Diagnosis Approximately size of *Prosciurus vetustus*. Cheek teeth brachyodont, mesostylid connected with metastylid crest, mesoconid weak, ectomesolophid weak or absent; anteroconid and anterior cingulum absent on p4; an accessory crest extending from ectolophid to hypolophid on m1; metalophid well developed on m2 ~ 3; hypolophid bends posteriorly to join with posterolophid on p4 ~ m1, but straight to join with ectolophid on m2 ~ 3.

Etymology Mongolia is the country where the fossils were collected.

Description All of the specimens are horizontal rami. The masseteric fossa is prominent with distinct upper and lower crests, and rounded anterior margin below the boundary of m1 and m2. The

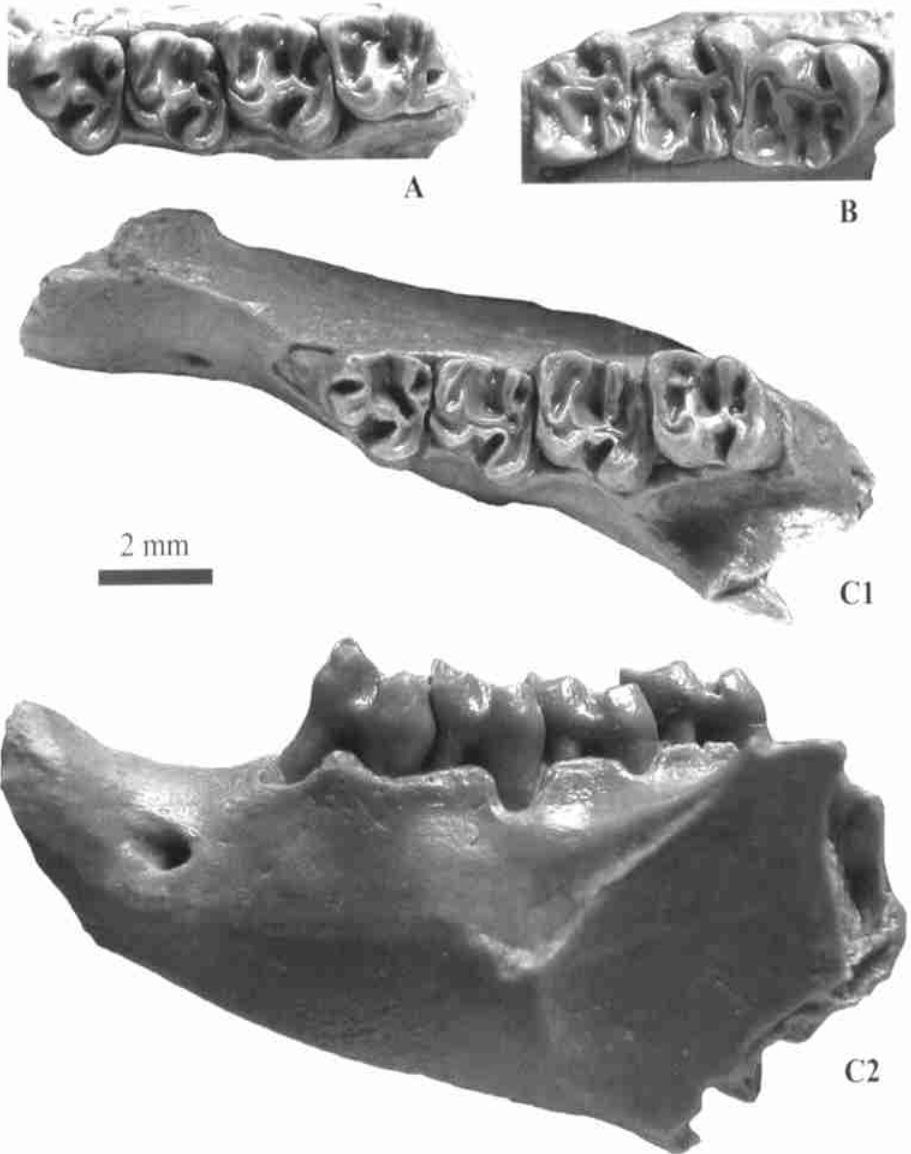


Fig. 3 *Prosciurus mongoliensis* sp. nov.

A. Occlusal view of left p4 ~ m3 (PC 17-65); B. Occlusal view of right m1 ~ 3 (PC 29-55); C. Partial left mandibular ramus with p4 ~ m3 (PC 29-53, holotype), C1. occlusal view; C2. lateral view

Table 2 Measurements of lower cheek teeth of some *Prosciurus* species (mm)

	<i>P. mongoliensis</i>			<i>P. cf. P. mongoliensis</i>	<i>P. pisinnus</i>
	PC 29-53 (holotype)	PC 29-55	PC 17-65	PC 29-54	PC 17-46 (holotype)
p4 ~ m3 L	8.3			6.9	
m1 ~ 3 L	6.2	6.1		5.3	
L	2.3		2	1.8	1.6
p4 Tr W	1.7		1.4	1.4	
Ta W	2.2		2.1	1.8	1.5
L	1.9	2.1	1.9	1.7	1.6
m1 Tr W	1.8	1.9	1.7	1.5	1.33
Ta W	2.2	2.1	2	1.7	1.6
L	2.1	2.2	2.1	2.1	1.7
m2 Tr W	2	1.9	1.9	1.6	1.5
Ta W	2.3	2.2	2.1	1.8	1.5
L	2.4	2.4		2	
m3 Tr W	2	1.9	1.8	1.7	
Ta W	1.9	1.9		1.6	
i2 L (a-p)	2.4	2.4		1.9	1.4
W	1.9	1.9		1.4	1.1

Abbreviations: L. length; L (a-p). length from anterior side to posterior side; W. width; Tr W. width of trigonid; Ta W. width of talonid.

scar for the m. masseter medialis ant. pars is distinct, located anterior to the masseteric fossa and below the posterior part of m1. The mental foramen is located anteriorly to p4. The diastema between i2 and p4 is shorter than the length of the lower cheek tooth series. The upper margin of the diastema is weakly crested and concave anteroposteriorly.

The cheek teeth are brachyodont with rather developed lophids. The p4 is trapezoid in occlusal view with narrower anterior side. The trigonid is slightly higher than the talonid. The metaconid is slightly higher than the protoconid in height. The very narrow and deep trigonid basin is closed posteriorly by a complete metalophid, but open anteriorly. The protoconid has a weak anterior arm, but neither anterior cingulum nor anteroconid is visible. The weak mesostylid connects with the distinct metastylid crest. The hypoconid expands mainly buccally. The entoconid is separated from the posterolophid by a distinct groove. The hypolophid bends posteriorly to meet the posterolophid at the distinct hypoconulid. The posterior valley between the hypolophid and posterolophid is small and the central basin is large. The ectolophid is short, straight and with a weak but distinct mesoconid. No distinct ectomesolophid is seen. The p4 has two roots.

The m1 is rhombic in occlusal view. The trigonid is slightly narrower and higher than the talonid. The metaconid, the highest cusp, slightly shifts anteriorly. The protoconid, larger than the metaconid, is located not opposite to the latter at the anterior margin of the tooth, but slightly posterior to the latter. The complete, high metalophid is convex anteriorly, but the short metalophid does not reach the metaconid. The trigonid basin is wider than that in p4, but is closed anteriorly and open widely posteriorly. The talonid of m1 is similar to that of the p4. But the mesostylid is more distinct. A weak but distinct ectomesolophid is visible. An accessory crest extends from the ectolophid to the bending hypolophid to close the posterobuccal part of the central basin into a small basin. The m1 has two roots.

The m2 is slightly larger than the m1. The trigonid basin is wider than in m1. The mesostylid is more developed and extends buccally. The metalophid is more developed, extends posterolingually to reach or almost reach to the mesostylid. The hypolophid is transverse and straight to join with the ectolophid. The posterior valley is wider and the central basin is relatively smaller.

The other features of m2 are similar to those of the m1.

The m3 is similar to the m2 in the basic features. But it is oval in occlusal view with a straight anterior side. The trigonid basin is wider. An accessory crest from posterior wall of the metalophid extends posterobuccally to reach or almost reach to the lingual end of the metalophid. The talonid is subequal to the trigonid in width. The direction of the buccal part of the mesostylid is variable.

Dimensions See table 2.

Comparison The above described specimens are almost identical with those of *Prosciurus* in the basic features (Wood, 1962; Wang, 1986): the cheek teeth are brachydont; the trigonid is higher than the talonid; the metaconid shifts forwards and the protoconid is located posteriorly to the metaconid on m1 ~ 3; the metalophid is absent on p4, but complete and convex anteriorly on m1 ~ 3; the mesoconid and mesostylid are present; the mesolophid is absent and the hypolophid is complete. Therefore, they are referred to the genus *Prosciurus*. Up to now, *Prosciurus* is known to include 7 species: *P. vetustus*, *P. relictus*, *P. saskatchewaensis*, *P. parvus*, *P. magnus*, *P. ordosicus* and *P. ? shantungensis* (Wood, 1937, 1980; Rensberger and Li, 1986; Wang, 1987; Korth, 1989). The Mongolian specimens are smaller than those of *P. saskatchewaensis* and *P. magnus*, but larger than *P. parvus*. Morphologically they are different from *P. vetustus*, *P. relictus*, *P. saskatchewaensis*, *P. ? shantungensis*, *P. parvus* and *P. magnus* in having weakly developed mesoconid on lower cheek teeth, and mesostylid joining with metastylid crest on m1 ~ 3. They further differ from *P. vetustus* in having more posteriorly located masseteric fossa, weakly developed ectomesolophid, longer metalophid and hypolophid joining with ectolophid on m2 and m3, m1 and m2 being wider than length; from *P. relictus* in having longer metalophid on m2 ~ 3, weakly developed ectomesolophid, and more developed but posteriorly bending hypolophid joining with posterolophid on p4 ~ m1; from *P. saskatchewaensis* in having incomplete metalophid, weakly developed ectomesolophid on lower molars, bending posteriorly hypolophid joining posterolophid on p4 ~ m1, and lacking anterolophid on p4; from *P. parvus* in having more developed metalophid, narrower mesostylid, weakly developed ectomesolophid, more developed, transverse hypolophid joining with ectolophid on m2 ~ 3, and lacking cingulum behind protoconid; from *P. ? shantungensis* in having lower crowned teeth, higher metaconid, narrower mesostylid, weakly developed ectomesolophid and hypoconulid, lower hypolophid joining with ectolophid; from *P. magnus* in having more developed metalophid and hypolophid, smaller mesostylid; and from *P. ordosicus* in having higher crowned cheek teeth. Thus, a new species, *P. mongoliensis* is here named.

Prosciurus cf. *P. mongoliensis* sp. nov.

(Fig. 4; Table 2)

Specimen A segment of right mandibular ramus with i2, p4 ~ m3 (PC 29-54).

Locality and horizon Shunkt, Önnögov, Mongolia; late early Oligocene - ?late Oligocene Shand Member of Hsanda Gol Formation.

Description and remarks The horizontal ramus is similar to that of *P. mongoliensis* in basic features. But the diastema crest between i2 and p4 is not so distinct as in *P. mongoliensis*. The lower incisor, completely preserved in PC 29-54, is laterally compressed and triangular in the cross-section with a narrow labial side. A thin enamel layer covers the labial side. No distinct grooves or crests can be seen on the labial surface. The cheek teeth are also similar to those of *P. mongoliensis* in the basic features. However, in the new specimen the p4 has a more distinct ectomesolophid; the hypolophid is gently curved on p4 and m1; no distinct crest from the ectolophid to the hypolophid is visible on m1; the metalophid is short on the m2 ~ m3; the mesoconid and ectomesolophid are more distinct on m1 ~ m3; and, finally, all the teeth are smaller (see Table 2). All these features are different from those of *P. mongoliensis*. With these differences we temporarily refer this ramus to *Prosciurus* cf. *P. mongoliensis*.

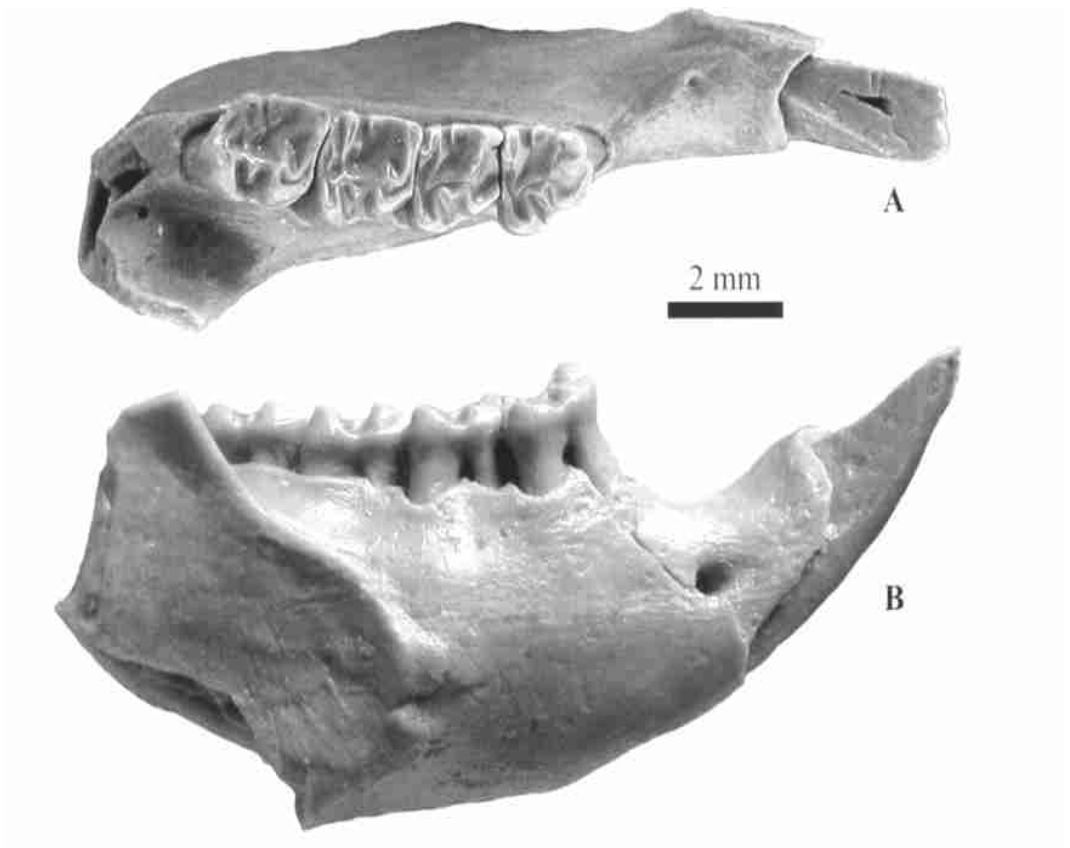


Fig. 4 Partial right mandibular ramus with i2, p4~m3 (PC 29-54) of *Prosciurus* cf. *P. mongoliensis*
A. occlusal view; B. lateral view

Prosciurus pisinnus **sp. nov.**

(Fig. 5; Table 2)

Holotype A segment of left mandibular ramus with i2 and p4~m2 (PC 17-46).

Locality and horizon Ulaan Khongil, Öörhangay, Mongolia; early early Oligocene Tatal Member of Hsanda Gol Formation.

Diagnosis Small-sized *Prosciurus*. Cheek teeth brachydont, with short metalophid, low and transverse hypolophid reaching to ectolophid, well-developed mesoconid and ectomesolophid, more anterobuccally extending hypoconid, distinct cingulum; mesostylid connected with metastylid crest on p4 and isolated on lower molars; protoconid with more developed anterior arm on p4.

Etymology Pisinnus, Latin, small, little, implicating the small size of the species.

Description The horizontal branch of the lower jaw is slim. The prominent masseteric fossa has a right angular anterior margin below anterior part of m2 and distinct upper and lower crests. The distinct scar for the m. masseter medialis ant. pars is located anterior to the masseteric fossa and below between m1 and m2. The mental foramen is located anterior to the p4. The diastema between i2 and p4 is shorter than the length of the lower cheek tooth series. The concave upper margin of the diastema has a distinct longitudinal crest.

The cheek teeth are brachydont. The p4 is triangular in occlusal view. The trigonid is narrower and higher than the talonid. The metaconid is broken, but its preserved part shows that it is conic and higher than the protoconid. The V-shaped protoconid has two arms: the anterior arm almost

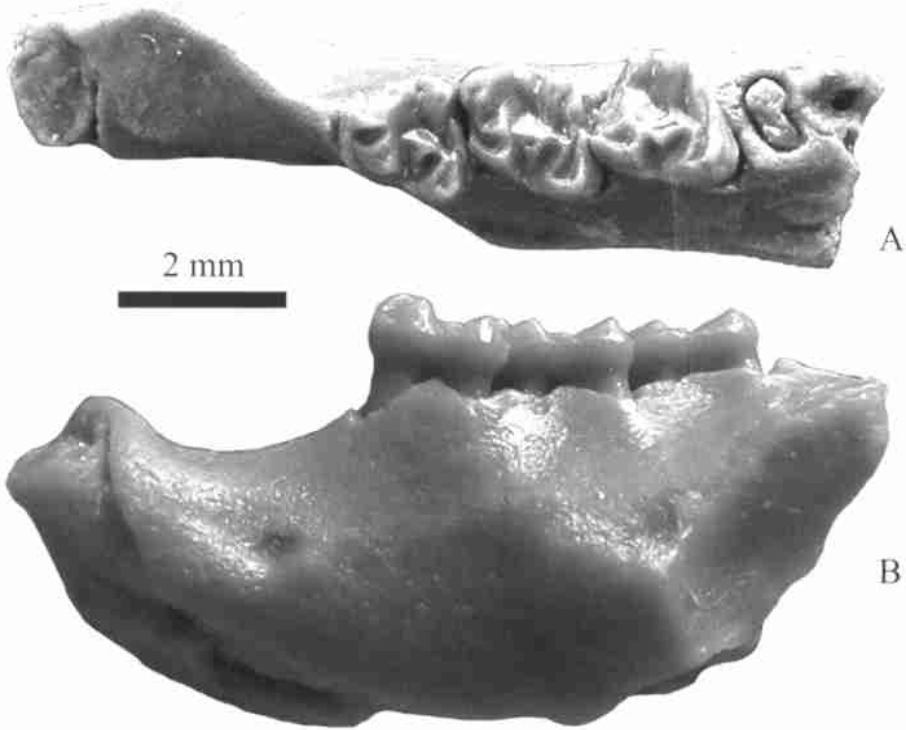


Fig. 5 Partial left mandibular ramus with i2, p4~m2 (PC 17-46, holotype) of *Prosciurus pisinnus* sp. nov.
A. occlusal view; B. lateral view

reaches to the base of the metaconid; the posterior arm extends to the metaconid to form complete, low metalophid. The narrow and deep trigonid basin is closed both anteriorly and posteriorly. The mesostylid is distinct, but connected with metastylid crest and separated from the entoconid by a wide valley, of which there is a low accessory cusp at the bottom. Among the main cusps the entoconid is the smallest and lowest one, and the hypoconid is the largest and extends anterobuccally. The short posterolophid is separated from the entoconid by a groove. No distinct hypoconulid is seen. The ectolophid extends from the hypoconid to the base of the metalophid. Both the mesoconid and ectomesolophid are well developed. The hypolophid is transverse and lowers buccally to meet the base of the ectolophid. An accessory crest extends from the hypolophid into the central basin. The distinct anterior cingulum is present on the anterior side of the protoconid. The weak and distinct buccal cingulum extends from the anterior cingulum to the buccal side of the hypoconid. The posterior cingulum is weak but distinct on the posterior wall of the p4. The p4 has two roots.

The m1 is rhombic in occlusal view. The trigonid is slightly higher and narrower than the talonid. The metaconid, higher than the protoconid, shifts anteriorly and is widely separated from the protoconid. The latter is not located at the anterior margin, but moves backward to posterobuccal to the metaconid. The complete and high metalophid is convex anteriorly. The metalophid is short. The trigonid basin is widely open posteriorly. The mesostylid is isolated and separated from both the metastylid crest and entoconid by grooves. A small hypoconulid is present on the posterolophid. The hypolophid is a single transverse crest, lowers buccally to meet the ectolophid. The distinct lingual cingulum is located lingually to the mesostylid between the metaconid and entoconid. The other features of m1 are similar to those of the p4. The m2 is broken at its

anterolingual corner. The m2 is similar to the m1 in the basic features. But it is slightly larger than the m1. The lingual cingulum is not so distinct, but there is an accessory cusp between the mesostylid and entoconid as in p4. The mesoconid and ectomesolophid is less developed than in the m1.

Comparison The above description shows clearly that PC 17-46 is almost identical with *Prosciurus* in basic features, and is to be referred to this genus. Among the known 9 species of *Prosciurus* (*P. vetustus*, *P. relictus*, *P. saskatchewaensis*, *P. parvus*, *P. magnus*, *P. ordosicus*, *P. ? shantungensis*, *P. mongoliensis*, and *P. cf. P. mongoliensis*), it is closest to *P. parvus* in size. But PC 17-46 is different from *P. parvus* in having transverse, lower hypolophid joining with ectolophid, more developed cingulum in lower cheek teeth, and V-shaped protoconid in p4. It differs from all the other 8 species in being smaller in size and having distinct cingulum. In addition, PC 17-46 further differs from *P. vetustus* in having lower and transverse hypolophid joining with ectolophid; from *P. relictus* in length of m1 and m2 being subequal to or longer than width, having more anterobuccally extending hypoconid on lower cheek teeth and mesostylid connecting with metastylid crest on p4; from *P. saskatchewaensis* in having incomplete metalophid and more anterobuccally extending hypoconid; from *P. magnus* in having more developed and transverse hypolophid joining with the ectolophid; from *P. ? shantungensis* in having lower crown, higher metaconid, narrower mesostylid, lower hypolophid, and smaller hypoconulid; from *P. mongoliensis* and *P. cf. P. mongoliensis* in having lower crown, well-developed mesoconid and ectomesolophid, more anterobuccally extending hypoconid on lower cheek teeth, lower and transverse hypolophid joining with ectolophid on p4 ~ m1, isolated mesostylid on m1 ~ 2, and more developed anterior arm of protoconid of p4. These differences led us to erect a new species for the specimen PC 17-46, which is named as *P. pisinnus* here.

Discussion *Prosciurus* has been known to be mainly distributed in North America, with only a few poorly preserved specimens from Asian Oligocene identified as belonging to this genus. Altogether four forms (*Prosciurus lohicolus*, *P. arboraptus*, *P. ? shantungensis* and *P. ordosicus*) were reported from Asia (Matthew and Granger, 1923; Shevryeva, 1971; Rensberger and Li, 1986; Wang, 1987). However, two of them, *P. lohicolus* and *P. arboraptus*, were excluded from this genus later (Wang, 1986, 1987). *P. lohicolus* was included in *Anomoemys* of the Cylindrodontidae, and *P. arboraptus* in another genus *Haplomys*. The other two species, *P. ? shantungensis* and *P. ordosicus*, were based on single isolated tooth per each. Together with the three new forms from Mongolia, *Prosciurus* now includes five species in Asia. This not only proves that the genus *Prosciurus* does exist in Asia, but also shows that *Prosciurus* experienced already considerable diversity during Oligocene in Asia. What is more important is the fact that some of the Asian species are more similar to the North American forms rather than to the Asian ones. For example, *P. pisinnus* and *P. mongoliensis* are morphologically more similar to the North American *P. relictus* and *P. vetustus* respectively. This led us to think that some of the Asian *Prosciurus* forms might have their origin from North America. However, the paucity of the material made us refrain from drawing such a conclusion right now. More and better material is needed in order to solve this problem conclusively.

3 Conclusion

As is now known, in Asia the Oligocene sciurids include four species of three genera: *Sciurus* sp. and *Oligosciurus dangheensis* from Danghe area in Gansu, China, and *Kherem hsandgoliensis* and *K. asiatica* from Mongolia. The material of the two formers is too poor to show their relationships with other members of the family. *Kherem* is more similar to the North American cedromurines, especially *Oligospermophilus*, but widely differs from their European counterparts. Three genera of Sciuridae were reported from Oligocene of Europe: *Palaeosciurus*, *Heteroxerus* and

Oligopetes. One of the major differences of *Palaeosciurus* from *Kherem* is the absence of entolophid on lower cheek teeth. *Heteroxerus* is different from *Kherem* in lacking ectoloph and having well-developed hypocone on upper molars. The differences between *Oligopetes* and *Kherem* are even larger (see Heissig, 1979). The above comparison shows clearly that *Kherem* has closer relationships with the American sciurids rather than with the European ones, and is to be referred to the North American subfamily Cedromurinae.

The new material of *Prosciurus* found in Mongolia has finally confirmed the existence of the genus *Prosciurus* in Asia. The Asian Oligocene apodontids now include eight species of four genera: *Plesispermophilus* sp. from Kazakhstan, *Haplomys arboraptus*, *Promeniscomys sinensis*, *Prosciurus ordosicus*, *P. ? shantungensis*, *P. mongoliensis*, *P. cf. P. mongoliensis*, and *P. pisinus*. Among them *Plesispermophilus* is the only genus shared by Asia and Europe. All the other three genera have closer relationships with those of North America. While *Prosciurus* and *Haplomys* are common to Asia and North America, *Promeniscomys* is closely related to North American *Meniscomys*.

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