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陕西蓝田晚中新世灞河组沙鼠类化石[1)]

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摘要: 沙鼠是一类由早中新世米古仓鼠类(myocricetodontines)演化而来的啮齿动物,现生的种类主要分布于非洲、阿拉伯半岛和亚洲干旱的沙漠—荒漠草原地区。其高阶元的系统分类尚未取得一致的意见,但古生物学者一般认为,沙鼠类动物自成一科,并可分为 3 个亚科:米古仓鼠亚科(Myocricetodontinae)、裸尾沙鼠亚科(Taterillinae)和沙鼠亚科(Gerbillinae)(Jaeger, 1977; Tong, 1989; Chaline et al., 1977; Wessels, 1999)。

我国的现生沙鼠共有 3 属 7 种,均属 Gerbillinae 亚科,主要分布于蒙新高原及其南邻地带(王应祥,2003)。最早的化石记录是甘肃泉头沟中中新世的 *Mellalomys gansus* 和 *Myocricetodon plebius*(邱铸鼎, 2001)。在其他新近纪地点发现的有甘肃庆阳、瓦窑堡和灵台,山西榆社和内蒙古化德、高德格的 *Pseudomeriones abbreviatus*(Teilhard, 1926; Young, 1927; Schaub, 1934; 李传夔, 1981; Fahlbusch et al., 1983; 郑绍华、张兆群, 2000; Qiu and Storch, 2000; 李强等, 2003),以及甘肃宁县的 *Pseudomeriones complicidens*(张兆群, 1999)。*Mellalomys* 和 *Myocricetodon* 属归入 Myocricetodontinae,而 *Pseudomeriones* 属归入 Gerbillinae。

本文记述 *Myocricetodon* 和 *Abudhabia* 两属沙鼠,后者被归入 Taterillinae 亚科,代表该亚科在我国的首次发现。材料系中芬古生物工作者于 1997～2000 年在陕西蓝田晚中新世的灞河组中采集的。根据共生哺乳动物化石的研究,该动物群的时代为晚中新世早期,即中国哺乳动物年代的保德期早期,大致与欧洲陆相哺乳动物时代的瓦里西期(Vallesian)晚期或 MN10 相当(Zhang et al., 2002; Qiu et al., 2004)。

蓝田米古仓鼠 Myocricetodon lantianensis **sp. nov.**

特征 米古仓鼠属中的小种;M1 具宽的单叶前边尖和略退化的纵向脊;臼齿与 *M. plebius* 的相似,但 M1 后部较为横向收缩,前边尖较宽,纵向脊更退化,M1 和 M2 主尖"尖对"(cusp-pairs)近于成行排列,m1 下前边脊舌侧支和次小尖退化。

新种的牙齿形态与甘肃泉头沟 *M. plebius* 的相似,可能说明两者有较为亲近的关系。与 *M. plebius* 相比,其 M1 具较宽的前边尖、M1 和 M2 内外侧主尖连接更紧密及纵向脊较退化、m1 下前边脊舌侧支和下次小尖更退化等,被认为属于较进步的特征。

刘氏米古仓鼠 Myocricetodon liui **sp. nov.**

特征 米古仓鼠属中一较小种;M1 具双叶前边尖、小的内附尖和退化的纵向脊,m1 和 m2 具宽的唇侧齿带;臼齿与 *M. sivalensis* 的相似,但纵向脊较为退化、齿带和附属尖较显著,M1 和 M2 的后部较为横向收缩、后外谷较狭窄。

Myocricetodon liui 与 *M. lantianensis* 的主要区别是其 M1 前边尖双叶,m1 唇侧前边脊发育、臼齿纵向脊明显退化、具有附属尖和宽的齿带。在牙齿形态上,它与西瓦里克的 *M. sivalensis* 最为相似,但其臼齿的纵向脊更退化、附属尖和齿带更显著、M1 和 M2 的后部明显横向收缩、

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后外谷更狭窄。它与 *M. sivalensis* 的相似表明了两者的亲缘关系,而差异可能说明后者较前者更为古老。

灞河阿布扎比鼠 Abudhabia baheensis **sp. nov.**

特征 阿布扎比鼠属中的小种;臼齿主尖"尖对"连接紧密,具发育程度不同的纵向脊痕迹;M1 前脊短,前尖和原尖间由低脊连接,具后齿带痕迹;M2 和 m2 的后部宽,前齿带相当显著;M3 和 m3 不甚退化。

Abudhabia baheensis 是该属现知最为原始的一种,代表 Taterillinae 亚科化石在我国的首次发现。其个体小,臼齿有残留的纵向脊,M2 和 m2 的前齿带显著,M3 和 m3 相对不那么退化,被认为是原始的性状。该属的演化趋势似乎是个体增大,臼齿纵向脊退化,M1 前脊增宽,M2 和 m2 的前齿带退化,M3 和 m3 简单化。新种具有明显介于米古仓鼠和现生裸尾仓鼠的牙齿特征,特别是臼齿保留着纵向脊、窄的 M1 前边尖、显著的 M2 和 m2 前边脊,以及相对复杂的第三臼齿,这也似乎都证实了裸尾沙鼠类动物起源于米古仓鼠类的推断。

根据上述沙鼠化石的进化水平判断,化石层位的时代大体属于晚中新世的早期,因为新种 *Myocricetodon lantianensis* 和 *M. liui* 分别比中中新世的 *M. plebius* 和 *M. sivalensis* 进步,而 *Abudhabia baheensis* 比现知晚中新世和上新世的种都原始。

米古仓鼠属和阿布扎比鼠属同样见于亚洲和非洲新近纪中期,蓝田的发现表明它们分布向东延伸了,说明晚中新世期间东亚与北非和西、南亚密切的动物地理关系和相似的生态环境。沙鼠类动物适应于干旱环境,蓝田两属沙鼠的出现,似乎指示了这一时期在东亚和西北非之间存在着一个开阔地带,耐旱的小哺乳动物可以通过阿拉伯半岛在这一地带进行交流。

关键词: 陕西蓝田,中新世,灞河组,沙鼠科

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GERBILLIDS FROM THE LATE MIOCENE BAHE FORMATION, LANTIAN, SHAANXI

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Abstract This paper describes three new species of Gerbillidae in two genera-*Myocricetodon lantianensis* sp. nov., *M. liui* sp. nov., and *Abudhabia baheensis* sp. nov. from the late Miocene Bahe Formation at Lantian, Shaanxi Province. *M. lantianensis* and *M. liui* show relative similarity to *M. plebius* from the middle Miocene of Quantougou, Gansu and *M. sivalensis* from the middle Miocene Siwaliks, Pakistan in dental pattern, and were closely allied to the two Asian middle Miocene gerbils, respectively. *Abudhabia baheensis* is the first record of the subfamily Taterillinae in China, and is considered to be the most primitive species of the genus so far known. The Lantian gerbils represent the eastern extension of distribution of the two genera. Their presence not only indicates the close biogeographic affinities of East Asia with North Africa and Southwest Europe during the late Miocene, but also suggests the existence of an open and xeric region between eastern Asia and northwestern Africa, where interchange of small mammals, via the Arabian Peninsula took place.

Key words Lantian, Shaanxi, late Miocene, Bahe Formation, Gerbillidae

1 Introduction

Gerbils are suggested to descend from a line of Myocricetodontinae in the early Miocene (Jaeger, 1977; Flynn et al., 1985). Similar to jerboas, they are adapted to a xeric environment and the extant sand rats are distributed mainly in semi-desert or desert regions of Africa, the Arabian Peninsula and Asia. Extant gerbils in China, with three genera (*Meriones*, *Brachiones*, and *Rhombomys*) and seven species, occur in the Mongolia-Xinjiang Plateau and the adjacent arid areas south of the plateau (Wang, 2003). There are differences of opinion in regard to the phylogenetic classification of gerbils within muroids. Before higher-level systematics is settled, the authors follow most paleontologists in considering gerbils as a family-level taxon and in recognizing three subfamilies in the Gerbillidae (Jaeger, 1977; Tong, 1989, Chaline et al., 1977; Wessels, 1999), i.e. the Myocricetodontinae Lavocat, 1961, the Taterillinae Chaline et al., 1977, and the Gerbillinae Alston, 1876.

Only a few fossil genera and species of Gerbillidae, with a handful of specimens are known in China, and the oldest record is *Mellalomys gansus* and *Myocricetodon plebius* from the middle Miocene of Quantougou, Gansu (Qiu, 2001). Other taxa from the Neogene deposits are *Pseudomeriones abbreviatus* from the late Miocene or Pliocene of Qingyang, Wayaopu, and Lingtai in Gansu, Yushe in Shanxi, Huade and Qagan Nur (Gaodege) in Nei Mongol (Teilhard, 1926; Young, 1927; Schaub, 1934; Li, 1981; Fahlbusch et al., 1983; Zheng and Zhang, 2000; Qiu and Storch, 2000; Li et al., 2003), and *Pseudomeriones complicidens* from the Pliocene of Ningxian, Gansu (Zhang, 1999). All these documented taxa, representing two subfamilies, Myocricetodontinae and Gerbillinae, are known only in the northern/northwestern parts of China.

This paper deals with two genera of gerbillids, of which *Abudhabia* represents evidently Taterillinae, a subfamily first known from the Neogene of China. The material was collected from Lantian, Shaanxi Province by the team members of a joint project supported by the Chinese Academy of Sciences and the Finnish Academy of Sciences during the field season of 1997～2000 by means of screen-washing. Associated with the gerbils are 10 forms of small mammals and some large mammals from 6 localities of the Bahe Formation (Qiu et al., 2004). The authors (Qiu et al., 2004) presented a detailed description of the genus *Progonomys* from these localities, which argues for an early late Miocene age for the lower portions of the Bahe Formation, corresponding to early Baodean of Chinese Land Mammal Age or correlated with late Vallesian or MN10 of Europe. For the geological background of these localities, the reader is referred to the paper by Zhang and others (2002), and the paper by Kaakinen and Lunkka (2003).

2 Systematics

Gerbillidae Alston, 1876

Myocricetodontinae Lavocat, 1961

Myocricetodon **Lavocat, 1952**

Myocricetodon lantianensis **sp. nov.**

(Fig. 1, 1～3)

2002 *Myocricetodon* cf. *M. trerki* Zhang et al., p. 170, table 1 [part]

2003 *Myocricetodon* cf. *M. trerki* Qiu et al., p. 446, table 1 [part]

Etymology Named after the Lantian area, from where the new species was collected.

Holotype A right M1 (1.65 ×1.10 mm); V 14034.

Type locality Loc. 12, Lantian County, Shaanxi Province (China).

Stratum typicum Bahe Formation, early Baodean, early late Miocene.

Paratypes Loc. 12: 4 isolated teeth (1 M1, 1.65 ×1.05; 1 M2, 1.30 ×0.90; 2 m1, 1.50 ×0.95 mm), V 14035.1～4. Loc. 19: a posterior part of M2, V 14035.5. Loc. 6: an anterior portion of m1, V 14035.6.

Diagnosis A small species with broad single-cusped anterocone and slightly reduced longitudinal crest on M1; molars similar to *M. plebius*, but M1 with narrow posterior portion and wide anterocone, M1 and M2 with cusp-pair arrangement nearly in rows and more reduced longitudinal crest, m1 with reduced lingual branches of anterolophid and hypoconulid.

Description M1: The occlusal outline is elliptical, with a relatively narrow posterior portion. The anterocone is single-cusped and broad. The lingual and labial main cusps are slightly alternately arranged, with the anterior limit of the paracone being almost opposite the posterior limit of the protocone, and the anterior limit of the metacone almost opposite the midline of the hypocone. The hypocone and the metacone are fused completely. The anterolophule is thick and connects the anterior arm of the protocone with the anterocone. The short and developed protoloph joins the posterior arm of the protocone, and delimits a deep anterior furrow between the protocone and paracone. The longitudinal crest is robust, joined to the connection of protocone and paracone. Three roots are present.

M2: The occlusal outline is long and narrow. The anterocone is reduced to a robust labial branch of the anteroloph. The cusp-pairs of the protocone and paracone, and of the hypocone and metacone form anterolingually-posterolabially directed ridges at a moderately worn stage. The anterolophule is short and weak, connecting the anterior arm of the protocone with the anteroloph. The longitudinal crest is reduced and interrupted, and shows a tendency to join the paracone from the anterior arm of the hypocone. Three roots are present.

m1: The three m1s are all eroded or damaged. The high and single-cusped anteroconid is placed near the metaconid and has a strong labial branch of anterolophid, connecting to the base of the protoconid. The main cusps are more or less arranged alternately. The anterolophulid, metalophid and hypolophid are undeveloped. The longitudinal crest is low and short, connecting the protoconid to the hypoconid. The entoconid joins directly the longitudinal crest. The posterolophid is prominent and connected to the base of the entoconid. The sinusid is directed obliquely anteriorly. The tooth is two-rooted.

Comparison and discussion The dental characters of the specimens described above fit the diagnosis of *Myocricetodon* as emended by Jeager (1977): small size myocricetodontine with reduction of mesoloph(id) and longitudinal crest, simplicity of connections between protocone and paracone.

The new species *Myocricetodon lantianensis* can be readily distinguished from *M. seboui* Jaeger, 1977, *M. ouaichi* Jaeger, 1977, *M. eskihisarensis* Wessels et al., 1987 and *M. chinjiensis* (Lindsay, 1988) by its lack of an enterostyle on the M1 and M2; from *M. sivalensis* Lindsay, 1988 in its M1 having a simpler anterocone and missing a clear cingulum and accessory cusps; from *M. trerki* Jaeger, 1977 by its smaller size, m1 having normal placement of protoconid and hypoconid and weakly developed cingula. *Myocricetodon lantianensis* more or less resembles *M. cherifiensis* Lavocat, 1952, *M. parvus* (Lavocat, 1961), *M. irhoudi* Jaeger, 1977, and *M. ouedi* Jaeger, 1977; distinctions from these taxa include the size difference, the presence of a more distinct "normal" longitudinal crest, the absence of a "new" longitudinal crest connecting paracone with hypocone on the M1, and the simple anteroconid and anterolophid on the m1. The new species is more or less comparable to *M. ternanensis* Tong et Jaeger, 1993, but differs from it in larger size and having a less distinct connection between the anteroconid and protoconid. *Myocricetodon lantianensis* is rather similar to *M. plebius* Qiu, 2001 from the middle Miocene Quantougou Formation of Gansu, China in dental pattern, but slightly different in M1 having more reduced posterior portion, a broad anterocone, better fused cusp-pairs, M1 and M2 having more reduced longitudinal crests, m1 having a reduced lingual branch of the anterolophid and a weaker hypoconulid.

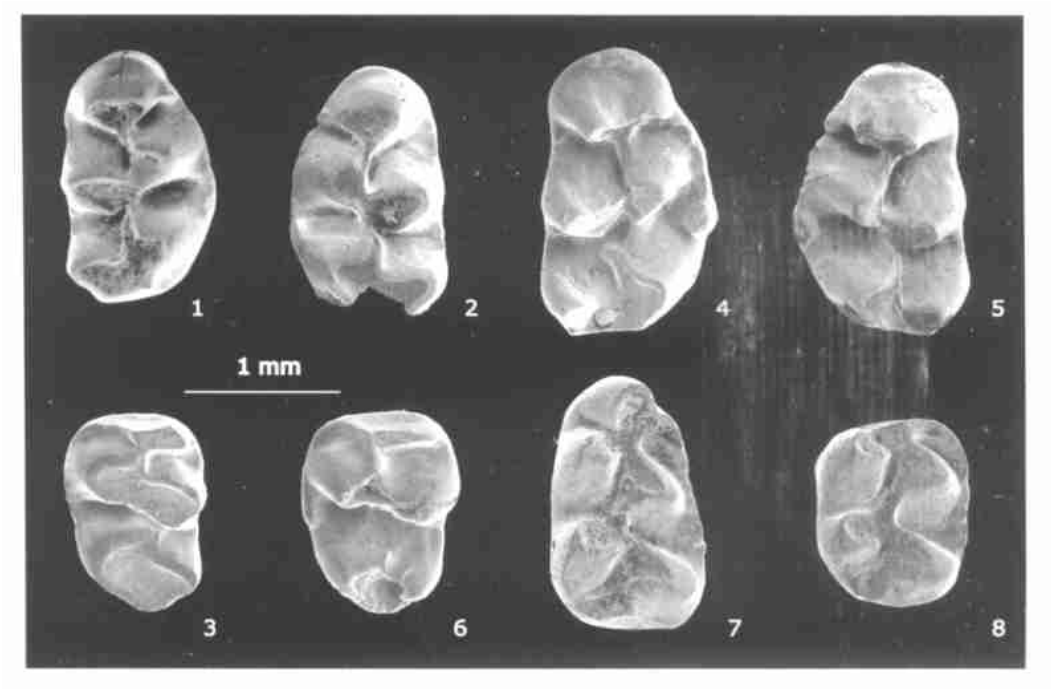

Fig. 1　1～3. *Myocricetodon lantianensis* sp. nov. 1. r M1, Holotype (V 14034); 2. l M1 (V 14035.1); 3. l M2 (V 14035.2)
4～8. *Myocricetodon liui* sp. nov. 4. r M1, Holotype (V 14036); 5. l M1 (V 14037.1); 6. l M2 (V 14037.2); 7. r m1 (V 14037.3); 8. r m2 (V 14037.4), all occlusal view

The similarity of the Lantian taxon to *M. plebius* seems to imply that the two Chinese species have close affinities. The extension of anterocone in M1, the better fused cusp-pairs and the more reduced longitudinal crests in M1 and M2, and the reduction of lingual branch of anterolophid and of hypoconulid in m1 are here interpreted as being derived features for the new species.

Myocricetodon liui **sp. nov.**
(Fig. 1, 4～8)

2002 *Myocricetodon* cf. *M. trerki* Zhang et al., p. 170, table 1 [part]
2003 *Myocricetodon* cf. *M. trerki* Qiu et al., p. 446, table 1 [part]

Etymology　Dedicated to Professor Liu Dongsheng, in recognition of his pioneer investigation on the Bahe Formation that produces the new species.

Holotype　A right M1 (1.95 ×1.10 mm); V 14036.

Type locality　Loc. 12, Lantian County, Shaanxi Province (China).

Stratum typicum　Bahe Formation, early Baodean, early late Miocene.

Paratypes　Loc. 12: 4 isolated teeth (1 M1, 1.85 ×1.10; 1 M2, 1.25 ×0.95; 1 m1, 1.55 ×0.95; 1 m2, 1.15 ×1.00 mm), V 14037.1～4.

Diagnosis　A small species with bilobed anterocone, small enterostyle and reduced longitudinal crest on M1, and broad labial cingulids on m1 and m2; molars similar to *M. sivalensis*, but with more reduced longitudinal crest, more prominent cingula and accessory cusps, M1 and M2 being narrower in its posterior portion, and narrower posteroectosinus.

Description　M1: The anterocone is unequally bilobed with labial lobe larger and higher than lingual lobe in the type specimen, and shows a shallow anterior inflection in the other specimen. The lingual and labial main cusps are arranged in rows. The protocone and hypocone are placed rel-

atively close to lingual side. The anterolophule is narrow and low, connecting the anterior arm of the protocone with the posterior wall of anterocone. The protoloph and the metaloph are short, with the latter posteriorly directed and joining the posteroloph. The longitudinal crest is low and weak, consisting of two parts - the posterior arm of the protocone and the anterior arm of the hypocone. There is a distinct anterior cingulum and a prominent lingual cingulum that bears an evident enterostyle. A very narrow posteroectosinus is present. There are three roots.

M2: The anteroloph is complete, with a striking labial branch, extending transversely to the anterolabial corner of the tooth, and a very weak lingual branch, as a crest, sloping to the base of the crown. The protocone is nearly fused with the paracone, the hypocone and metacone are rather reduced. The anterolophule is thin but distinct. The longitudinal crest is absent. The clear posteroloph is extended to the hypocone to close a deep posteroectosinus. A lingual cingulum is visible between the protocone and the hypocone. There are three roots.

m1: The single-cusped anteroconid is high and sharp with a very swollen labial branch of its anterolophid. The main cusps are alternating. The anterolophulid is short and thick, joining the anteroconid to the connection between the protoconid and the metaconid. The longitudinal crest is complete, narrower anteriorly and connecting the protoconid to the hypoconid. The entoconid is directly connected to the longitudinal crest. The posterolophid is prominent and connected to the base of the entoconid. A labial cingulum extending from the anterolophid to the hypoconid is developed and bears a small tubercle close to the protoconid. The sinusid is slightly directed obliquely anteriorly. Two roots are present.

m2: The lingual and labial walls of the teeth are parallel. The lingual branch of the anterolophid is absent and the labial branch is prominent. The longitudinal crest is complete and curved, joining the protoconid to the hypoconid. The entoconid is directly connected to the longitudinal crest. The posterolophid bears a marked hypoconulid. The labial cingulum is continuous from the anterolophid to the base of hypoconid, bearing a cuspulid near the protoconid. Two-rooted.

Comparison and discussion The above described specimens, representing another new species of *Myocricetodon* from Lantian, are characterized by the bilobed anterocone of M1 and strong labial anterolophid of m1, the reduction of a "normal" longitudinal crest and the absence of a "new" one, and the presence of accessory cusps.

This new taxon *Myocricetodon liui* can be distinguished from *M. lantianensis* and *M. plebius* by its larger size, arrangement of cusps in rows, development of cingula in the molars, relatively labial placement of protocone and hypocone in upper molars and lingual location of protoconid and hypoconid in lower molars, M1 and M2 having more reduced longitudinal crests that consist of two parts in M1, and M1 having bilobed anterocone and accessory cusps, m1 with strong labial branch of anterolophid. It is readily distinguished from *M. irhoudi*, *M. ouedi*, *M. ternanensis*, *M. cherifiensis*, *M. parvus* and *M. trerki* by the presence of a reduced "normal" longitudinal crest.

Myocricetodon liui is similar to *M. seboui*, *M. ouaichi*, *M. eskihisarensis* and *M. chinjiensis* in the presence of an enterostyle in M1, but the accessory cusp in the new species is much less striking and missing an enterostyle-protocone connection. The new species mostly resembles *M. sivalensis* in dental pattern, especially in bilobed anterocone of M1, the cusp arrangement, the presence of distinct cingula and accessory cusps. Differences from the Siwalik species are the narrower posterior portion of M1, the more reduced longitudinal crest that consists of two parts, the more prominent cingula with stronger accessory cusps, and the narrower posteroectosinus of M1. The similarities and differences probably suggest that the two species were closely allied and *M. sivalensis* was near the ancestry of *M. liui*.

Taterillinae Chaline et al., 1977

Abudhabia **De Bruijn et Whybrow, 1994**

Abudhabia baheensis **sp. nov.**

(Fig. 2)

2002 *Abudhabia* sp. nov. Zhang et al., p. 170, table 1

2003 *Abudhabia* sp. nov. Qiu et al., p. 446, table 1

Etymology Named after the Bahe Formation from which the new species was found.

Holotype A left maxillary fragment with M1 and M2; V 14038 (M1, 2.00 ×1.30; M2, 1.30 ×1.25 mm).

Type locality Loc. 12, Lantian County, Shaanxi Province (China).

Stratum typicum Bahe Formation, early Baodean, early late Miocene.

Paratypes Loc. 12: 50 isolated teeth (14 M1, 7 M2, 3 M3, 11 m1, 11 m2, 4 m3, some are damaged), V 14039.1～50; Loc. 19: 12 isolated teeth (1 M1, 3 M2, 1 M3, 2 m1, 5 m2), V 14039.51～62; Loc. 13: a left maxillary fragment with an M1, 2 isolated teeth (1 M2, 1 m1), V 14039.63～65; Loc. 6: 1 m1, V 14039.66; Loc. 37: 1 M2, V 14039.67; Loc. Ms32: 1 m2, V 14039.68.

Measurements (Table 1)

Table 1 Measurements of molars of Abudhabia baheensis **sp. nov. from Locs. 12 (type locality), 19, 13, 6, 37 and Ms 32** (mm)

Tooth	Loc.	Length			Width		
		N	Mean	Range	N	Mean	Range
M1	12	12	1.99	1.90～2.05	14	1.33	1.25～1.45
	19				1	1.35	
	13	1	2.00		1	1.35	
M2	12	8	1.39	1.30～1.50	7	1.26	1.20～1.30
	19	3	1.37	1.30～1.40	3	1.32	1.25～1.40
	13	1	1.35		1	1.25	
	37	1	1.40		1	1.30	
M3	12	3	0.73	0.70～0.75	3	0.97	0.95～1.00
	19	1	0.75		1	1.00	
m1	12	9	1.88	1.80～1.95	10	1.25	1.20～1.30
	19	2	2.00	1.90～2.10	2	1.25	1.20～1.30
	37	1	2.10		1	1.25	
	6	1	1.85		1	1.20	
m2	12	11	1.38	1.25～1.50	11	1.28	1.20～1.35
	19	4	1.41	1.40～1.45	3	1.35	1.30～1.40
	Ms	1	1.35		1	1.25	
m3	12	4	0.85	0.80～0.90	4	0.95	0.90～1.00

Diagnosis A small species with closely connected cusp-pairs and variable remnant of longitudinal crest on molars, a short anterior ridge, low connection between the anterocone and the protocone, and trace of posterior cingulum on M1; a rather pronounced anterior cingulum and relatively wide posterior portion on M2 and m2; and a less reduced M3 and m3.

Description (Material from the type locality)

M1: The transverse ridges are moderately elevated, and transverse valleys are rather deep. The

anterior ridge shows a distinct anterior furrow in early stages of wear. The middle ridge, formed by anteroposteriorly compressed and closely connected protocone and paracone, is constricted and shows a deep anterior infolding and a shallower posterior inflection at the middle part of the tooth. The posterior ridge is a fused hypocone and metacone, joined posteriorly and showing a deep anterior cleft between the two cusps. The middle ridge is the longest and the anterior one, the shortest, is about two-thirds or less the length of the middle one. The lingual main cusps (protocone and hypocone) are slightly anterior in position relative to the labial ones, and protrude anteriorly lingual to the midline of the tooth in most of the specimens. The protrusion of protocone touches the base of the lingual anterocone in all the specimens; a short connection between the anterocone and the protocone is present in well-worn specimens. The protruding of hypocone approaches the posterior base of protocone in one-third of specimens; thus, connection between the two cusps (remnant of longitudinal crest) could be seen by very late wear in these teeth. A very weak anterior cingulum is visible in a few teeth, and trace of a posterior cingulum is present in little worn specimens. Three-rooted.

M2 is subrectangular and narrower posteriorly than anteriorly. The anterior ridge shows equally deep anterior infolding and posterior sculpting between its two parts. The posterior ridge, joined posteriorly by the hypocone and the metacone, has a deep anterior cleft. The lingual main cusps are larger than and slightly anterior to the labial ones. The hypocone-protruding is variably developed and approaches the base of the protocone in 4 of 8 cases. The protocone-protruding is incorporated with the anteroloph that may represent a reduced fusion of anterocones. The lingual branch of the anteroloph is either absent or a very weak short crest sloping to the base of the crown, while the labial branch (anterior cingulum) is strong and extends to the anterolabial corner of the tooth. Trace of a posterior cingulum can also be seen in little worn specimens. Three-rooted.

M3 is subtriangular in outline and wider than long. The protocone and paracone form a strong anterior transverse ridge, showing a distinct posterior infolding. The metacone is a third small cusp, part of a reduced posterior ridge that may include an indistinct hypocone. Trace of the lingual branch of anteroloph is visible in two of the three teeth. There is a large anterior root and a smaller posterior one.

m1: The anteroconid is strong and single-cusped with a striking posterolabially directed crest descending to the base of the protoconid. The labial main cusps are slightly posterior in position to the lingual ones. The principle cusp-pairs are connected closely, but not fused in early stage of wear. Both the cusp-pairs are joined anteriorly and show a deep posterior valley between the two cusps, and a small and shallow anterior sculpting on the posterior ridge. A low anterolophulid, connecting the anteroconid with the metaconid, is present in all the specimens. An indistinct low crest between the bases of protoconid and entoconid (remnant of longitudinal crest) is present in 6 of 10 teeth. This becomes a thin protoconid-entoconid connection by very late wear. The posterolophid (posterior cingulum) extending from the hypoconid bears a pronounced round hypoconulid situated in the middle of the posterior border and separated from the entoconid. Two-rooted.

m2 is slightly narrower posteriorly than anteriorly. The two oblique ridges formed by fused principal cusps and the valley between the two ridges are similar to those of m1 in shape and arrangement, but the posterior ridge is relatively shorter than the anterior one. A low and narrow longitudinal crest joins the posterior spur of the protoconid directly to the entoconid or the connection joining entoconid and hypoconid in all the specimens. There is a well-developed labial branch of anterolophid (anterior cingulum) descending to the anterolabial base of protoconid. The posterolophid bears a small hypoconulid, which is reduced relative to that of m1. Two-rooted.

m3 is subtriangular and slightly longer than wide. The anterior ridge is similar to that of m2 in shape, but smaller. The hypoconid and the entoconid merge into a strong posterior cusp, connected with the protoconid and displaced towards the lingual side. The labial branch of the anterolophid is low, but evident. There are two roots.

(Comparisons with the material from the other localities)

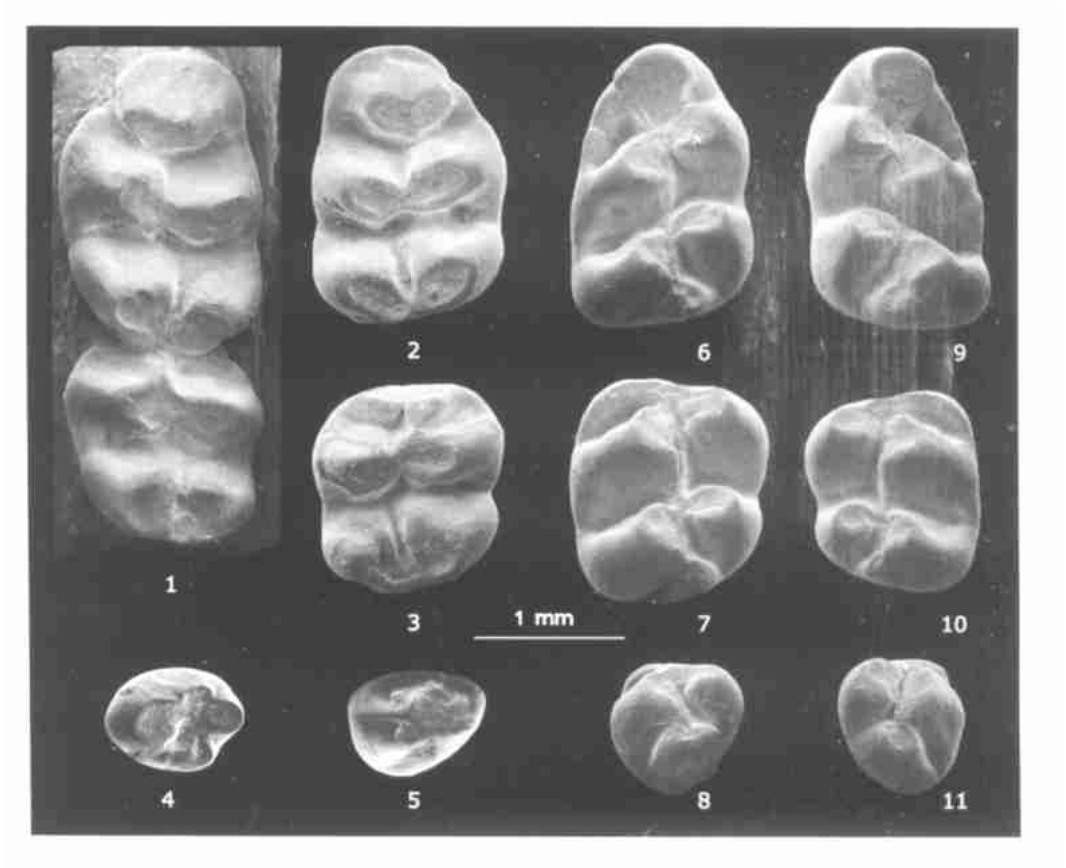

Fig. 2　*Abudhabia baheensis* sp. nov. , occlusal view
1. A left maxillary fragment with M1 and M2 , Holotype (V 14038) ; 2. r M1 (V 14039. 1) ; 3. r M2 (V 14039. 2) ; 4. r M3 (V 14039. 3) ; 5. l M3 (V 14039. 4) ; 6. l m1 (V 14039. 5) ; 7. l m2 (V 14039. 6) ; 8. l m3 (V 14039. 7) ; 9. r m1 (V 14039. 8) ; 10. r m2 (V 14039. 9) ; 11. r m3 (V 14039. 10)

The samples of this taxon from the other localities at Lantian are relatively small. Except for an m1 from Loc. 19 and another m1 from Loc. 13 , all the specimens fall within the range exhibited by the material from the type locality both as to size and pattern. The two first lower molars are bigger than those of Loc. 12. In addition , the labial branch of the anteroloph on the M2s from Loc. 19 is relatively weaker.

Comparison and discussion　The specimens described correspond in morphology to the diagnosis of *Abudhabia* as emended by de Bruijn (1999) : The m1 always has the posterior cingulum developed as an isolated cusp. The M2 and m2 have remnants of the anterior cingulum. Cusp-pairs of the M1 , M2 and m2 form transverse ridges. The m1 has alternating main cusps and an anteroconid with a posterolabially directed crest as in most cricetids.

The Lantian gerbil is smaller than the type species *Abudhabia baynunensis* (de Bruijn and Whybrow , 1994) . It differs from the latter in having less rounded cusps on molars , narrower anterocone(id) and closed connection of cusp-pairs on M1 and m1 , a remnant of longitudinal crest in some of the first two molars (especially on M2 and m2 , but there is no trace of longitudinal connection on the second molars of *A. baynunensis*) , in M2 and m2 being wider in posterior portion with a lophate labial branch of anteroloph(id) (not a cuspid as in *A. baynunensis*) , and in having a less

reduced M3 and m3.

Of the five named species of *Abudhabia* , the new taxon is most similar to *A. pakistanensis* in having anterior protruding on the labial cusps of M1 and M2 , showing remnant of longitudinal crest on M1 , the labial branch of anteroloph of M2 being lophate , but it differs from the latter in smaller size with weaker anterior cingulum and shorter anterior ridge on M1.

Abudhabia kabulense , considered to be a young species of the genus (Sen , 1983 ; Wessels , 1998) , resembles the new species in having poorly developed "posterocentral cusp "on M1 , an anterior protrusion of the labial cusps of M1 and M2 , and showing connections between cusp-pairs in well-worn M1 and M2. The two species differ by the larger size , the poor development of anteroloph (id) of M2 and m2 , and the more reduced M3 and m3 of *A. kabulense*.

Munthe (1987) described a gerbil named *Protatera yardangi* from the late Miocene of Sahabi , Libya , which was questioned by Flynn and Jacobs (1999) , and de Bruijn (1999) suggested referral to *Abudhabia*. Judging from Munthe 's description , *Abudhabia yardangi* has a remnant of longitudinal crest on the first molars. It is also similar to *A. baheensis* in having a poorly developed "posterocentral cusp "on M1 , but differs from the Chinese gerbil in larger size and more pronounced anterior cingulum on M1.

Abudhabia radinskyi is a rather derived taxon of *Abudhabia* , which is similar to *Tatera* in overall morphology of cheek teeth (Flynn et al. , 2003). The new species *A. baheensis* can be easily distinguished from the Afghanistan gerbil by its much smaller molar dimensions , having longitudinal connections , narrower anterocone (id) on the first molars , much stronger anterior cingula on the second molars , and less reduced M3 and m3.

Abudhabia baheensis from Lantian represents the first record of the subfamily Taterillinae in China. The genus shows great similarity in morphology among the species across northern Africa and Asia. The differences of smaller size , narrower anterocone (id) , less reduced longitudinal crest , more pronounced anterior cingulum on M2 and m2 , and less reduced M3 and m3 are here interpreted as primitive features. The evolutionary tendency of the genus *Abudhabia* seems to be characterized by an increase in size , a reduction of longitudinal connection , a great development of the anterior ridge in M1 , reduction of anterior cingulum in M2 and m2 , and simplicity of M3 and m3. The simple anterocone of M1 , the presence of remnant of longitudinal crest on the first molars , the distinct longitudinal connection and strong anterior cingulum on M2 and m2 , and the less reduced M3 and m3 of the new species might confirm the derivation of taterillines from myocricetodontines.

3 Conclusions

The Bahe Fauna contains two genera and three species of Gerbillidae. The presence of gerbillids in this fauna indicates an arid and open environment in the Lantian area , probably similar to the southern parts of Mongolia-Xinjiang Plateau today , where their relatives are still common. Such an environment is also suggested by the diversity of Dipodidae and the joint occurrence of Ochotonidae. It is likely that the climate at Lantian was drier during the early late Miocene than the present day.

At the present , it is difficult to assess a more precise age of the Lantian Fauna using the gerbils , because of the inadequate knowledge of biochronology for these animals. The presence of *Abudhabia* , however , suggests that the fauna is not older than late Miocene , because all the known *Abudhabia* are of late Miocene age (*A. pakistanensis* , *A. baynunensis* and *A. yardangi*) or near the Miocene/Pliocene limit (*A. kabulense*) in age. The Lantian sample seems to be the oldest for its more primitive characters in dental pattern. An earlier late Miocene age is also suggested by the presence of *Myocricetodon lantianensis* , which is close to *M. plebius* from the middle Miocene of Quantougou , Gansu , but more derived. In addition , *A. pakistanensis* is dated paleomagnetically to 8.6 Ma (L. J. Flynn , personal communication) , so the Lantian samples are likely older. This may be consistent with the joint occurrence of *Progonomys* (Qiu et al. , 2004) and *Protalactaga* that is

commonly known in the middle Miocene deposits of China.

Myocricetodon and *Abudhabia* are widely distributed in the late Miocene. They are groups known from northern Africa to western and southern Asia, and to eastern Asia (Fig. 3). The Lantian sample represents the eastern extension of its distribution. The presence of the Lantian gerbils not only indicates the close biogeographic affinities of East Asia with North Africa and Southwest Europe during the late Miocene, but also strongly suggests the existence of a xeric open region between eastern Asia and northwestern Africa, where interchange of small mammals, via the Arabian Peninsula was possible.

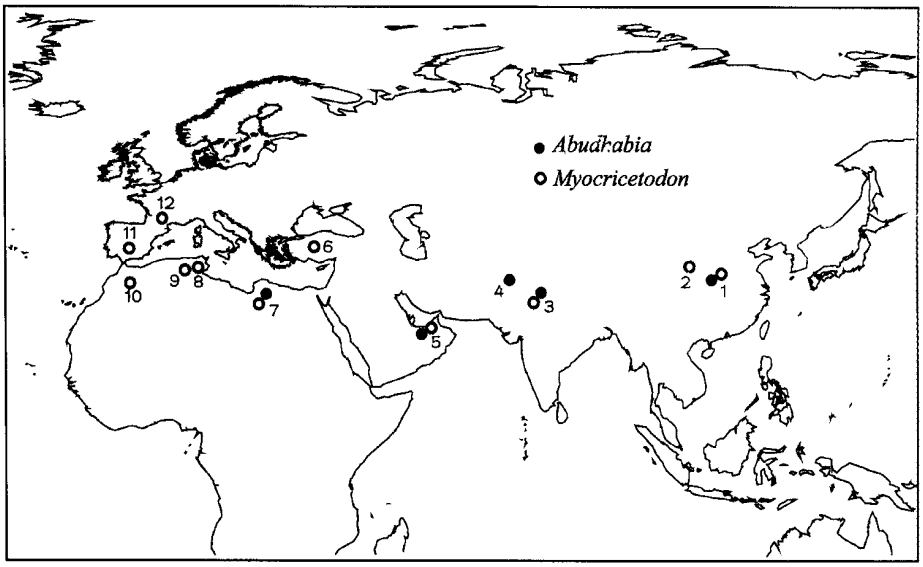

Fig. 3　Geographic distribution of *Myocricetodon* and *Abudhabia* discussed in the text Localities: 1. Lantian, China; 2. Quantougou, China; 3. Siwaliks of Pakistan; 4. Kabul Basin, Afghanistan; 5. Baynunah, United Arab Emirates; 6. Yeni Eskihisar, Turkey; 7. Sahabi, Libya; 8. Jebel Semmene, Tunisia; 9. Amama, Algeria; 10. Oued Zra, Morocco; 11. Pino Mojon, Spain; 12. La Tour, France

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References

Bruijn H de, 1999. A late Miocene Insectivore and rodent fauna from the Baynunah Formation, Emirate of Abu Dhabi, United Arab Emirates. In: Whybrow P, Hill A eds. Fossil Vertebrates of Arabian. Newhaven: Yale Univ Press. 186～197

Bruijn H de, Whybrow P J, 1994. A late Miocene rodent fauna from the Baynunah Formation, Emirate of Abu Dhabi, United Arab Emirates. Proc K Ned Akad Wet, Ser B, **97**(4): 407～422

Chaline J, Mein P, Petter F, 1977. Les grandes lignes d'une classification évolutive des Muroidea. Mammalia, **41**: 245～252

Fahlbusch V, Qiu Z D, Storch G, 1983. The Neogene mammalian faunas of Ertemte and Harr Obo in Nei Mongol, China. 1. Report on field work in 1980 and preliminary results. Scientia Sinica, Ser B, **26**: 205～224

Flynn L J, Jacobs L L, 1999. Late Miocene small-mammal faunal dynamics: The crossroads of the Arabian Peninsula. In: Whybrow P, Hill A eds. Fossil Vertebrates of Arabian. Newhaven: Yale Univ Press. 410～419

Flynn L J, Jacobs L L, Lindsay E H, 1985. Problems in muroid phylogeny. In: Luckett W P, Hartenberger J L eds. Evolutionary Relationships among Rodents. New York: Plenum Press. 589～616

Flynn L J, Winkler A J, Jacobs L L et al., 2003. Tedford's gerbils from Afghanistan. In: Flynn L J ed. Vertebrate Fossils and Their Context - Contributions in Honor of Richard H. Tedford. New York: Bull Am Mus Nat Hist, **279**: 603～624

Jaeger J J, 1977. Les Rongeurs du Miocene moyen et superieur du Maghreb. Palaeovertebrata, **8**(1): 1～166

Kaakinen A, Lunkka J P, 2003. Sedimentation of the late Miocene Bahe Formation and its implications for stable environments adjacent to Qinling mountains in Shaanxi, China. J Asian Earth Sci, **22**:67～78

Lavocat R, 1952. Sur une faune de mammifères Miocènes découverte àBeni-Mellal (Atlas Marocain). C R Acad Sci, **235**: 189～191

Lavocat R, 1961. Le gisement de vertebrés Miocène de Beni-Mellal (Maroc). Notes Mém serv géol Maroc, **155**: 52～67

Li C K(李传夔), 1981. Pontian sand-rat from Yushe Basin, Shansi. Vert PalAsiat(古脊椎动物学报), **19**(4): 321～326(in Chinese with English summary)

Li Q(李强), Wang X M(王晓鸣), Qiu Z D(邱铸鼎), 2003. Pliocene mammalian fauna of Gaotege in Nei Mongol (Inner Mongolia), China. Vert PalAsiat(古脊椎动物学报), **41**(2): 104～114

Lindsay E H, 1988. Cricetid rodents from Siwalik deposits near Chinji Village. Part I: Megacricetodontinae, Myocricetodontinae and Dendromurinae. Palaeovertebrata, **18**(2): 95～154

Munthe J, 1987. Small-mammal fossils from the Pliocene Sahabi Formation of Libya. In: Boaz N T, El-Arnauti A, Gaziry A W et al. eds. Neogene Paleontology and Geology of Sahabi. New York: Alan R Liss. 135～144

Qiu Z D(邱铸鼎), 2001. 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, Storch G, 2000. The early Pliocene micromammalian fauna of Bilike, Inner Mongolia, China (Mammalia: Lipotyphla, Chiroptera, Rodentia, Lagomorpha). Senckenbergiana lethaea, **80**(1): 173～229

Qiu Z D, Zheng S H, Sen S et al., 2003. Late Miocene micromammals from the Bahe Formation, Lantian, China. In: Reumer J W, Wessels W eds. Distribution and migration of Tertiary mammals in Eurasia. Deinsea, **10**: 443～453

Qiu Z D(邱铸鼎), Zheng S H(郑绍华), Zhang Z Q(张兆群), 2004. Murids from the late Miocene Bahe Formation, Lantian, Shaanxi. Vert PalAsiat(古脊椎动物学报), **42**(1): 67～76

Schaub S, 1934. Über einige fossile Simplicidentaten aus China und der Mongolei. Abh Schweiz Pal Ges, **54**:1～40

Sen S, 1983. Rongeurs et lagomorphs du gisement Pliocène de Pule-e Charkhi, basin de Kabul, Afghanistan. Bull Mus Natl Hist Nat, Sect C: Sci Terre, Ser 4, **5**: 33～74

Teilhard de Chardin P, 1926. Mammifères Tertiaires de Chine et de Mongolie. Ann Paléont, **15**:1～52

Tong H, 1989. Origine et évolution des Gerbillidae (Mammalia, Rodentia) en Afrique du Nord. Mém Soc Géol, **155**: 1～115

Tong H, Jaeger J J, 1993. Muroid rodents from the Middle Miocene Fort Ternan Locality (Kenya) and their contribution to the phylogeny of Muroids. Palaeontographica, **229**: 51～73

Wang Y X(王应祥), 2003. A complete checklist of mammal species and subspecies in China - A taxonomic and geographic reference. Beijing: China Forestry Publishing House. 1～394(in Chinese with English summary)

Wessels W, 1998. Gerbillidae from the Miocene and Pliocene of Europe. Mitt Bayer Staatsslg Paläont hist Geol, **38**: 187～207

Wessels W, 1999. Family Gerbillidae. In: Rossner G E, Heissig K eds. The Miocene Land Mammals of Europe. Munchen: Verlag Pfeil. 395～400

Wessels W, Ünay E, Tobien H, 1987. Correlation of some Miocene faunas from Northern Africa, Turkey and Pakistan by means of Myocricetodontinae. Proc K Ned Akad Wet, Ser B, **90**(1): 65～82

Young C C, 1927. Fossil Nagetiere aus Nord-China. Paleont Sin, Ser C, **5**(3): 1～82

Zhang Z Q(张兆群), 1999. Pliocene micromammal fauna from Ningxian, Gansu Province. In: Wang Y Q, Deng T eds. Proc VII Ann Meet Chinese Soc Vert Paleont(第七届中国古脊椎动物学学术年会论文集). Beijing: China Ocean Press. 167～177 (in Chinese with English summary)

Zhang Z Q(张兆群), Gentry A W, Kaakinen A et al., 2002. Land mammal faunal sequence of the late Miocene of China: new evidence from Lantian, Shaanxi Province. Vert PalAsiat(古脊椎动物学报), **40**(3): 166～178

Zheng S H(郑绍华), Zhang Z Q(张兆群), 2000. Late Miocene-Early Pleistocene micromammals from Wenwanggou of Lingtai, Gansu, China. Vert PalAsiat(古脊椎动物学报), **38**(1): 58～71(in Chinese with English summary)