THE EOMYIDAE IN ASIA: BIOGEOGRAPHY, DIVERSITY AND DISPERSALS

YURI KIMURA1,2,*, ISAAC CASANOVAS-VILAR2, OLIVIER MARIDET3,4, DANIELA C. KALTHOFF5, THOMAS MÖRS6, YUKIMITSU TOMIDA1

1 Department of Geology and Paleontology, National Museum of Nature and Science, 4-1-1 Amakubo, Tsukuba, Ibaraki, 305-0005, Japan; e-mail: ykimura.research@gmail.com.
2 Institut Català de Paleontologia Miquel Crusafont, ICTA-ICP. Edifici Z. Carrer de les Columnes, s/n., Campus de la Universitat Autònoma de Barcelona, E-08193 Cerdanyola del Vallès, Barcelona, Spain.
3 JURASSICA Museum, Route de Fontenais 21, CH-2900 Porrentruy, Switzerland.
4 Département des Géosciences, Université de Fribourg, Chemin du Musée 6, CH-1700 Fribourg, Switzerland.
5 Department of Zoology, Swedish Museum of Natural History, P.O. Box 50007, SE-104 05 Stockholm, Sweden.
6 Department of Palaeobiology, Swedish Museum of Natural History, P.O. Box 50007, SE-104 05 Stockholm, Sweden.
*corresponding author

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Abstract: In Asia, the first find of an eomyid rodent was reported almost one century after the first studies of the family Eomyidae in North America and Europe. Since then, eomyid rodents have been increasingly found in Asia particularly over the past two decades. Here, we review the Asian record of this family at the genus level. Currently, 22 species within 14 genera were reported from Asia, including seven endemic genera and rare materials of apeomyine eomyids. Eomyids emphasize the palaeogeographic importance of Asia in considering intercontinental dispersal events of small mammals. With newly compiled data for Asian eomyids, we also compare genus-level diversity trends through time among North America, Europe, and Asia. Despite data standardizations limited with respect to potential biases in the fossil record, we found that the Asian eomyid diversity closely follows ecological shifts induced by climate changes. In general, Asian eomyid genera disappeared earlier than their European counterparts. We suggest that this pattern is not dictated by differences in the quality of the fossil record and is related to the expansion of drier habitats over large areas of Asia.

Key words: Rodentia, Eomyidae, palaeobiogeography, intercontinental dispersal, Valley of Lakes, Nei Mongol, Inner Mongolia, Junggar Basin, endemism

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Introduction

The Eomyidae is an extinct family of small to medium-sized rodents, which are presumed to be phylogenetically close to geomyoid rodents (gophers, kangaroo rats) based on shared cranial characters (Wahlert 1978, Flynn 2008). Many of them are considered to have occupied similar niches to extant dormice, preferably inhabiting warm-temperate forest environments (Engesser 1999). However, eomyids probably occupied more ecological niches than dormice, as suggested by their more diverse dental morphology from bunodont to lophodont with increasing crown heights (Engesser 1999). Although most species of eomyid rodents are known based on isolated teeth only and a few mandible and skull fragments, two beautifully preserved specimens unearthed from the late Oligocene locality Enspel (Germany) evidence the great ecological disparity of this family. One of them, Eomys quercyi, preserves the outline of a patagium supported by a cartilage originating from the elbow, much like that of scaly-tailed flying squirrels (Anomaluridae), revealing that this rodent was a glider (Storch et al. 1996). The other specimen preserves soft body parts of Eomyodon volkeri, showing that the species is a generalised terrestrial form (Engler and Martin 2015).

In Asia, the first reported eomyid fossil is a right jaw belonging to a new species of the American genus Leptodontomys from the late Miocene of North China (Zheng and Li 1982). Almost one century had passed since the first studies of the Eomyidae in North America and Europe (Cope 1884, Schlosser 1884). In the 1990s, a handful of eomyid fossils had been found in North China and Kazakhstan, including Sympleokeomys zyasanicus, which marks the oldest occurrence (late Eocene) of the family in Asia (Emry et al. 1997), and Asian species of Eomys, Pseudoetheridomys,
and Eomyodon (Wang and Emry 1991, Lopatin 2000, Wang 2002). Meanwhile, in Japan, a small eomyid fossil was discovered in the early Miocene deposits of Gifu and identified as Pseudotheridomys sp. (Tomida and Setoguchi 1994). In the 2000s, Wu et al. (2006) erected the Asian genus Asianeomys and transferred the following species to it: the Asian species of Pseudotheridomys (P. asiaticus from Inner Mongolia, China, P. yanshini from Kazakhstan) and Eomyodon dangheensis from Gansu Province, China. To date, six species of Asianeomys have been recorded from North China (Wu et al. 2006, Maridet et al. 2011, Gomes Rodrigues et al. 2014, Qiu and Li 2016), Mongolia (Maridet et al. 2015), and Kazakhstan (Lopatin 2000), with recent finds of the richest material in Inner Mongolia, China (Qiu and Li 2016) and Central Mongolia (Maridet et al. 2015). Most recently, the Japanese material ascribed to Pseudotheridomys sp. was transferred to a new genus, Japaneomys, closely related but basal to Asianeomys (Kimura et al. 2019), and Omboomys was erected for a small-sized bunodont eomyid lacking mesoloph(id) from Mongolia (Maridet et al. 2015). Likewise, apeomyine eomyids were recently discovered in Asia although the reported materials include only one tooth of Apeomys from Sihong, Jiangsu Province, central East China (Qiu 2017) and a single tooth of Megapeomys from Kani, Gifu, central Japan (Tomida 2011). Discoveries of eomyid rodents have been centered in mid-high latitudes, which have been more intensively studied, but they also occur in southern regions. Currently, up to three endemic genera (Heteroeomys, Plesieomys, Yuneomys) were discovered from the hominoid-bearing sites in Lufeng, Yunnan Province, southwestern China (Qiu 2006, 2017). As summarised above, the fossil records in continental Asia and a locality in Japan have remarkably increased our understanding of the evolution and biogeography of the Eomyidae for the last two decades. Yet, no updated account has been published since the last review of Chinese eomyids by Qiu (1994). Here, we review the Asian record of eomyids at the genus level. For each genus, we provide a list of the included Asian species and main sites as well as a brief description of their dental characteristics including further considerations and remarks. Furthermore, we compiled taxonomic data for each species from a given locality based on original references and compared genus-level diversity trends of the family Eomyidae in North America, Europe, and Asia.

Material and methods

The first and last occurrences of all eomyid rodents were compiled for North America, Europe, and Asia in order to explore diversity dynamics of the family in each of these continents (Tab. 1). For North American taxa, data were taken from the Paleobiology Database (PBDB, downloaded on July 3, 2017 from https://paleobiodb.org/classic/displayDownloadGenerator) and updated to include the recent new findings reported by Flynn (2008), Korth (2008), and Korth and Samuels (2015). For European
Table 1. First and last occurrences of eomyid rodents at the genus level in Asia, Europe, and North America, corresponding to Text-fig. 10 and Appendix.

| Genus             | First occurrence (Ma) | Last occurrence (Ma) | Region   | Reference for min age | Reference for max age |
|-------------------|-----------------------|----------------------|----------|-----------------------|----------------------|
| Apeomys           | 16.9                  | 16.9                 | Asia     | Qiu (2017)            | Qiu (2017)            |
| Asianeomys        | 26.5                  | 18.4                 | Asia     | Qiu et al. (2013); Qiu and Li (2016) | Wang (2002); Wang et al. (2008); PBDB |
| Eomyomys          | 25.4                  | 25.4                 | Asia     | Wang and Emry (1991)  | Wang and Emry (1991)  |
| Heteroeromys      | 8.5                   | 8.5                  | Asia     | Qiu (2006)            | Qiu (2006)            |
| Japaneomys        | 18.5                  | 18.5                 | Asia     | Kimura et al. (2019)  | Kimura et al. (2019)  |
| Keramidomys       | 19.5                  | 6.4                  | Asia     | Qiu et al. (2013); Qiu and Li (2016) | Qiu et al. (2013); Qiu and Li (2016) |
| Leptodontomys     | 19.5                  | 6.2                  | Asia     | Qiu et al. (2013); Qiu and Li (2016) | Qiu et al. (2013); Qiu and Li (2016) |
| Ligerimys         | 19.5                  | 18.4                 | Asia     | Qiu et al. (2013); Qiu and Li (2016) | Qiu et al. (2013); Qiu and Li (2016) |
| Megapeomys        | 18.5                  | 18.5                 | Asia     | Takeuchi (1992); Tomida (2011); Mörs et al. (2016) | Takeuchi (1992); Tomida (2011); Mörs et al. (2016) |
| Omboomys          | 9.2                   | 9.2                  | Asia     | Maridet et al. (2015) | Maridet et al. (2015) |
| Pentabuneomys     | 19.5                  | 9.4                  | Asia     | Qiu et al. (2013); Qiu and Li (2016) | Qiu et al. (2013); Qiu and Li (2016) |
| Plesiomeromys     | 8.5                   | 8.5                  | Asia     | Qiu (2006)            | Qiu (2006)            |
| Symbolemomys      | 35.6                  | 35.6                 | Asia     | Emry et al. (1997); PBDB | Emry et al. (1997); PBDB |
| Yanuemys          | 8.5                   | 8.5                  | Asia     | Qiu (2006, 2017)      | Qiu (2006, 2017)      |
| Apeomys           | 23.2                  | 16.8                 | Europe   | Mörs and Flink (2018) | Maridet et al. (2013) |
| Eomyodon          | 24.3                  | 22.4                 | Europe   | Maridet et al. (2013) | Maridet et al. (2013) |
| Eomopades         | 16.8                  | 4.2                  | Europe   | Maridet et al. (2013) | Maridet et al. (2013) |
| Eomys             | 33.2                  | 23.1                 | Europe   | Maridet et al. (2010) | Maridet et al. (2013) |
| Estramomys        | 5.2                   | 2.2                  | Europe   | Maridet et al. (2013) | Maridet et al. (2013) |
| Keramidomys       | 15.3                  | 5.2                  | Europe   | Maridet et al. (2013) | Maridet et al. (2013) |
| Ligerimys         | 20.9                  | 16.8                 | Europe   | Maridet et al. (2013) | Maridet et al. (2013) |
| Megapeomys        | 18.4                  | 16.8                 | Europe   | Mörs and Flink (2018) | Maridet et al. (2013) |
| Pentabuneomys     | 18.4                  | 15.3                 | Europe   | Maridet et al. (2013) | Maridet et al. (2013) |
| Pseudotheridomys  | 25.0                  | 16.8                 | Europe   | Maridet et al. (2013) | Maridet et al. (2013) |
| Rhodanomys        | 23.7                  | 20.9                 | Europe   | Maridet et al. (2013) | Maridet et al. (2013) |
| Ritterneria       | 22.4                  | 20.1                 | Europe   | Maridet et al. (2013) | Maridet et al. (2013) |
| Adjidaumo         | 38.8                  | 33.6                 | North America | PBDB | PBDB |
| Arikaboseomys     | 22.6                  | 22.6                 | North America | PBDB | PBDB |
| Aulolothomys      | 38.8                  | 35.6                 | North America | PBDB | PBDB |
| Centimamonys      | 35.6                  | 35.6                 | North America | PBDB | PBDB |
| Cristajidaumo     | 38.8                  | 35.6                 | North America | PBDB | PBDB |
| Cupressimus       | 35.6                  | 35.6                 | North America | PBDB | PBDB |
| Kansassimos       | 7.6                   | 7.6                  | North America | PBDB | PBDB |
| Leptodontomys     | 28.6                  | 7.6                  | North America | PBDB | Korth (2008) |
| Litoyoderimys     | 38.8                  | 35.6                 | North America | PBDB | PBDB |
| Megapeomys        | 18.2                  | 18.2                 | North America | PBDB | PBDB |
| Metalajidaumo     | 33.6                  | 28.6                 | North America | PBDB | PBDB |
| Metanomias        | 43.3                  | 35.6                 | North America | PBDB | PBDB |
| Namatomys         | 35.6                  | 35.6                 | North America | PBDB | PBDB |
| Orelljadajidaumo  | 33.6                  | 33.6                 | North America | PBDB | PBDB |
| Paradajidaumo     | 38.8                  | 32.1                 | North America | PBDB | PBDB |
| Paranomatomys     | 35.6                  | 35.6                 | North America | PBDB | PBDB |
| Protajidaumo      | 43.3                  | 38.8                 | North America | PBDB | PBDB |
| Pseudotheridomys  | 25.6                  | 14.8                 | North America | PBDB | PBDB |
| Viejajidaumo      | 38.8                  | 38.8                 | North America | PBDB | PBDB |
| Yoderimys         | 35.6                  | 35.6                 | North America | PBDB | PBDB |
| Zemidontomys      | 35.6                  | 35.6                 | North America | PBDB | PBDB |
| Montanamus        | 35.3                  | 35.3                 | North America | Flynn (2008) | Flynn (2008) |
| Aquafriasomys     | 38.5                  | 38.5                 | North America | Flynn (2008) | Flynn (2008) |
| Apeomyoides       | 15.4                  | 15.4                 | North America | Flynn (2008) | Flynn (2008) |
| Comancheomys      | 7.1                   | 7.1                  | North America | Flynn (2008) | Flynn (2008) |
| Ronquillomys      | 6.0                   | 6.0                  | North America | Flynn (2008) | Flynn (2008) |
| Zetamys           | 25.6                  | 25.6                 | North America | PBDB | PBDB |
taxa, we utilized the dataset of Maridet et al. (2010, 2013), supplemented by Mörs and Flink (2018). We follow Engesser (1979) in considering Leptodontomys and Eomyops to be distinct genera although the validity of Eomyops is currently debated (Qiu 1994, Ruiz-Sánchez et al. 2009, Prieto 2012). For the Asian taxa, we compiled a detailed dataset based on the original literature (see Appendix). Age for upper and lower boundaries of MP and MN zones are taken from the Geologic Time Scale 2012 (Hilgen et al. 2012, Vandenberghe et al. 2012).

The median of the estimated range was used for the age of each fossil specimen. We excluded any entry whose age estimates range over 6 million years or identification is indeterminate at the species level. The choice of 6 million years for the quality control of the data is rather arbitrary to include the single occurrence of Asian Apeomys although age estimates are less than 3 million years for most of the localities. All genera but Zetamys, for which the age uncertainly of the only known locality is over 10 million years (Martin 1974), met the above criteria and were therefore included in the analysis. Genetic richness herein is represented by actual occurrences using a range-through approach in one million-year time bins. The time bins start at 45.5 Ma and end at 0.5 Ma. The upper limit of a bin is included, and the lower limit is excluded. For more sophisticated data standardisations, readers are directed to an excellent review about sampling bias and data more sophisticated data standardisations, readers are directed to an excellent review about sampling bias and data

Abbreviations

| Abbreviation | Description |
|--------------|-------------|
| MN           | Mammal Neogene zone for European land mammal age |
| MP           | Mammal Paleogene zone for European land mammal age |
| M or m       | Molar, the upper case for the upper dentition and the lower case for the lower dentition |
| P or p       | Premolar, the upper case for the upper dentition and the lower case for the lower dentition |
| IVPP         | Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China |
| IZ NAS RK    | Institute of Zoology, National Academy of Sciences, Republic of Kazakhstan |
| NHMW         | Museum of Natural History Vienna, Vienna, Austria |
| NMNS         | National Museum of Nature and Science, Tokyo, Japan |

Systematic palaeontology

A total of 47 eomyid genera have been described to date. Of these, fourteen genera are reported from Asia, and half of them are endemic to Asia or only known from the type locality. In this section, we review the Asian eomyids, especially focusing on the endemics with a brief description of diagnostic dental traits, locality occurrences (Text-fig. 1), and stratigraphic ranges (Text-fig. 2). The taxonomic data were newly compiled along with geological and biostratigraphical information in Appendix, which were also used to explore the eomyid diversity patterns in Asia in the last part of this study.

Family Eomyidae Winge, 1887
Subfamily Eomyinae Winge, 1887
Tribe Eomyini Winge, 1887

Genus Symplekomys Emry, Wang, Tjutkova et Lucas, 1997

Text-figs 1–3

Type species. Symplekomys zaysanicus Emry, Wang, Tjutkova et Lucas, 1997.

Included Asian species. The type and only species.

Dental characteristics. Medium-sized eomyid, apparently retaining P3 as in Yoderimyinae; branching mesoloph(id) and interconnecting lophules in synclines/synclinids II and III, forming complex bunolophodont patterns; no lingual part of the anteroloph; hypolophid connecting to posterolophid; presence of spurs in transverse loph(id) s.

Asian occurrences (age). For the type and only species, locality K10 in Zaysan Basin, Sunduk, Kazakhstan (Aksyir Formation, Ergilian, late Eocene).

Comments. The genus is peculiar compared to other known eomyids in having extremely complex occlusal patterns with interconnecting lophules in synclines/synclinids II and III as well as retaining P3 as in the subfamily Yoderimyinae (Emry et al. 1997). The authors note that the presence of P3 is a primitive condition in the Eomyidae and was independently retained in Symplekomys. Phylogenetic relationships of Symplekomys with other eomyids have not been resolved.

Genus Asianeomys Wu, Meng, Ye et Ni, 2006

Text-figs 1, 2, 4

Type species. Asianeomys junggarensis Wu, Meng, Ye et Ni, 2006.

Included Asian species. Asianeomys junggarensis, Asianeomys asiaticus, Asianeomys dangheensis, Asianeomys fahlbuschi, Asianeomys yanshini, Asianeomys engesseri. Asianeomys engesseri could be a junior synonym of A. fahlbuschi according to Qiu and Li (2016). Note that “Eomyodon” bolligeri from Kazakhstan possibly belongs to the genus Asianeomys (Maridet et al. 2015).

Dental characteristics. Bunolophodont; small to medium-sized eomyid; P4 with or without anteroloph; entoloph connecting to the posterior end of the protocone rather than protoloph, differing from Pseudotheridomys, so that the synline II is longer than the synline I; three-rooted p4 lacking anterocoonid; four roots on m1–m2; hypolophid connecting to the anterior arm of the hypoconid, differing from more posterior connection in Eomyops; mesoloph(id) usually long; hypolophid present on m3 (Wu et al. 2006, Qiu and Li 2016).

Asian occurrences (age). For A. junggarensis, localities XJ98035, XJ98024, XJ200209, Tiersihabahe of North Junggar Basin, China (Tiersihabahe mammal assemblage zone I, late Oligocene, 24.4 to 23.2 Ma by Meng
et al. 2006) (Wu et al. 2006). For *A. dangheensis*, locality XJ99005, North Junggar Basin, China (Suosuoquan Mammal assemblage zone II, early Miocene, 21.9 to 21.7 Ma by Meng et al. 2006) (Wu et al. 2006); 6 different sections (Del, Huch Teeg, Tatal Gol, Unkheltseg, Luuny Yas, Hotuline Teeg) within 660 km² in Central Mongolia (Valley of Lakes) (Loh Formation, local biozones C1, C1/D, D, late Oligocene to early Miocene, 25.6 to 21 Ma by Daxner-Höck et al. 2017) (Maridet et al. 2015); IVPP Loc. DH199904, Aksay Kazak Autonomous County, Gansu, China (Paoniuquan Formation, Tabenbulukian, 28.4 to 23 Ma) (Wang 2002, Wang et al. 2008). For *A. fahlbuschi*, locality XJ99005, North Junggar Basin, China (Suosuoquan mammal assemblage zone II, early Miocene, 21.9 to 21.7 Ma by Meng et al. 2006) (Wu et al. 2006); two sites located 40 km apart in central Inner Mongolia, China, Aoerban and Gashunyinadege in stratigraphic order (the lower red member of the Aoerban Formation to Gashunyinadege bed, late Xiejian to early Shanwangian, correlated to MN 2 – MN 3, 21.7 to 17.2 Ma) (Qiu and Li 2016). For *A. asiaticus*, IVPP Loc. 77048, Saint Jacques, Inner Mongolia, China (Wulangulage Formation, late Oligocene, 27.8 to 23 Ma) (Wang and Emry 1991).
A. yanshini, Altynshokysu locality, Aktyubinsk, Kazakhstan (Aral Formation, correlated with the Central Mongolian local biozone C, ~27.4 to ~25.6 Ma, by Bendukidze 2009) (Lopatin 2000). For A. engesseri, locality XJ99005, North Junggar Basin, China (Suosuoquan mammal assemblage zone II, early Miocene, 21.9 to 21.7 Ma by Meng et al. 2006) (Wu et al. 2006). For A. aff. engesseri, locality XJ200604, northern Xinjiang province, China (age close to Sihong and Gashunyindege localities, late early Miocene, ~17 to ~18 Ma, Deng 2006) (Maridet et al. 2011). For cf. Asianeomys bolligeri, 2 different sections within 10 km in central Mongolia (Valley of Lakes) (Local biozone C, late Oligocene, ~27.4 to ~26.5 Ma by Daxner-Höck et al. 2017) (Maridet et al. 2015). For “Eomyodon” bolligeri from Kazakhstan, North Aral Region (Altyn shokysu locality, bone bed I and II, Aral Formation, late Oligocene, correlated with the Central Mongolian local biozone C, ~27.4 to ~25.6 Ma by Bendukidze 2009) (Lopatin 2000).

C o m m e n t s. Wu et al. (2006) erected the genus Asianeomys for material from the Junggar Basin in Xinjiang, North China. They transferred all Asian species of eomyid rodents known at the time to the new genus: two species of Pseudotheridomys (”P.” asiaticus, ”P.” yanshini) and one species of Eomyodon (”E.” dangheensis). The Asian occurrence of Pseudotheridomys (particularly, ”P.” asiaticus, slightly earlier than the European occurrence of the genus) was once considered to be possible evidence for Asian origin of the genus (Korth 2008), but currently no valid species of Pseudotheridomys is reported from Asia. Because Asianeomys has Eomys-like upper dentition and Pseudotheridomys-like lower dentition, it is difficult to properly identify the genus when only small samples are available. To date, Asianeomys has been reported from North China, Mongolia, and Kazakhstan. The genus is more closely related to Keramidomys than Pseudotheridomys based on dental similarity to a basal species Keramidomys, K. fahlbuschi, recently discovered in Inner Mongolia, China (Qiu and Li 2016, Kimura et al. 2019).

Genus Eomys Schlosser, 1884

C o m m e n t s. Eomys orientalis is the only Asian species of Eomys. It was first discovered from the Oligocene of Inner Mongolia, China (Wang and Emry 1991). Wang and Emry (1991) pointed out that E. orientalis is similar to European Eomys in the more lingually extended synclines, whereas the species is also similar to North American Adjidaumo in having a weakly developed synclind IV. Overall, Eomys orientalis is most similar to E. antiquus, which represents the earliest occurrence (early Oligocene, MP 21) of the family in Europe (Maridet et al. 2010). Until recently, the record of Asian Eomys had been limited to the type locality with a handful of specimens described in Wang and Emry (1991). However, Maridet et al. (2015) recently reported new material provisionally assigned to Eomys cf. orientalis from the early Oligocene of Central Mongolia.

Genus Keramidomys Hartenberger, 1966

C o m m e n t s. Two species are known from Asia: K. fahlbuschi Qu, 1996 and K. magnus Qu et Li, 2016 (see Appendix). Keramidomys has been reported from multiple localities within an area of 13,000 km² in central Inner Mongolia, China. In addition, few specimens were found in Siberia (Russia), Valley of Lakes (Mongolia), and Xinjiang (China) (Appendix 1). The stratigraphic range of the genus is as long as that of cosmopolitan Leptodontomys in Asia, ranging from the Xiejian (correlated to MN 2 – MN 3, 21.7 to 17.2 Ma) to Baodean (correlated to MN 12 – MN 13,
7.4 to 5.3 Ma), geologically from the Aolerban Formation and Gashunyinadege bed to the Bilutu bed, represented by *K. fahlbuschi* (Qiu and Li 2016). The other species known from the region is *K. magnus*, which presents a shorter range than *K. fahlbuschi*, recorded in late Miocene local faunas equivalent in age to MN 9 to MN 13. *Keramidomys* is thought to have originated in East Asia and later dispersed into Europe (Mein 2009), considering the earlier occurrence of Asian *K. fahlbuschi*, which is generally less lophodont than European species (Qiu and Li 2016, Kimura et al. 2019). It first appears in the European record at MN 5 (Mein 2009), which postdate the regional climax of the eomyid diversity.

**Genus Leptodontomys Shotwell, 1956 or Eomyops Engesser, 1979**

**Comments.** The genera *Eomyops* and *Leptodontomys* may be synonyms. Many different European species had been long assigned to the North American genus *Leptodontomys* until Engesser (1979) erected the new genus *Eomyops* for the European forms which differ from *Leptodontomys* in details of the mandible morphology and the presence of two ridges on the enamel of the lower incisors. Yet, the validity of *Eomyops* has been questioned and is still debated because cheek teeth of both genera are remarkably similar (Qiu 1994, de Brujin et al. 2012). Generally, Asian species are ascribed to *Leptodontomys* (Qiu and Li 2016) or *Leptodontomys/Eomyops* (Mariedet et al. 2015) until lower incisors of Asian species are found to clarify their taxonomic attribution.

Two species are known from Asia: *Leptodontomys gansus* Zheng et Li, 1982 and *L. lii* Qiu, 1996 (Text-fig. 2, Appendix). *Leptodontomys gansus* was the first eomyid to be discovered in Asia (Zheng and Li 1982) and is represented by a right mandible with a complete set of cheek teeth. Later on, more specimens of the same species were discovered from nine localities in large areas within 32,500 km² in central Inner Mongolia, China (Qiu and Li 2016), stratigraphically ranging from the Aolerban Formation and the Gashunyinadege bed (correlated to MN 2 – MN 3, 21.7 to 17.2 Ma) to the Ertemte Formation (correlated to MN 13, 7.1 to 5.3 Ma). *Leptodontomys lii* was first found from the middle Miocene Moegen II locality in central Inner Mongolia, China (Qiu 1996), and later additional materials were found from older and younger deposits in the same areas, mostly overlapping with the stratigraphic occurrences of *L. gansus* except for the late late Miocene Ertemte2 and Harr Obo2 localities, where the latter species are present. *Leptodontomys lii* is similar in dental morphology to *L. gansus* but is distinguishable by larger tooth size with more bulbous main cusps and more pronounced mesoloph(id) with slightly higher crown (Qiu and Li 2016). A fossil of *Leptodontomys/Eomyops* sp. was also found in the local biozone D1/2 (late early Miocene) in Mongolia (Mariedet et al. 2015). A small m1/m2 fossil found in Olkhon Island (Lake Baikal, Siberia) was assigned to *Eomyops oppligeri* ENGESSER, 1990 based on its size and morphology (Daxner-Höck et al. 2013). However, the taxonomic assignment should be reconsidered because the fossil is also within the size range of and is comparable in morphology to *Leptodontomys gansus* as shown in fig. 72: 1 of Qiu and Li (2016).

Qiu (1994) noticed that middle to late Miocene Chinese *Leptodontomys* are intermediate between North American *Leptodontomys* and European *Eomyops* in dental traits on the lower molars and mandible shape. Therefore, Qiu (1994) suggested European *Eomyops* was derived from North American *Leptodontomys* species that dispersed through Asia although the first appearance of Chinese *Leptodontomys* in Tunggur (late middle Miocene), Inner Mongolia, was younger than the first appearance of European *Eomyops* (then, dated to the earliest middle Miocene, MN 5) when his study was published. Currently, fossils of Asian *Leptodontomys* have been discovered from early Miocene deposits such as the lower red member of the Aolerban Formation and the Gashunyinadege bed, correlated to MN 2 – MN 3, in Inner Mongolia, China (Qiu and Li 2016), and thus significantly older than the first European record of *Eomyops*, MN 4 of Morteral-20 A in Valencia, Spain (Ruiz-Sánchez et al. 2009). Owing to the series of discoveries in Inner Mongolia, *Leptodontomys* along with *Keramidomys* are the longest-ranging eomyids in Asia (and the same is true for Europe; see Engesser 1999).

**Genus Pentabuneomys Engesser, 1990**

**Comments.** The genus *Pentabuneomys* included a single species from Europe (*Pentabuneomys rhodanicus* HUGUENY and MEIN 1968); MN 3 to MN 4, early Miocene) and another from North America (*P. engesseri* KORTH, 2008, early Arikareean, late Oligocene) until the discovery of *Pentabuneomys fejfari*, which is currently its only Asian representative (Qiu and Li, 2016). *Pentabuneomys fejfari* was described based on the total of nearly 40 specimens from the early Miocene Lower Aolerban fauna/Gashunyinadege fauna (correlated to MN 2 – MN 3) and the late Miocene Amuwusu fauna (correlated to MN 9). *Pentabuneomys* was erected by Engesser (1990) to separate European “*Eomys*” *rhodanicus* from other *Eomys* species. *Pentabuneomys* differs from *Eomys* in having bulbous cusps with a large circular mesoconeni/mesoonid and the presence of a deeper valley between the hypolophid and the posterior cingulum (Engesser 1990, Korth 2008). Korth (2008) reported the first record of *Pentabuneomys* from North America. The North American species, *P. engesseri* is not only chronologically older but also more plesiomorphic than European *P. rhodanicus* in completely lacking the mesolophid and the ectolophid. Thus, it could be possible that the genus originated in North America and later dispersed into Europe through Asia in the late Oligocene to early Miocene. Korth (2008) suggested that *Pentabuneomys* was derived from a *Leptodontomys*-like ancestor with reduced lophs in cheek teeth. Qiu and Li (2016) also discussed the similarity between *Leptodontomys/Eomyops* and *Pentabuneomys* to suggest that Asian *P. fejfari* is intermediate in occlusal morphology between European *Eomyops* *hebeiseni* and *Pentabuneomys rhodanicus*. The phylogenetic relationships of *Pentabuneomys* in relation to the genera mentioned above is still uncertain.

**Genus Ligerimys Stehlin et Schaub, 1951**

**Comments.** Three specimens from early Miocene localities (equivalent to MN 2 – MN 3) in Inner Mongolia
Included Asian species. The type and only species.

**Dental characteristics.** Small-sized bunodont eomyid. It is clearly smaller than other Asian endemic genera such as *Asianeomys* and *Heteroeomys* and slightly smaller than *Japaeomys*. Characterized by a slender morphology and a low crown, but with cusp(id)s noticeably higher than the mid-portion of the tooth in antero-posterior view. Other noticeable characteristics are upper teeth missing mesoloph, whereas in lower teeth the mesolophid is rare and weakly developed (thus, the molars only have three syncline(id)s with the central one being much wider and larger than the others). M1/2 with trapezoidal outline and oblique, short longitudinal crest joining directly the metaconid to the posterior end of the protocone. p4s with oblique longitudinal crest joining the hypoconid with the metaconid or with the metaconid (but never with the protoconid).

Asian occurrences (age). For the type and only species, locality Builstyn Khudag, Mongolia (Tuy Gol Formation, local biozone E, late Miocene, younger than 13 Ma).

Comments. Late Miocene *Omboomys* is an endemic eomyid genus in the late Miocene of northeastern Asia. However, the origin of *Omboomys* is unknown due to the lack of an intermediate fossils between the late early Miocene and the late Miocene in the Valley of Lakes in Mongolia (Daxner-Höck et al. 2017). The general bunodont morphology, the small size and low crown along with the trapezoidal shape of the M1/2, and the curved longitudinal crest connecting to the protocone in P4–M1/2 suggest its closer phylogenetic affinity to *Leptodontomys/Eomyops* than any other genus of Eomyidae known in the Miocene of Eurasia. The disappearance of the mesoloph(id)s is also observed in other eomyid clades in the Miocene of Europe such as the *Rhodanomys-Ritteneria* clade or the *Keramidomys-Estramomys* clade (Engesser 1990, 1999). Considering the more likely affinity of *Omboomys* with *Leptodontomys/Eomyops*, the disappearance of the mesoloph[id]s seems to be a convergent evolution, resulting from a local evolutionary history leading to *Omboomys* in northeastern Asia.

**Genus Heteroeomys** Qiu, 2006

*Type species.* *Heteroeomys yunnanensis* Qiu, 2006.

**Genus Omboomys** Maridet, Daxner-Höck, Badamgarav et Göhlich, 2015

*Type species.* *Omboomys builstynensis* Maridet, Daxner-Höck, Badamgarav et Göhlich, 2015.
Included Asian species. The type and only species.

Dental characteristics. Bunodont; medium-sized eomyid, similar in size to *Asianeomys*, slightly larger than *Plesieomys* and within large size variation of *Eomyops*; main cusps symmetrically developed; lingual portion of the anteroloph greatly reduced; anteroloph weakly developed; syncline II longer than other synclines; mesolophid of medium length with minute terminal cuspule present; metaloph poorly developed; lingual syncline symmetrical; short anterolophid connecting to metalophid through a longitudinal crest; hypolophid variably absent or interrupted (modified from Qiu 2006).

Asian occurrences (age). For the type and only species, locality Shihuiba, Lufeng, Yunnan Province, China (Shihuiba Formation, late Miocene, not well dated but see Flynn and Qi 1982, Ni and Qiu 2002, Appendix); Leilao, Yuanmou, Yunnan Province, China (Xiaohe Formation, early Baodean, biostratigraphically around 9 Ma by Flynn and Qi 1982, Ni and Qiu 2002).

Comments. Eomyid rodents were only reported from the modern Palaearctic realm until a series of finds in the late Miocene hominoid localities, Shihuiba and Leilao, Yunnan Province in southwestern China, which is part of the modern Oriental realm (Qiu 2006) (Text-fig. 1). The Yunnan eomyids are represented by three endemic genera with bunodont tooth patterns: *Heteroeomys*, *Plesieomys*, *Yuneomys*. They not only demonstrate that eomyids were distributed in tropical forest environments of Asia but also suggest regionally unique evolutionary histories of Asian eomyid genera (modified from Qiu 2006). Qiu (2006) pointed out that *Plesieomys* is morphologically similar to *Pseudadjidaumo* and within large size variation of *Eomyops*; main cusps symmetrically developed; lingual portion of the anteroloph greatly reduced; anteroloph weakly developed; syncline II longer than other synclines; mesolophid of medium length with minute terminal cuspule present; metaloph poorly developed; lingual syncline symmetrical; short anterolophid connecting to metalophid through a longitudinal crest; hypolophid variably absent or interrupted (modified from Qiu 2006).

Asian occurrences (age). For the type and only species, locality Shihuiba, Lufeng, Yunnan Province, China (Shihuiba Formation, late Miocene, not well dated but see Flynn and Qi 1982, Ni and Qiu 2002, Appendix); Leilao, Yuanmou, Yunnan Province, China (Xiaohe Formation, early Baodean, biostratigraphically approximately 9 Ma after Flynn and Qi 1982, Ni and Qiu 2002).

Comments. Qiu (2006) pointed out that *Plesieomys* is morphologically similar to *Pseudadjidaumo* in cusp size, weakly developed loph(id)s, and closed synclines I and IV. The Yunnan specimens were assigned to a new genus because loph(id)s are less developed than in *Pseudadjidaumo*, which is known from the Mojave Desert in North America (Lindsay 1972). In *Plesieomys*, a mesoloph enlarged at the terminal point is considered to be a diagnostic trait.
Leptodontomys, new species of (Qiu 2006). However, it was seen Flynn and Qi 1982, Ni and Qiu 2002, Appendix). Only species, locality Shihuiba, Lufeng, Yunnan Province, from Qiu 2017; this study).

Dental characteristics. Bunodont; small ecomid, smaller or equivalent in size to Leptodonotomys and Eomyops; short mesophol; complete entoloph; small mesoconid; anterolophid connecting to the metalophid through a longitudinal crest at the midline of the tooth. Differing from the above genera in having m1/2 with metalophid and hypolophid less developed, short, and directed transversely; symmetrical arrangement of cuspids and lophids between the anterior and posterior lobes (i.e., metaconid, protoconid, anterolophid vs. entoconid, hypoconid, posterolophid); mesopholid absent (modified from Qiu 2017; this study).

Asian occurrences (age). For the type and only species, locality Shihuiha, Lufeng, Yunnan Province, China (Shihuiha Formation, late Miocene, not well dated but see Flynn and Qi 1982, Ni and Qiu 2002, Appendix).

Comments. The genus was originally described as a new species of Leptodonotomys (Qiu 2006). However, it was later transferred to a newly erected genus, Yuneomys (Qiu 2017). Thus, all of the Yunnan eomcid genera (Heteroemmys, Lesieemys, Yuneomys) are endemic to southwestern China although they are morphologically similar to Eomyops and Yuneomys. Scarce specimens of Yuneomys preclude accurate differential diagnosis, particularly in comparison with Eomyops and Leptodonotomys, which show considerable variation in cheek tooth morphology. The upper dentition of Yuneomys is in fact identical to that of the two genera. Here, we tentatively retain Y. pusillus encased in Yuneomys. Nevertheless, as stated above, we suggest that the validity of Yuneomys and Yuneomys should be reexamined, particularly taking into account the large variation in Eomyops and Leptodonotomys.

Subfamily Apeomyinae Fejar, Rummel et Tomida, 1998

Comments. The subfamily Apeomyinae, which contains Apeomys, Megapeomys, Apeomyoides, and Arkareemys is known based on extremely scarce materials and is restricted to the late Oligocene and early Miocene (Fahlbusch 1968, Korth 1992, Engesser 1999, Smith et al. 2006, Flynn 2008, Mörs and Flink 2018). Nevertheless, apeomyine emyids are Holarctic in distribution, occurring in Europe (Apeomys, Megapeomys), North America (Megapeomys, Apeomyoides, Arkareemys), and Asia (Apeomys, Megapeomys).

Genus Megapeomys Fejar, Rummel et Tomida, 1998

Comments. Megapeomys is phylogenetically closest to Apeomys (Engesser 1999). In the Asian record Megapeomys is as scarce as Apeomys and may predate it slightly. A single species of Megapeomys, M. repenningi, was described in Asia based on a single tooth from the early Miocene of central Japan (Fejar et al. 1998, Tomida 2011). Tomida (2011) noted that M. repenningi resembles contemporaneous European M. lavocati on occlusal morphology, but the former species is more basal in having a distal root unsplit. According to Mörs and Flink (2018), M. repenningi is similar in size to a second and larger European species, M. lindsayi, which is morphologically...
similar to *M. lavocati*. The single North American species of *Megapeomys, M. bobwilsoni*, is larger and more hypsodont, and the distal root is completely split into two separate roots.

**Genus Apeomys** Fahrbusch, 1968

Comments. In Asia, a high-crowned P4 specimen was discovered in 1994 from the late early Miocene Xiaocawan Formation in Sihong, Jiangsu Province, central East China. It was recently identified as the only Asian species of *Apeomys, A. asiaticus* Qu 2017 (Text-fig. 2, Appendix). Compared to European *A. tuerkheimae* and *A. oldrichi*, Asian *A. asiaticus* has more derived dental features such as the anteroloph fused with the protoloph, absence of the mesoloph, and the closed syncline III (Qu 2017).

### Biogeographic significance of Asian eomyids

Over the past two decades, more and more eomyid fossils have been discovered in East Asia and the Asian part of Russia. To date, 22 species within 14 genera were reported from Asia, including seven endemic genera and rare material of apeomyine eomyids from southwestern China and Japan (Text-fig. 2). The total number of eomyid genera in Asia is now equivalent to that in Europe. For most of the endemic genera, phylogenetic relationships and their evolutionary history are of high interest but remain uncertain. On the other hand, the other seven non-endemic genera emphasize biogeographic importance of Asia in intercontinental dispersal events. Interestingly, four of these genera (*Pentabuneomys, Leptodontomys/Eomysops, Apeomys, Megapeomys*) show Holarctic distributions. Based on chronological occurrence and dental morphology, *Pentabuneomys* and *Leptodontomys/Eomysops* show a unidirectional migration, dispersing from North America into Eurasia probably by the early Miocene. Apeomyine eomyids likely had higher dispersal ability, showing at least two intercontinental dispersal events. *Apeomys* most likely originated in North America and then migrated into Eurasia during the late Oligocene given that two more basal apeomyine eomyids (*Zophoapeomys, Proapeomys*) predate *Apeomys whistleri* in North America (Korth 2008, Korth and Samuels 2015). Later, the apeomyine *Megapeomys* dispersed into North America, as suggested by the occurrence of a more basal species of *Megapeomys* in Japan than in North America (Tomida 2011) and the presence of more derived apeomyid taxa (*Apeomyoides savagel*) in North America (Korth 2008, Korth and Samuels 2015). The remaining three genera of the Asian eomyids are *Eomys, Keramidomys*, and *Ligerimys*, all of which occurred in Europe as well. In Eurasia, *Eomys* represents the oldest-known eomyid genus (locality Möhren 19, Germany, MP 21; locality Ronzon, France, MP 21, earliest Oligocene; Maridet et al. 2010) and is therefore associated with the first dispersal event of eomyid rodents from North America into Europe (Fahrbusch 1973, 1979, Engesser 1999). In Asia, scarce material of *E. orientalis* has been recovered from the early to late Oligocene of Central Mongolia and Inner Mongolia, China (Wang and Emry 1991, Maridet et al. 2015). More evidence of early dispersals of eomyid rodents is expected from these areas. Given that recent phylogenetic analysis indicates that *Keramidomys* is related to the Asian endemics *Asianeomys* and *Japaneomys* (Kimura et al. 2019), *Keramidomys* likely originated in Asia and later dispersed westward. Asian *Ligerimys* is unique compared to other eomyids because its geographic range was mainly limited to western Europe before the discovery of early Miocene *L. asiaticus* (MN 2 – MN 3) in Inner Mongolia (Qiu and Li 2016). The occurrence of Asian *Ligerimys* suggests that this genus opportunistically dispersed eastward from Europe, seemingly without leaving diverse local descendants.

### Eomyid diversity through time with emphasis on Asia

Eomyid rodents originated in North America during the middle Eocene (Korth 1994) and then dispersed into Asia during the late Eocene (Emry et al. 1997) and into Europe by the early Oligocene (Engesser 1999). They were remarkably successful and widely distributed in the Holarctic but disappeared by the end of the Miocene in North America and by the early Pleistocene in Eurasia (Engesser 1999, Flynn 2008). Text-fig. 10 compares the occurrences of eomyid genera in the fossil record of North America, Europe, and Asia (Tab. 1). After the earliest occurrence of eomyid rodents in the middle Eocene (~43.3 Ma) of North America, eomyid rodent diversity steadily increased and achieved a high plateau by 39 Ma, lasting for ~3 million years. The increased diversity occurred during progressive global cooling in the late Eocene (Zachos et al. 2001). Taking singleton taxa into consideration, the highest peak of eomyid diversity occurred in the late Eocene (~36 Ma) (updated in this study; see also Korth 1994, Flynn 2008). Even though eomyids dispersed from North America during the late Eocene (Asia) and earliest Oligocene (Europe), their diversity was initially low outside North America (Text-fig. 10). In North America, eomyid diversity progressively declined across the Eocene-Oligocene boundary, coinciding with the onset of Antarctic glacialion and the first occurrence of permanent ice-sheets (Zachos et al. 2001). This was a time of major turnover events in mammal faunas, the so-called “Grande Coupure” (= the Great Cut) in Europe and Mongolian Remodelling in Asia (see Meng and McKenna 1988, Costa et al. 2011). Eomyid diversity continuously decreased and reached a low level in the early Oligocene, but it slightly bounced back in the late early Oligocene, counting singleton taxa. However, North American eomyids hit their lowest diversity during the major expansion of the Antarctic glacialion (i.e., Oi-2b glacial event) in the late Oligocene. Only a single genus, the ubiquitous *Leptodontomys*, survived the cooling event. After the Oi-2a and Oi-2b glaciation events at 28 Ma – 26.7 Ma (Wade and Pälike 2004), eomyid diversity in North America remained at a low level and did not recover even during the mid-Miocene Climatic Optimum (17 Ma to 15 Ma), whereas eomyids flourished both in Europe and Asia at that time (Text-fig. 10). They were apparently diverse and successful in the warm (tropical to subtropical) dense forest environments in the late Eocene of North America, and their rapid decline during the Oligocene coincides with the expansion of open habitats including dry woodlands and grasslands (Retallack 2001, Strömberg 2011).
In Eurasia, eomyid rodents diversified somewhat but were never as diverse as the late Eocene taxa of North America. They diversified sufficiently after their diversification and subsequent decline in North America. A singleton genus, *Symplokeomys*, from Kazakhstan is the only Eurasian representative contemporaneous with the highest eomyid diversity in North America (Text-figs 2, 10). *Eomys* is the earliest taxon to appear more persistently in the fossil record of Eurasia. Although the genus is more commonly known from the Oligocene of Europe (e.g., Comte and Vianey-Liaud 1987, Engesser 1990, Maridet et al. 2010), *Eomys* fossils, including those under provisional taxonomic assignments, have been reported from Mongolia (Daxner-Höck 2010, Maridet et al. 2015) in addition to the type locality of the only Asian species, *E. orientalis*, from Inner Mongolia (Wang and Emry 1991) (see Appendix). Eomyid rodents experienced their highest generic diversity during the middle to late Burdigalian stage in Eurasia. A remarkable peak is observed in Europe at 17 Ma (Engesser 1999), which corresponds to the beginning of the mid-Miocene Climatic Optimum (Zachos et al. 2001), whereas a slight increase of generic diversity predated the warming event in Asia (Text-fig. 10). In Europe, the subsequent decline in eomyid diversity coincides with the end of the mid-Miocene Climatic Optimum (Zachos et al. 2001), but complex biotic factors may also have played an important role. Particularly, “modern” cricetid rodents like *Democricetodon* and *Megacricetodon* dispersed into Europe.
at ~18 Ma and soon became major components of rodent faunas (Daams et al. 1988, Aguilar et al. 1999). These early cricetids, showing a generalized bunolophodont dentition, are considered to have been opportunists adapted to diverse environments including more arid habitats (Gómez Cano et al. 2017); however, they may also have competed with eomyids in more forested environments.

On the other hand, Asian eomyid diversity remained rather static during most of the Miocene, especially after the middle Burdigalian diversity peak (Text-fig. 10). The genera present in this interval are the long-ranging *Asianeomys*, *Keramidomys*, and *Leptodontomys*, which are well-represented in the intensively surveyed sections of Inner Mongolia (e.g., Qiu and Li 2016). Ecometric studies show that central East Asia was consistently more arid than Southern Europe throughout the Neogene (Eronen et al. 2010, Fortelius et al. 2014), which could have limited eomyid diversity.

By the end of the Pliocene, eomyid rodents disappeared in North America and Asia, whereas they survived until the early Pleistocene in northern Europe. Global climatic cooling resulted in the extension of grass-dominated ecosystems in the late Miocene (Quade and Cerling 1995, Cerling et al. 1997, Tipple and Pagani 2007), whereas in Europe, warm-temperate forest environments persisted in many areas and at higher latitudes although arid landscapes existed in the Mediterranean regions since the middle Miocene (Jiménez-Moreno and Suc 2007, but see Quan et al. 2014). The persistent warm-temperate forest environments may explain the much later extinction of eomyids in Europe. In Asia, even after extensive field efforts, no eomyid fossils have been found in Pliocene localities in Inner Mongolia, China (Qiu and Storch 2000). It seems reasonable that the earlier regional disappearance is a true signal in Inner Mongolia due to the ongoing aridification in central Asia linked to the intensification of the monsoon climate (e.g., An et al. 2001, Liu and Yin 2002, Biasati et al. 2010). However, considering the discovery of late Miocene eomyids (Qiu 2006, Qiu 2017) from Yunnan Province (southwestern China), it is possible that eomyid refuges existed during a certain time period in southern China or continental Southeast Asia. The exploration of new regions and the intensive sampling of known fossiliferous areas may eventually test such a hypothesis.

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## Appendix

Species occurrences of all eomyid rodents in Asia. Each entry represents a species from a single locality.

| Entry | Scientific Name | Country | Province/Region | City/Town (Geographic Region) | Fossil Locality | Lithostratigraphic Unit | Biostratigraphic Zone | Regional Biozone | Age (Ma) | Rationale for the age assignment | Biostratigraphic Zone | Regional Biozone | Age (Ma) | Rationale for the age assignment | References |
|-------|----------------|---------|-----------------|-------------------------------|-----------------|--------------------------|-----------------------|------------------|---------|---------------------------------|-----------------------|------------------|---------|---------------------------------|------------|
| 1     | Asianeomys asiaticus | China | Jiangsu | Shihong | Zhengji | Xiaosuowan Formation | Shanwangian | Upper boundary of MN 5 | Shanwangian | 14.2 | Upper boundary of MN 5 | 16.5 | Lower boundary of MN 4 | Qiu (2017) |
| 2     | Asianeomys asiaticus | China | Inner Mongolia | Ulaanbaatar | Ulaanbaatar | IVPP Loc. 77048 | Ulamhangy Formation | Shanwangian | 23.0 | Upper boundary of Chuanbian (= the Oligocene/Miocene boundary) | 23.0 | Lower boundary of Chuanbian | Wang and Emry (1991) |
| 3     | Asianeomys boldergii | Kazakhstan | Aktubinsk | Chelkar (North Asian Region) | Aktunskoye Formation | correlated to Central Mongolian local biozone C | 25.6 | Upper boundary of Central Mongolian local biozone C | 25.6 | Lower boundary of Central Mongolian local biozone C | Lopatin (2000); Bendiková (2009); Dusanek et al. (2017) for correlated age |
| 4     | Asianeomys danghenensis | China | Xinjiang | (Junggar Basin) | Xi99005 | Suosuoquan Formation | Xiejian | Suosuoquan mammal assemblage zone H | 21.7 | Magnetostratigraphy | Xiejian | Suosuoquan mammal assemblage zone H | 21.7 | Magnetostratigraphy | Meng et al. (2006); Wu et al. (2006); Bi et al. (2013) |
| 5     | Asianeomys danghenensis | Mongolia | (Valley of Lakes) | Del | Loh Formation | local biozone C1 | 24.2 | Magnetostratigraphy | local biozone C1 | 25.6 | Magnetostratigraphy | local biozone C1 | 25.6 | Magnetostratigraphy | Mao et al. (2015) |
| 6     | Asianeomys danghenensis | Mongolia | (Valley of Lakes) | Huncheng | Loh Formation | local biozone C1 | 24.2 | Magnetostratigraphy | local biozone C1 | 25.6 | Magnetostratigraphy | local biozone C1 | 25.6 | Magnetostratigraphy | Mao et al. (2015) |
| 7     | Asianeomys danghenensis | Mongolia | (Valley of Lakes) | Tatal Gol | Loh Formation | local biozone D | 24.2 | Magnetostratigraphy | local biozone D | 25.6 | Magnetostratigraphy | local biozone D | 25.6 | Magnetostratigraphy | Mao et al. (2015) |
| 8     | Asianeomys danghenensis | Mongolia | (Valley of Lakes) | Ushkuhse | Loh Formation | local biozone D | 21.0 | Faunal comparison with biozone D (the occurrence of Democricetodon sui) | local biozone D | 23.0 | Magnetostratigraphy | local biozone D | 23.0 | Magnetostratigraphy | Mao et al. (2015) |
| 9     | Asianeomys danghenensis | Mongolia | (Valley of Lakes) | Longyu | Loh Formation | local biozone D | 21.0 | Faunal comparison with biozone D (the occurrence of Democricetodon sui) | local biozone D | 23.0 | Magnetostratigraphy | local biozone D | 23.0 | Magnetostratigraphy | Mao et al. (2015) |
| 10    | Asianeomys danghenensis | Mongolia | (Valley of Lakes) | Hondoiling | Loh Formation | local biozone D | 21.0 | Faunal comparison with biozone D (the occurrence of Democricetodon sui) | local biozone D | 23.0 | Magnetostratigraphy | local biozone D | 23.0 | Magnetostratigraphy | Mao et al. (2015) |
| 11    | Asianeomys danghenensis | China | Aksu Kazakh Autonomous County, Gansu | Yandantu, Minzhu | IVPP Loc. DH199904 | Paoniuquan Formation | Tabenbulakian | Upper boundary of Tabenbulakian | Tabenbulakian | 23.0 | Upper boundary of Tabenbulakian | 25.6 | Lower boundary of Tabenbulakian | Wang (2002); Wang et al. (2008); PBDB |
| 12    | Asianeomys engesi | China | Xinjiang | (Junggar Basin) | Xi99005 | Suosuoquan Formation | Xiejian | Suosuoquan mammal assemblage zone H | 21.7 | Magnetostratigraphy | Xiejian | Suosuoquan mammal assemblage zone H | 21.7 | Magnetostratigraphy | Meng et al. (2006); Wu et al. (2006); Bi et al. (2013) |
| 13    | Asianeomys fahlbuschi | China | Inner Mongolia | Sonid Zaoki | Lower Aserbaid | Lower Red Mudstone Member, Aserbaid Formation | Xiejian (correlated to MN 3) | 17.2 | Upper boundary of MN 3 | Xiejian (correlated to MN 3) | 19.5 | Lower boundary of MN 3 | Qiu et al. (2013); Qiu and Li (2016) |
| 14    | Asianeomys fahlbuschi | China | Inner Mongolia | Sonid Zaoki | Gashunyinde | Gashunyinde Formation | Shanwangian | Correlated to MN 3 | Shanwangian | 17.2 | Upper boundary of MN 3 | 19.5 | Lower boundary of MN 3 | Qiu et al. (2013); Qiu and Li (2016) |
| 15    | Asianeomys fahlbuschi | China | Xinjiang | (Junggar Basin) | Xi99005 | Suosuoquan Formation | Xiejian | Suosuoquan mammal assemblage zone H | 21.7 | Magnetostratigraphy | Xiejian | Suosuoquan mammal assemblage zone H | 21.7 | Magnetostratigraphy | Meng et al. (2006); Wu et al. (2006); Bi et al. (2013) |
| 16    | Asianeomys jangiuzensis | China | Xinjiang | Tieersihabahe (Junggar Basin) | XJ98035 | Tieersihabahe Formation | Tabenbulakian | Tieersihabahe mammal assemblage zone I | Tabenbulakian | 23.2 | Magnetostratigraphy | Tabenbulakian | 25.4 | Magnetostratigraphy | Meng et al. (2006); Wu et al. (2006); Bi et al. (2013) |
| 17    | Asianeomys jangiuzensis | China | Xinjiang | Tieersihabahe (Junggar Basin) | XJ98024 | Tieersihabahe Formation | Tabenbulakian | Tieersihabahe mammal assemblage zone I | Tabenbulakian | 23.2 | Magnetostratigraphy | Tabenbulakian | 25.4 | Magnetostratigraphy | Meng et al. (2006); Wu et al. (2006); Bi et al. (2013) |
| 18    | Asianeomys jangiuzensis | China | Xinjiang | Tieersihabahe (Junggar Basin) | XJ200209 | Tieersihabahe Formation | Tabenbulakian | Tieersihabahe mammal assemblage zone I | Tabenbulakian | 23.2 | Magnetostratigraphy | Tabenbulakian | 25.4 | Magnetostratigraphy | Meng et al. (2006); Wu et al. (2006); Bi et al. (2013) |
| Entry | Scientific Name | Country | Province/ Region/ Prefecture | Fossil Locality | Lithostratigraphic Unit | Biostratigraphic Zone | Regional Biozone | Age (Ma) | Rationale for the age assignment | Biostratigraphic Zone | Regional Biozone | Age (Ma) | Rationale for the age assignment | References |
|-------|----------------|---------|-----------------------------|----------------|------------------------|----------------------|-------------------|----------|-------------------------------|----------------------|-------------------|----------|-------------------------------|------------|
| 19 | Asianeomys yunnanensis | Kazakhstan | Aktyubinsk | Chuluk (North Aral Region) | Atyshkohysky | Anal Formation | correlated Central Mongolian local biozone C | 25.6 | Upper boundary of Central Mongolian local biozone C | correlated Central Mongolian local biozone C | 27.4 | Lower boundary of Central Mongolian local biozone C | Lopatin (2000); Bendukidze et al. (2009); Dannen-Höck et al. (2017) |
| 20 | Asianeomys sp. | China | Xinjiang | (Junggar Basin) | XJ90005 | Suoosoquan Formation | Xiejian | Suoosoquan mammal assemblage zone II | 21.7 | Magnetostratigraphy | Xiejian | Suoosoquan mammal assemblage zone II | Meng et al. (2006); Wu et al. (2006); Bi et al. (2013) |
| 21 | Asianeomys sp. | China | Inner Mongolia | Ulanurals | UTL6 | Ulanurals Formation | correlated to Mongolian local biozone C | 24.2 | Upper boundary of Central Mongolian local biozone C | | 25.6 | Lower boundary of Central Mongolian local biozone C | Gomes Rodrigues et al. (2014) and references therein; Dannen-Höck et al. (2017) |
| 22 | Asianeomys aff. engesseri | China | Xinjiang | Uragin, Habahe (Junggar Basin) | XJ 200604 | | | 18.05 | Taxonomic comparison with the Siwoosuqan mammal assemblage zone II (the occurrence of Microdrommys orientalis) | | 21.9 | Taxonomic comparison with the Suoosoquan mammal assemblage zone II | Maized et al. (2011) |
| 23 | Asianeomys sp. | China | Xinjiang | Uragin, Habahe (Junggar Basin) | XJ 200604 | | | 18.05 | Taxonomic comparison with the Siwoosuqan mammal assemblage zone II (the occurrence of Microdrommys orientalis) | | 21.9 | Taxonomic comparison with the Suoosoquan mammal assemblage zone II | Maized et al. (2011) |
| 24 | Asianeomys bolligeri | Mongolia | (Valley of Lakes) | Taatsin Gol (right) | Loh Formation | local biozone C | 25.6 | Upper boundary of Central Mongolian local biozone C | local biozone C | 27.4 | Lower boundary of Central Mongolian local biozone C | Maized et al. (2015) |
| 25 | Asianeomys bolligeri | Mongolia | (Valley of Lakes) | Taatsin Gol (west) | Loh Formation | local biozone C | 25.6 | Upper boundary of Central Mongolian local biozone C | local biozone C | 27.4 | Lower boundary of Central Mongolian local biozone C | Maized et al. (2015) |
| 26 | Eomyopsiden sp. | China | Inner Mongolia | Quanshan District | IVPP Loc. 78018 | Walungalage Formation | 23.0 | Upper boundary of Chattian (= the Oligocene/ Miocene boundary) | | 27.8 | Lower boundary of Chattian | Wang and Emry (1991) |
| 27 | *Eomyops appligeri* | Russia | Siberia | Olkhon Island, Lake Baikal | Tagay | | | ~13 | Taxonomic comparison (roughly correlated to MN 7±4) | | ~13 | Taxonomic comparison (roughly correlated to MN 7±4) | Dannen-Höck et al. (2013) |
| 28 | Eomyops/ Lepidokononmys | Mongolia | (Valley of Lakes) | Ulaan Tolgoi | Loh Formation | local biozone D1/2 | 13.0 | *Ar/Ar age on basalt II layer | local biozone D1/2 | 15.97 | Miocene boundary | Maized et al. (2015) |
| 29 | Eomys orientalis | China | Inner Mongolia | Saint Jacques | IVPP Loc. 77049.2 | Walungalage Formation | 23.0 | Upper boundary of Chattian (= the Oligocene/ Miocene boundary) | | 27.8 | Lower boundary of Chattian | Wang and Emry (1991) |
| 30 | Eomys orientalis | China | Inner Mongolia | Quanshan District | IVPP Loc. 78018 | Walungalage Formation | 23.0 | Upper boundary of Chattian (= the Oligocene/ Miocene boundary) | | 27.8 | Lower boundary of Chattian | Wang and Emry (1991) |
| 31 | Eomys aff. orientalis | Mongolia | (Valley of Lakes) | Taatsin Gol (right) | Hasanda Gol Formation | local biozone B | 28.0 | *Ar/Ar age on basalt II layer | local biozone B | 31.5 | *Ar/Ar age on basalt II layer | Maized et al. (2015) |
| 32 | Eomys aff. orientalis | Mongolia | (Valley of Lakes) | Hasanda Gol | local biozone B | 28.0 | *Ar/Ar age on basalt II layer | local biozone B | 31.5 | *Ar/Ar age on basalt II layer | Maized et al. (2015) |
| 33 | Eomys cf. orientalis | Mongolia | (Valley of Lakes) | Taatsin Gol | Hasanda Gol Formation | local biozone A | 31.5 | *Ar/Ar age on basalt II layer | local biozone A | 33.9 | the Eocene/ Oligocene boundary | Maized et al. (2015) |
| 34 | Eomys sp. | Mongolia | (Valley of Lakes) | Taatsin Gol (right) | Hasanda Gol Formation | local biozone B | 28.0 | *Ar/Ar age on basalt II layer | local biozone B | 31.5 | *Ar/Ar age on basalt II layer | Maized et al. (2015) |
| 35 | Heteroeomys yunnanensis | China | Yunnan | Lufeng | Shishiaba | Shishiaba Formation | not well dated | Biostratigraphic comparison with Siwalik rhizomyid rodents by Flynn and Qiu (1982) but not well dated | not well dated | Biostratigraphic comparison with Siwalik rhizomyid rodents by Flynn and Qiu (1982) but not well dated | Flynn and Qiu (1982); Ni and Qiu (2002); Qiu (2006) |
| 36 | Heteroeomys yunnanensis | China | Yunnan | Yuanmou Leilao | Xiaode Formation | not well dated | Biostratigraphic comparison with Siwalik rhizomyid rodents by Flynn and Qiu (1982) but not well dated | not well dated | Biostratigraphic comparison with Siwalik rhizomyid rodents by Flynn and Qiu (1982) but not well dated | Flynn and Qiu (1982); Ni and Qiu (2002); Qiu (2006) |
| 37 | Japaneomys yamatoi | Japan | Gifu | Kani Dora | Nakamura Formation | 17.2 | Upper boundary of MN 3 | 19.8 | K-Ar dating in the upper Hachiyama Formation | | 21.3 | K-Ar dating in the upper Hachiyama Formation | Kimura et al. (2019) |
| Entry | Scientific Name | Country | Province/Region/Reference | County/City/Town (Geographic Region) | Fossil Locality | Lithostratigraphic Unit | Upper boundary | Lower boundary | Rationale for the age assignment | Rationale for the age assignment | References |
|-------|----------------|---------|---------------------------|-------------------------------------|----------------|------------------------|----------------|--------------|---------------------------------|---------------------------------|-----------|
| 38    | Keramidomys fahlbuschi | China Inner Mongolia | Sonid Zuogi | Lower Aoerban | Lower Red Mudstone Member, Aoerban Formation | Xiejian (correlated to MN 3) | 17.2 Upper boundary of MN 3 | Xiejian (correlated to MN 2) | 21.7 | Lower boundary of MN 2 | Qiu et al. (2013); Qiu and Li (2016) |
| 39    | Keramidomys fahlbuschi | China Inner Mongolia | Sonid Zuogi | Gashunyadage | Gashunyadage bed | Shannwanggian (correlated to MN 3) | 17.2 Upper boundary of MN 3 | Xiejian (correlated to MN 2) | 19.5 | Lower boundary of MN 3 | Qiu et al. (2013); Qiu and Li (2016) |
| 40    | Keramidomys fahlbuschi | China Inner Mongolia | Sonid Zuogi | Upper Aoerban | Upper Red Mudstone Member, Aoerban Formation | Shannwanggian (correlated to MN 3) | 14.2 Upper boundary of MN 3 | Xiejian (correlated to MN 2) | 19.5 | Lower boundary of MN 3 | Qiu et al. (2013); Qiu and Li (2016) |
| 41    | Keramidomys fahlbuschi | China Inner Mongolia | Sonid Youqi | H-X Highwat Road original mark 46 | Tunggur Formation | Tunggurian (correlated to MN 78/8) | 11.2 Upper boundary of MN 7/8 | Tunggurian (correlated to MN 78/8) | 12.9 | Lower boundary of MN 7/8 | Qiu et al. (2013); Qiu and Li (2016) |
| 42    | Keramidomys magnus | China Inner Mongolia | Sonid Zuogi | Balunhalagen | Balunhalagen bed | Shanwangjian (correlated to MN 15) | 7.6 Upper boundary of MN 11 | Shanwangjian (correlated to MN 9) | 9.5 | Lower boundary of MN 9 | Qiu et al. (2013); Qiu and Li (2016) |
| 43    | Keramidomys magnus | China Inner Mongolia | Sonid Zuogi | Bilatu | Bilatu bed | Baodean (correlated to MN 13) | 5.3 Upper boundary of MN 13 | Baodean (correlated to MN 12) | 7.6 | Lower boundary of MN 12 | Qiu et al. (2013); Qiu and Li (2016) |
| 44    | Keramidomys magnus | China Inner Mongolia | Sonid Zuogi | Amuwusu | Amuwusu bed | Shanwangjian (correlated to MN 9) | 9.9 Upper boundary of MN 9 | Shanwangjian (correlated to MN 9) | 11.2 | Lower boundary of MN 9 | Qiu et al. (2013); Qiu and Li (2016) |
| 45    | Keramidomys magnus | China Inner Mongolia | Sonid Zuogi | Shala | Shala bed | Baodean (correlated to MN 11) | 7.6 Upper boundary of MN 11 | Baodean (correlated to MN 10) | 9.9 | Lower boundary of MN 10 | Qiu et al. (2013); Qiu and Li (2016) |
| 46    | Keramidomys magnus | China Inner Mongolia | Sonid Zuogi | Balunhalagen | Balunhalagen bed | Baodean (correlated to MN 11) | 7.6 Upper boundary of MN 11 | Baodean (correlated to MN 10) | 9.9 | Lower boundary of MN 10 | Qiu et al. (2013); Qiu and Li (2016) |
| 47    | Keramidomys magnus | China Inner Mongolia | Sonid Zuogi | Bilatu | Bilatu bed | Baodean (correlated to MN 13) | 5.3 Upper boundary of MN 13 | Baodean (correlated to MN 12) | 7.4 | Lower boundary of MN 12 | Qiu et al. (2013); Qiu and Li (2016) |
| 48    | Keramidomys aff. schweizeri / K. aff. fahlbuschi | Russia Siberia | Oikhon Island, Lake Bileikol | Tagay | | | | | | | Dauzer-Hock et al. (2013) |
| 49    | Leptodontomys sp. | Mongolia (Valley of Lakes) | Ulaan Tolgoi | Loh Formation | Local biozone D1/2 | 13.0 *Ar/39Ar Age on basalt MB layer | 13.0 *Ar/39Ar Age on basalt MB layer | 13.0 *Ar/39Ar Age on basalt MB layer | 13.0 *Ar/39Ar Age on basalt MB layer | Qiu et al. (2013); Qiu and Li (2016) |
| 50    | Keramidomys sp. | China Xinjiang | Burqin, Habahe (Junggar Basin) | XJ 200604 | | | | | | | Maridet et al. (2015) |
| 51    | Lepidodontomys gansus | China Inner Mongolia | Sonid Zuogi | Gashunyadage | Gashunyadage bed | Shannwanggian (correlated to MN 3) | 17.2 Upper boundary of MN 3 | Xiejian (correlated to MN 2) | 19.5 | Lower boundary of MN 3 | Qiu et al. (2013); Qiu and Li (2016) |
| 52    | Lepidodontomys gansus | China Inner Mongolia | Sonid Youqi | H-X Highwat Road original mark 46 | Tunggur Formation | Tunggurian (correlated to MN 78/8) | 11.2 Upper boundary of MN 7/8 | Tunggurian (correlated to MN 78/8) | 12.85 | Lower boundary of MN 7/8 | Qiu et al. (2013); Qiu and Li (2016) |
| 53    | Lepidodontomys gansus | China Inner Mongolia | Sonid Zuogi | Balunhalagen | Balunhalagen bed | Shanwangjian (correlated to MN 11) | 7.6 Upper boundary of MN 11 | Shanwangjian (correlated to MN 9) | 9.5 | Lower boundary of MN 9 | Qiu et al. (2013); Qiu and Li (2016) |
| 54    | Lepidodontomys gansus | China Inner Mongolia | Sonid Youqi | Amuwusu | Amuwusu bed | Shanwangjian (correlated to MN 9) | 9.9 Upper boundary of MN 9 | Shanwangjian (correlated to MN 9) | 11.2 | Lower boundary of MN 9 | Qiu et al. (2013); Qiu and Li (2016) |
| 55    | Lepidodontomys gansus | China Inner Mongolia | Abag | Huizeghhe | Huizeghhe bed | Baodean (correlated to MN 11) | 7.6 Upper boundary of MN 11 | Baodean (correlated to MN 10) | 9.9 | Lower boundary of MN 10 | Qiu et al. (2013); Qiu and Li (2016) |
| 56    | Lepidodontomys gansus | China Inner Mongolia | Sonid Youqi | Shala | Shala bed | Baodean (correlated to MN 11) | 7.6 Upper boundary of MN 11 | Baodean (correlated to MN 10) | 9.9 | Lower boundary of MN 10 | Qiu et al. (2013); Qiu and Li (2016) |
| 57    | Lepidodontomys gansus | China Inner Mongolia | Sonid Zuogi | Bilatu | Bilatu bed | Baodean (correlated to MN 13) | 5.3 Upper boundary of MN 13 | Baodean (correlated to MN 12) | 7.4 | Lower boundary of MN 12 | Qiu et al. (2013); Qiu and Li (2016) |
| 58    | Lepidodontomys gansus | China Inner Mongolia | Huade | Ertemte2 | Ertemte Formation | Baodean (correlated to MN 13) | 5.3 Upper boundary of MN 13 | Baodean (correlated to MN 12) | 7.1 | Lower boundary of MN 13 | Qiu et al. (2013); Qiu and Li (2016) |
| 59    | Lepidodontomys gansus | China Inner Mongolia | Huade | Haer Qbo2 | Ertemte Formation | Baodean (correlated to MN 13) | 5.3 Upper boundary of MN 13 | Baodean (correlated to MN 12) | 7.1 | Lower boundary of MN 13 | Qiu et al. (2013); Qiu and Li (2016) |
| Entry | Scientific Name          | Country | Province/Region | City/Town | Geographic Region | Fossil Locality | Lithostratigraphic Unit | Upper boundary | Lower boundary | References |
|-------|-------------------------|---------|----------------|-----------|------------------|----------------|-------------------------|----------------|---------------|------------|
| 60    | *Leptodontomys vanus*   | China   | Gansu          | Songshan  | Tianshu Xian     | Loc. 1          | Lower Red Mudstone Member, AEROBAN Formation | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 13) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 61    | *Leptodontomys sp.*     | China   | Inner Mongolia | Sonid Zuoqi | Lower AEROBAN | Gashunyinadage bed | Shunmanzhang (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 62    | *Leptodontomys sp.*     | China   | Inner Mongolia | Sonid Zuoqi | Gashunyinadage bed | Shunmanzhang (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 63    | *Leptodontomys sp.*     | China   | Inner Mongolia | Sonid Zuoqi | H-X Highway Road original mark 46 | Tungur Formation | Tungur (correlated to MN 3) | Tungur (correlated to MN 3) | Tungur (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 64    | *Leptodontomys sp.*     | China   | Inner Mongolia | Sonid Zuoqi | Amouswu | Amouswu bed | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 65    | *Leptodontomys sp.*     | China   | Inner Mongolia | Sonid Zuoqi | Bahuininga | Bahuininga bed | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 66    | *Leptodontomys sp.*     | China   | Inner Mongolia | Abag | Huitinghe | Huitinghe bed | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 67    | *Leptodontomys sp.*     | China   | Inner Mongolia | Sonid Zuoqi | Shala | Shala bed | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 68    | *Leptodontomys sp.*     | China   | Inner Mongolia | Sonid Zuoqi | Bilatu | Bilatu bed | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 69    | *Leptodontomys sp.*     | China   | Yunnan         | Yuanzhou   | Loc. 5905 | not well dated | Biostratigraphic comparison with Siwalik rhizomyid rodents by Flynn and Q. (1982) | not well dated | not well dated | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 70    | *Leptodontomys sp.*     | China   | Inner Mongolia | Sonid Zuoqi | Lower AEROBAN | Lower Red Mudstone Member, AEROBAN Formation | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 71    | *Leptodontomys sp.*     | China   | Inner Mongolia | Sonid Zuoqi | Gashunyinadage bed | Shunmanzhang (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 72    | *Megacephomyom yunnanensis* | China   | Inner Mongolia | Sonid Zuoqi | Shala | Shala bed | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 73    | *Microtoomys baibarjasti* | Mongolia | (Valley of Lakes) | Buir bイン Khudug | Tungur Formation | local biozone E | Shunmanzhang (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 74    | *Pentabuneomys yunnanensis* | China   | Inner Mongolia | Sonid Zuoqi | Lower AEROBAN | Lower Red Mudstone Member, AEROBAN Formation | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 75    | *Pentabuneomys yunnanensis* | China   | Inner Mongolia | Sonid Zuoqi | Gashunyinadage bed | Shunmanzhang (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 76    | *Pentabuneomys yunnanensis* | China   | Inner Mongolia | Sonid Zuoqi | UEBOROBAN | Upper Red Mudstone Member, AEROBAN Formation | Shunmanzhang (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 77    | *Pentabuneomys yunnanensis* | China   | Inner Mongolia | Sonid Zuoqi | Amouswu | Amouswu bed | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 78    | *Pentabuneomys yunnanensis* | China   | Inner Mongolia | Sonid Zuoqi | Bahuininga | Bahuininga bed | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | Kueiian (correlated to MN 3) | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 79    | *Platycnemys mirabilis* | China   | Yunnan         | Shuliubu | Shuliubu Formation | not well dated | Biostratigraphic comparison with Siwalik rhizomyid rodents by Flynn and Q. (1982) | not well dated | not well dated | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |
| 80    | *Symplokeomys ceyreri*  | Kazakhstan | Sundak (Zayansu) | Loc. K10 | Aksyir Formation | Ergilgin | Upper boundary of Xialian | Ergilgin | Ergilgin | Taghmy et al. (1997); PRIBB |
| 81    | *Tamarinys pusillus*    | China   | Yunnan         | Shuliubu | Shuliubu Formation | not well dated | Biostratigraphic comparison with Siwalik rhizomyid rodents by Flynn and Q. (1982) | not well dated | not well dated | P. F. Flynn and Q. (1982); Ni and Q. (2002); Q. (2006) |