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# Late Miocene micromammals from the Bahe Formation, Lantian, China

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A micromammalian assemblage from the Bahe Formation of Lantian, Shaaxi, China is reported in the present paper. This Bahe association consists of 17 species referred to ten families, of which at least one third are new genera of Dipodidae, Cricetidae and incertae familiae, and two genera are new for the fossil record in China (*Abudhabia* and *Progonomys*). It seems likely that the rodent component shows a mixture of elements found elsewhere in European, African and Asian rodent faunas. The association represents a new step in the sequence of micromammalian faunas of the Chinese Neogene, with an age of early late Miocene (early Baodean, correlated, in European terms, with late Vallesian-early Turolian or MN9-11 equivalent). The Bahe association reflects a generally drier open steppe environment during the early late Miocene than that which characterized earlier and later intervals.

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## INTRODUCTION

Lantian is a county outside Xi'an, the capital city of Shaaxi Province. It borders the south-eastern edge of the city. Cenozoic deposits in this area are extensively developed and bear abundant mammalian fossils. Biostratigraphic investigations in this area started at the end of 1950s, and the stratigraphic sequence of the deposits was established in the early 1960s (Liu *et al.* 1960; Jia *et al.* 1966). The Neogene Bahe Formation is the most fossiliferous horizon in the Lantian Tertiary sedimentary units. Intensive excavations were carried out in 1963 and 1964, and more than 20 forms of mammals were documented from this formation, but only an indeterminate species of *Erinaceus* represented small mammals so far (Liu *et al.* 1978).

A joint research project on the Neogene, supported by the Chinese Academy of Sciences and the Finnish Academy of Sciences, resumed field studies in 1997 after a long hiatus. Since then, cooperative investigations concentrated mainly on the Bahe Formation along the southern bank of the Bahe River, to the west of the county seat, were done for each field season. Preliminary results from the fieldworks of 1997 and 1998 were presented by Zhang *et al.* (1999). One of the most remarkable achievements in the field seasons of 1997-2000 is the great expansion of the micromammalian record in the Bahe Formation. Nearly 300 specimens representing 17 taxa were collected, mainly by screen washing about 20 tons of sediments from ten localities (Fig. 1). Collections made

in these field campaigns have not only added new fossil taxa for the Lantian area, but also enriched our knowledge of small mammals in the Neogene of China.

The Bahe Formation, about 300 m thick, comprises mainly fluvio-lacustrine deposits represented most commonly by a series of brownish or red-yellowish conglomerates, sandstones and sandy mudstones. The formation is unconformably overlain by a series of dark reddish and brownish yellow clays and sandstones or conglomerates (the Lantian Formation), and the lower part of the formation in the working area is covered by Quaternary deposits in the work area. The fossil localities are in different levels from different sections of the formation (Zhang *et al.* 1999). For detail of the geological background of the formation, the reader is referred to coming papers by our Finnish colleagues. Associated with the small mammals are larger mammals, fish, amphibians and reptiles, and freshwater mollusks and charophytes in some localities. Remarks on the fossil small mammals collected from the Bahe Formation in the last four field seasons are given and related items of the association are discussed

in the present paper. We are pleased to dedicate this effort to Dr. Hans de Bruijn for his outstanding contribution to the study of fossil small mammals and for his works we have greatly respected.

## TAXONOMY

Order Insectivora  
Family Soricidae

### **Soricinae gen. et sp. indet.**

This indeterminate soricine is represented by eight specimens including one mandibular fragment with m1-2 from Localities 12 and 19. Teeth are not pigmented. The upper incisor is slightly fissident. The M2 is short and wide, having a pronounced hypocone and distinct posterior emargination, but lacking a paraloph and metaloph. The m1 and m2 are relatively short with a narrowly opened talonid basin and a low sharp entoconid. The two teeth do not bear an entocristid. The soricine seems to differ from all shrews known from the Neogene of China, and we leave any more precise assignment within the Soricinae undetermined.

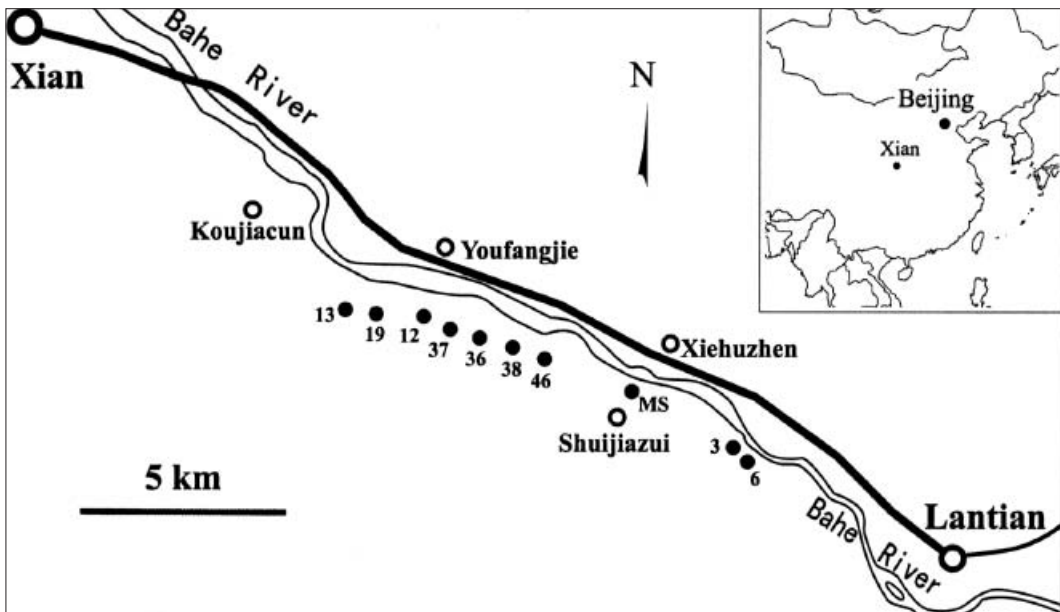


Figure 1 Map of the fossil localities in the Lantian area, China.

**Soricidae gen. et sp. indet. 1 and 2**

A mandibular fragment with damaged m1 from Locality 38 and an upper incisor from Locality 46 suggest the occurrence of two additional soricids in the collections. The upper incisor is not fissident and is distinctly larger than that of the indeterminate soricine from Loc. 12, and the damaged m1 is smaller than that of Loc. 12. The material is not good enough to allow any further identification below the level of family.

Order Rodentia

Family Aplodontidae

**?Pseudaplodon sp.**

A very worn M1 from Locality 6 is questionably assigned to the genus *Pseudaplodon*. The specimen is morphologically comparable to the corresponding tooth of *P. asiaticus* from Ertemte, Inner Mongolia, but much smaller. Systematic position of the taxon remains undetermined.

Family Sciuridae

**Eutamias sp.**

The genus *Eutamias* is commonly known from the Neogene deposits of northern China (Qiu 1991, 1996; Qiu & Storch 2000). Twenty-one specimens from Localities 6, 3, 13, 19, 46, MS-8, 36, including a fragmentary upper jaw and a lower jaw, are identified as an indeterminate species of this genus. It is similar in morphology to *E. ertemtensis* from Ertemte, Harr Obo and Bilike, and to the extant *E. sibiricus*, but distinct in larger size.

**Sciurotamias sp.**

Dental features such as the heavily built cheek teeth with compressed metaloph and an individual metacone in M1/2, and the posteriorly expanded m3, place the ten isolated teeth from Locality 19 and a damaged M1/2 from Locality 38 in this endemic genus of Sciuridae. It resembles the extant *S. forresti* and *S. davidianus* (more the former than the latter), but differs from both in the less expanded proto-

ne in upper molars and smaller size.

**Sciurus sp.**

The third sciurid recognized in the collection is represented by a mandibular fragment with m2-3 from Locality 36. The specimen is referred to *Sciurus* on the basis of the tooth morphology of recent tree squirrels, i.e. the larger size, the low but robust principal cusps, the relatively square outline and well developed mesoconid and mesostylid of m2.

Family Dipodidae

**Protalactaga major Qiu, 1996**

*Protalactaga* is an *Allactaga*-related dipodid genus known from the middle Miocene of Quantougou (Hsienshuiho), Gansu, and Tunggur, Inner Mongolia, in China (Young 1927; Qiu 1996, 2000), of Jebilet in Morocco (Jaeger 1977b), and probably of Bayraktepe in Turkey (Ünay 1981). Twenty-three isolated teeth from Localities 6, 12, 19, MS-14 fall in both size and morphology within the range exhibited by those of *P. major* from Quantougou and Tunggur. The main differences of the Lantian specimens are the more reduced M3 and m3.

**Paralactaga sp.**

A fragment of M1 or M2 from Locality 19 and a M3 from MS-36 represent the occurrence of this genus, which was previously known from the late Miocene, especially the uppermost Miocene and the Pliocene of northern China (Zheng & Li 1981; Fahlbusch *et al.* 1983; Qiu & Storch 2000; Zhang & Zheng 2000).

**Dipodidae gen. et sp. nov.**

This is the third Bahe dipodid and is represented by two m1 from Locality 19. It is comparable in the morphology of m1 to the extant three-toed jerboas, such as *Dipus*, *Paradipus*, *Scirtopoda* and the fossil genus *Sminthoides*, but its size is much smaller than the latter taxa. Detailed study may refer the specimens to a new genus and species, repre-

sending a rather primitive *Dipus*-related jerboa. Family Zapodidae

***Lophocricetus* cf. *L. gansus* (ZHENG & LI, 1982)**

The genus *Lophocricetus* is widespread in the late Miocene and early Pliocene deposits of northeastern Asia, and it might have been derived from a *Heterosminthus*-like ancestor (Schlosser 1924; Savinov 1970; Qiu 1985; Qiu & Storch 2000). Two dental patterns, the *L. grabaui*-type and the *L. pusillus*-type, can be recognized in this genus. One maxillary fragment with M1 and 24 isolated teeth from Localities 19 and MS12 demonstrate the presence of one taxon in this collection with *L. grabaui*-type of teeth and distinct entostyle in all the M1. In tooth morphology and size, this taxon is comparable to *L. gansus* from Songshan, Gansu, and Shala, Inner Mongolia, but much smaller than *L. grabaui* from Ertemte and Harr Obo.

Family Cricetidae

**Cricetidae gen. et sp. nov.**

Forty-three specimens including a maxillary and a mandibular fragment from Localities 6, 12, 19, 30, 38, MS4, 8 and 21 are assigned to a cricetid, which has a *Cricetulus*-like dental pattern with robust cusps, marked and bilobed anterocone on M1, simple anteroconid on m1, undeveloped mesoloph(id)s on molars. Further study may demonstrate these specimens as a new genus and species probably related to the endemic *Sinocricetus* of northern China.

Family Gerbillidae

***Myocricetodon* cf. *M. trecki* JAEGER, 1977**

*Myocricetodon* is quite diversified, with more than 10 species recognized in northern and eastern Africa, western and southern Asia (Lavocat 1952, 1961; Jaeger 1977a,b; Wessels *et al.* 1987; Wessels 1996, 1999; Lindsay 1988; Tong & Jaeger 1993). It is also

known from the middle Miocene of Quantougou, Gansu (Qiu 2001). Six teeth, including complete M1 and m1 from Localities 6, 12 and 19 are referred to the genus. It is characterized by the development of a 'new' longitudinal crest on the molars, the absence of accessory cusps in M1, and simple anterocone on M1 and anteroconid on m1. These features are similar to those of *Myocricetodon trecki* from Africa (Jaeger 1977b).

***Abudhabia* sp. nov.**

Forty-four specimens, including a maxillary fragment with M1-2, from Localities 6, 12, 13, 19 and 37, correspond in structure to the diagnosis of *Abudhabia* as proposed by de Bruijn and Whybrow (1994): M1 and m1 with postero-central cusp; M2 and m2 with remnants of the anterior cingulum; main cusps of M1, M2 and m2 forming transverse ridges; main cusps of m1 alternating; enterocone of upper molars absent. *Abudhabia* is a gerbillid rodent previously known from the late Miocene of Pakistan, and the early Pliocene of Afghanistan and Abu Dhabi (Sen 1983; Wessels 1999). The occurrence of this genus at Lantian represents the eastern extension of its distribution and the first record in China. The taxon from Bahe is more primitive than *Abudhabia kabulense* from Afghanistan and *A. baynunensis* from Abu Dhabi in its smaller size and having remnant longitudinal connections between cusp-pairs in some specimens.

Family Muridae

***Progonomys* cf. *P. cathalai* SCHAUB, 1938**

*Progonomys* is currently considered to be the oldest European murid (MN9-MN11) and the ancestor of most European Miocene murids. Nevertheless, there are different interpretations as for the definition of the genus (Mein *et al.* 1993; Aguilar & Michaux 1996; Van Dam 1997). Murid species from southern Asia, previously described as *Progonomys*

*debruijni* from Siwaliks (Jacobs 1978) and *P. yunnanensis* from Yunnan (Qiu & Storch 1990), have been excluded from *Progonomys* by Mein *et al.* (1993). It seems to be reasonable to exclude the Lufeng murids from this genus on the basis of the possession of a distinct connection between t4 and t8, a weak t7 in 20% of M1, t9 close to t6, and the presence of tma and strong labial cingulum on m1. Eighty-one isolated teeth from Localities 12, 19, 38, 13, 6, 46 and MS21, 36, 40 are referred to the genus *Progonomys* as most of their characters fit the diagnosis of *P. cathalai*, e.g. M1 t6 separated from t9, t4 connected to t8 by a low crest, the absence of t7, and three-rooted M1; m1 with a very small tma or no tma, and a narrow labial cingulum.

Incertae familiae

#### **Incertae familiae gen. et sp. indet.**

A semihypsodont M1 and a M2 from Locality 13, with simple occlusal structures, is assigned to an uncertain family. The M1 has two lingual and three buccal anticlines, one lingual and two buccal synclines, and the M2 has two lingual and two buccal anticlines, one lingual and one buccal syncline. The lingual synclines are anteriorly directed in M1 and M2. The anterior buccal syncline is slightly anteriorly directed, whereas the posterior one is posteriorly directed in M1. The two teeth cannot be referred to any known family. An undescribed fragmentary skull with similar dental pattern, but larger size, was reported from Gansu, China, which may be grouped together with the Bahe specimens and possibly form a new family of Rodentia after further investigation in the future.

Order Lagomorpha  
Family Ochotonidae

#### ***Ochotona* cf. *O. lagreli* SCHLOSSER, 1924**

*Ochotona lagreli* and *O. minor* are commonly known from the late Neogene deposits of North China (Qiu 1987; Qiu & Storch 2000).

A p3 and two molariform teeth from Locality 12 is similar to *O. lagreli* from Ertemte in size and morphology.

## **DISCUSSION**

### **Composition**

Small mammals are represented by nearly 300 specimens, including 17 lower taxa from ten families and three orders are recovered from ten localities in the Bahe Formation (Table 1). Among them at least one third are new, including new genera of Dipodidae, Cricetidae and incertae familiae, and two genera are new records for China (*Abudhabia* and *Progonomys*). Table 1 shows the preliminary list and the occurrence of the micromammalian associations from localities in the Bahe Formation.

A majority of the specimens (amounting to 80%) and most taxa (accounting for 70%) come from two localities (12 and 19) in the Bahe Formation. The two localities have many forms in common. Differences in taxonomic composition between them are: the absence of sciurids, two dipodids and *Lophocricetus* at Locality 12; the lack of *Ochotona* at Locality 19. These differences are probably due to inadequate sampling. Nevertheless, the common occurrence of most forms in the two localities seems to indicate that Locality 12 and Locality 19 are close in time. Material and taxa are rather scarce in other localities. Although some of those localities may produce a taxon that is unknown in Localities 12 or 19, such as *?Pseudaplodon* at Locality 6 or an indeterminate taxon of Incertae Familiae at Locality 13, they yield mostly taxa present in the two main localities. Preliminary morphologic comparison on the same elements from different localities does not yet indicate distinct differences. Detailed taxonomic investigation of single groups or genera may reveal minor differences among these localities in age and ecology, but it is considered inadvisable to treat them as representing more than one faunal unit at present.

The Bahe association is characterized by

Table 1 List of the Bahe micromammalian assemblage by locality.

Taxa	Localities									
	12	19	38	13	6	3	37	46	36	MS
Insectivora										
Soricidae										
1 <i>Soricinae</i> gen. et sp. indet.	*	*								
2 <i>Soricidae</i> gen. et sp. indet. 1			*							
3 <i>Soricidae</i> gen. et sp. indet. 2								*		
Rodentia										
Aplodontidae										
4 ? <i>Pseudaplodon</i> sp.					*					
Sciuridae										
5 <i>Eutamias</i> sp.		*		*	*	*		*		*
6 <i>Sciurotamias</i> sp.		*	*							
7 <i>Sciurus</i> sp.									*	
Dipodidae										
8 <i>Protalactaga major</i>	*	*			*					*
9 <i>Paralactaga</i> sp.		*								*
10 <i>Dipodidae</i> gen. et sp. nov.		*								
Zapodidae										
11 <i>Lophocricetus</i> cf. <i>L. gansus</i>		*								*
Cricetidae										
12 <i>Cricetidae</i> gen. et sp. nov	*	*	*		*					
Gerbillidae										
13 <i>Myocricetodon</i> cf. <i>M. trecki</i>	*	*			*					
14 <i>Abudhabia</i> sp. nov.	*	*		*	*		*			*
Muridae										
15 <i>Progonomys</i> cf. <i>P. cathalai</i>	*	*	*	*	*			*		*
Incertae familiae										
16 <i>Incertae familiae</i> gen. et sp. indet.				*						
Lagomorpha										
Ochotonidae										
17 <i>Ochotona</i> cf. <i>O. lagreli</i>	*									



Table 2 Ranges of genera from Bahe in Miocene localities of North China.

Taxa	Miocene						Pliocene
	Tunggurian	Baodean					Yushean
	MN 8	9	10	11	12	13	14
	Tunggur	Amuwusu	Shala	Songshan	Ertemte	Har Obo	
	Quantougou		Lufeng	Baode	Mahui		
<i>Eutamias</i>	.....			.	.	.....	
<i>Sciurotamias</i>						.	
<i>Sciurus</i>						.....	
<i>Protalactaga</i>	.....						
<i>Paralactaga</i>							
<i>Lophocricetus</i>							
<i>Myocricetodon</i>	.....						
<i>Ochotona</i>							

the dominance of myomorph rodents. Insectivore, bat and lagomorph taxa are either absent or extremely rare. Compared to well-documented fossil faunas in North China, the Bahe association does not seem to represent a complete assemblage of micromammals for the area and the time of its origin. This is probably due to a bias in fossil accumulation and to the smaller amount of sediment processed.

**Age of the association**

The possibly incomplete representation of the microfauna confines our comparison of the Bahe association with the Miocene micromammalian faunas of North China (Zheng & Li 1982; Qiu 1996, 2000; Qiu & Wang, 1999; Flynn *et al.* 1997; Zhang & Zheng 2000). All genera known from the Bahe association can be found in the faunas ranging in age from middle Miocene to late Miocene (Table 2). The Bahe association is characterized by its mixture of genera, which used to be considered as key elements for dating middle and late Miocene faunas in the Chinese biochronology. It has most of the families and two or

three genera (*Eutamias*, *Protalactaga* and *Myocricetodon*) in common with the middle Miocene Tunggur fauna of Inner Mongolia and Quantougou fauna of Gansu (Tunggurian or equivalent to Astaracian, MN8 of European Land Mammalian age), as well as the early late Miocene Amuwusu fauna of Inner Mongolia (early Baodean or MN9 equivalent). Nevertheless, the appearance of Muridae, the joint occurrence of *Paralactaga*, *Lophocricetus*, *Abudhabia* and *Ochotona*, and the derived characters of the third upper and lower molars in *Protalactaga major*, suggest that the Bahe association is distinctly younger than the Tunggur and Quantougou faunas, even younger than the Amuwusu Fauna. The Bahe association also shows close affinities to the late Miocene Shala and Ertemte faunas of Inner Mongolia, the Mahui fauna of Shanxi, and the Songshan fauna of Gansu (Baodean, MN11-13). It shares *Eutamias*, *Lophocricetus*, *Paralactaga* and *Ochotona* with the Ertemte or Mahui faunas. However, the Bahe association is obviously older than these faunas because of the presence of *Protalactaga*, *Myocricetodon* and

Epoch	Europe		China	
	Mammal Units	MN	Mammal Units	Local faunas
Pliocene	Ruscinian	15	Yushean	Gaozhuang
		14		Bilike Harr Obo
Miocene	Turolian	13	Baodean	Ertemte
		12		Mahui
		11		Songshan
	Vallesian	10		Shala Lufeng
		9		Bahe
		8		Amuwusu
Astaracian	8	Tunggurian	Quantougou	
	7		Tunggur	

Figure 2. Proposed correlations between European and Chinese Mammal Units, and position of Chinese micromammalian faunas in the middle Neogene.

*Progonomys*. The Shala and Songshan faunas are comparable to the Bahe association by having *Lophocricetus*, *Paralactaga* and *Ochotona* in common, but still somewhat younger than the latter in the absence of *Progonomys*, *Myocricetodon* and *Protalactaga*. In addition, certain genera, such as *Sicista*, *Sminthoides*, *Sinocricetus*, *Nannocricetus*, *Kowalskia*, and *Prosiphneus* that are commonly known in the Ertemte Fauna, are numerous at Shala but notably absent at Bahe. The Bahe assemblages appear

to represent a new component in the sequence of micromammalian faunas of the Chinese Neogene, which represents a transition between middle and late Miocene faunas. The association is most probably attributable to the early Baodean of the Chinese land mammal ages, and can be correlated, in European terms, with MN10. This is supported by the joint appearance of *Progonomys* cf. *P. cathalalai* and *Myocricetodon* cf. *M. trerki* in the assemblages, which share an evolutionary grade similar to *P. cathalalai* and *M. trerki* of



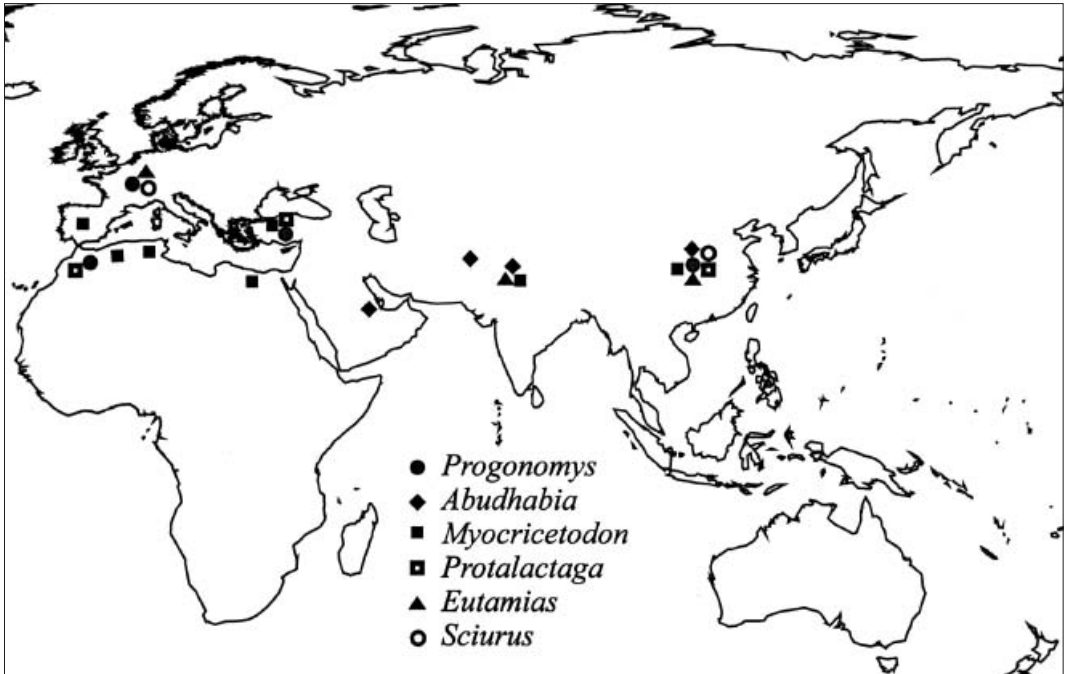


Figure 3 Occurrences in the Old World of genera known from the Bahe Formation.

Europe and North Africa. Nevertheless, it cannot be excluded that the Bahe association interval represented a stable fauna that started at MN9 and lasted into MN11 (Fig. 2).

### Biogeographic relationships

Except for *Sciurotamias* and *Lophocricetus*, which are endemic to East Asia, other recognized rodent genera suggest that the Lantian area had relationships to Europe, Africa, southwestern Asia and Indian subcontinent. Four of the eight genera (*Eutamias*, *Sciurus*, *Myocricetodon*, and *Progonomys*) occur in the European Miocene/Pliocene, three or four (*Protalactaga*, *Myocricetodon*, *Abudhabia* and *Progonomys*) are recorded from Africa and southwestern Asia, and three or four genera (*Eutamias*, *Abudhabia*, *Myocricetodon* and *Progonomys*) show affinity with the Indian subcontinent. It seems likely that the rodent association from the Bahe Formation consists of a mixture of faunal elements from northeastern Asia and southwestern Asia, northern Africa and southern Europe (Fig. 3).

This strongly suggests dispersal or immigration of small mammals among these continents during the early late Miocene.

### Paleoecology

Including previously collected Erinaceidae, all 11 certain families in the Bahe association survive today in the northern part of China. Except the eurytopic families, all have either a Holarctic or Palearctic distribution (*i.e.* Aplodontidae in the western coast of North America, Zapodidae restricted to Holarctic Region, and Dipodidae, Cricetidae, Gerbillidae and Ochotonidae mainly distributed over the Palearctic Region). None of them, however, is confined to the present tropical or subtropical areas of South China or to the Oriental Region. It is clear that the Bahe association reflects a faunal distribution like the temperate region in China, but unlike the exact faunal situation of the present day Lantian area. The diversity of Dipodidae, the presence of Gerbillidae and Ochotonidae, generally indicate a steppe or desert environment, or at least a dry and open environment,

similar to the southern parts of Mongolia-Xinjiang today, where their relatives are still common. This may be true also for the cricetids, the zapodid, and some of the sciurids. It is likely that the climate at Lantian was drier during the early late Miocene than in earlier and later intervals.

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## REFERENCES

- Aguilar, J.P. & Michaux, J., 1996 - The beginning of the age of Murinae (Mammalia: Rodentia) in southern France - *Acta Zoologica Cracoviensia* 39 (1): 35-45
- De Bruijn, H. & Whybrow, P.J., 1994 - A late Miocene rodent fauna from the Baynunah Formation, Emirate of Abu Dhabi, United Arab Emirates - *Proceedings Koninklijke Nederlandse Akademie van Wetenschappen* 97 (1): 407-422
- Fahlbusch, V., Qiu, Z.D. & Storch, G., 1983 - Neogene mammalian fauna of Ertemte and Harr Obo in Nei Mongol, China - Report on field work in 1980 and preliminary results - *Scientia Sinica B*, 26 (2): 205-224
- Flynn, L.J., Wu, W.Y. & Downs, W.R., 1997 - Dating vertebrate microfaunas in the late Neogene record of Northern China - *Palaeogeography Palaeoclimatology Palaeoecology* 133: 227-242
- Jacobs, L.L., 1978 - Fossil rodents (Rhizomyidae & Muridae) from Neogene Siwalik deposits, Pakistan - *Museum Northern Arizona Press, Bulletin* 52: 1-103
- Jaeger, J.J., 1977a - Rongeurs (Mammalia, Rodentia) du Miocène de Beni Mellal - *Palaeovertebrata* 7 (4): 91-125
- Jaeger, J.J., 1977b - Les Rongeurs du Miocène moyen et supérieur du Maghreb - *Palaeovertebrata* 8 (1): 1-66
- Jia, L.P., Zhang, Y.P., Huang, W.P., Tang, Y.J., Ji, H.X., You, Y.Z., Ding, S.Y. & Huang, X.S., 1966 - The Cenozoic of Lantian, Shaanxi - *Proceedings Conference Cenozoic of Lantian, Shaanxi*, Science Press: 1-31
- Lavocat, R., 1952 - Sur une faune de mammifères Miocènes découverte à Beni-Mellal (Atlas Marocain) - *Comptes Rendus de l'Académie des Sciences Paris* 235: 189-191
- Lavocat, R., 1961 - Le gisement de vertébrés Miocène de Beni-Mellal (Maroc) - *Notes et Mémoires du Service Géologique du Maroc* 155: 52-67
- Lindsay, E.H., 1988 - Cricetid rodents from Siwalik deposits near Chinji Village. Part I: Megacricetodontinae, Myocricetodontinae and Dendromurinae - *Palaeovertebrata* 18 (2): 95-154
- Liu, T.S., Ding, M.L. & Gao, F.Q., 1960 - The stratigraphic sections of Cenozoic between Xian and Lantian - *Scientia Geologica Sinica* 2 (4): 199-208
- Liu, T.S., Li, C.K. & Zhai, R.J., 1978 - Pliocene vertebrates of Lantian, Shensi - *Professional Papers on Stratigraphy and Palaeontology*, 7: 149-200
- Mein, P., Martin, S.E. & Agusti, J., 1993 - *Progonomys* Schaub, 1983 and *Huerzelerimys* gen. nov. (Rodentia); their evolution in Western Europe - *Scripta Geologica* 103: 41-64
- Qiu, Z.D., 1985 - The Neogene mammalian faunas of Ertemte and Harr Obo in Inner Mongolia (Nei Mongol), China. 3. Jumping mice (Rodentia: Lophocricetinae) - *Senckenbergiana Lethaea* 66 (1/2): 39-67
- Qiu, Z.D., 1987 - The Neogene mammalian faunas of Ertemte and Harr Obo in Inner Mongolia (Nei Mongol), China. 6. Hares and Pikas (Lagomorpha: Leporidae and Ochotonidae) - *Senckenbergiana Lethaea* 67 (5/6): 325-399
- Qiu, Z.D., 1991 - The Neogene mammalian faunas of Ertemte and Harr Obo in Inner Mongolia (Nei Mongol), China. 8. Sciuridae (Rodentia) - *Senckenbergiana Lethaea* 71 (3/4): 223-255
- Qiu, Z.D., 1996 - Middle Miocene micromammalian fauna from Tunggur, Nei Mongol - Beijing: Science Press, 216 pp.
- Qiu, Z.D., 2000 - Insectivore, dipodoidean and lagomorph from the middle Miocene Quantougou Fauna of Lanzhou, Gansu - *Vertebrata Palasiatica* 38 (4): 287-302

- Qiu, Z.D., 2001 - Glirid and gerbilled rodents from the middle Miocene Quantougou Fauna of Lanzhou, Gansu - *Vertebrata PalAsiatica* 39 (4): 299-306
- Qiu, Z.D. & Storch, G., 1990 - New murids (Mammalia: Rodentia) from the Lufeng hominoid locality, late Miocene of China - *Journal of Vertebrate Paleontology* 10 (4): 467-472
- 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. & Wang, X.M., 1999 - Small mammal faunas and their ages in Miocene of central Nei Mongol (Inner Mongolia) - *Vertebrata PalAsiatica* 37 (2): 120-139
- Savinov, P.R., 1970 - Jerboas (Dipodidae, Rodentia) from the Neogene of Kazakhstan - in: *Material on evolution of terrestrial vertebrates - Akademia Nauk USSR, Otdel Obshch. Biol.*, 91-134 (in Russian)
- Schlosser, M., 1924 - Tertiary vertebrates from Mongolia - *Palaeontologica Sinica C* 1 (1): 1-119
- Sen, S., 1983 - Rongeurs et Lagomorphes du gisement Pliocène de Pule-e Charki, Bassin de Kabul, Afghanistan - *Bulletin du Muséum National d'Histoire Naturelle*, 4 serie, section C (1): 33-74
- 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
- Ünay, E., 1981 - Middle and upper Miocene rodents from the Bayraktepe Section (Canakkale, Turkey) - *Proceedings Koninklijke Nederlandse Akademie van Wetenschappen B*, 84 (2): 217-238
- Van Dam, J., 1997 - The small mammals from the upper Miocene of the Teruel-Alfambra region (Spain): Paleobiology and paleoclimatic reconstructions - *Geologica Ultraiectina*, 156: 1-204
- Wessels, W., 1996 - Family Gerbillidae - pp. 395-400, in: Rössner, G.E. & Heissig, K. (eds.) - *The Miocene Land Mammals of Europe* - Verlag Dr. F. Pfeil, München
- Wessels, W., 1996 - Myocricetodontinae from the Miocene of Pakistan - *Proceedings Koninklijke Nederlandse Akademie van Wetenschappen* 99 (3-4): 253-312
- Wessels, W., Ünay, E. & Tobien, H., 1978 - Correlation of some Miocene faunas from Northern Africa, Turkey and Pakistan by means of Myocricetodontinae - *Proceedings Koninklijke Nederlandse Akademie van Wetenschappen* 90 (1): 65-82
- Young, C.C., 1927 - Fossile Nagetiere aus Nord-China - *Palaeontologica Sinica* 3 (3): 1-82
- Zhang, Z.Q. & Zheng, S.H., 2000 - Late Miocene-early Pliocene biostratigraphy of Loc. 93002 Section, Lingtai, Gansu - *Vertebrata PalAsiatica* 38 (4): 274-286
- Zhang, Z.Q., Zheng, S.H., Liu, L.P., Fortelius, M., Lunkka, J.P., Kaaknen, A. & Selanne, L., 1999 - Biostratigraphic study on the Bahe Formation - pp. 55-60, in: *Proceedings VII Annual Meeting Chinese Society of Vertebrate Paleontology*, China Ocean Press
- Zheng, S.H. & Li, Y., 1982 - Some Pliocene lagomorphs and rodents from Loc. 1 of Songshan, Tianzu Xian, Gansu Province - *Vertebrata PalAsiatica* 20 (1): 35-44

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