AN EARLY MIDDLE PLEISTOCENE MURID RODENT MOLAR FROM THE KOBIWAKO GROUP, JAPAN

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Abstract. A murid M\textsuperscript{1} obtained from the Hiraen Clay Member of the Kobiwako Group is the oldest record of the family in the Japanese Islands. The molar is assigned to the small Japanese field mouse, \textit{Apodemus argenteus}, an endemic species living in the islands today. It indicates that this species originated by the early Middle Pleistocene (0.65–0.7 Ma). Moreover, the molar contributes to reconstructing the Quaternary mammalian faunal succession in Japan, because the faunal content of mammalian biozone QM3 (0.5 to 0.73 Ma) is poorly known.

Key words. Murid, \textit{Apodemus argenteus}, early Middle Pleistocene, Kobiwako Group, central Japan.

Introduction

Until recently, murid remains from the Japanese Islands were known only from sediments younger than the early Middle Pleistocene. They were mostly obtained from cave and fissures, and their ages were ambiguous. A murid molar described here was collected from a lacustrine clay bed of the Kobiwako Group, which is dated with confidence as the early Middle Pleistocene. Therefore, this find is very important from biostratigraphic view, and is now regarded as the oldest record of murids in the islands.

Mammalian remains of the early Middle Pleistocene are extremely rare in Japan (Kamei \textit{et al.}, 1988). Only a few forms of large mammals are known. Therefore the present specimen provides the important information on micro-mammals of this period.

The main purpose of this paper is to present a detailed systematic description of the specimen. Furthermore, we briefly describe the stratigraphic sequence of the Kobiwako Group around the fossil locality, and discuss the biostratigraphic problems.

Geological setting

The Kisen River is a small stream that runs from west to east through the northern part of the Katata Hills into Lake Biwa (Figure 1). A branch of the river flowing down from the southern outskirts of Kurihara cuts a small gorge. The murid molar was found by one of us (Iida) in a clay block lying on the riverbed of the branch in October 1986. The block had undoubtedly fallen down from a
Figure 2. Columnar section of the Kobiwako Group observed along the gorge wall of the fossil locality.

clay bed exposed on the northern wall of the gorge. This bed is 5.6 m in thickness, and consists of bluish gray massive clay with remains of plants and freshwater shells (Figure 2). Teeth and bones of freshwater fishes are also contained but rare. They show the same state of preservation as that of the murid molar.

After finding the molar, 161 kg of sediment were collected from the clay bed, and washed through screen (0.5 mm mesh). Although remains of freshwater fishes and shells were obtained, no other mammalian fossils were found.

On the basis of the stratigraphy of the gorge wall, the clay bed is assigned to the lowest part of the Hiraen Clay Member. This member is the fifth lithologic unit of the Katata Formation, Kobiwako Group (Hayashi, 1974; Figure 3). Around the fossil locality, westward dipping beds allow the ascending stratigraphy of the formation to be observed from east to west (Figure 1).

Iida (1988, MS) inferred from the sedimentological analyses that the Hiraen Clay Member was deposited in a shallow lake. On the other hand, the Research Group for Natural History of Lake Biwa (1986) studied green algae, diatoms, protozoans, molluscs and insects from the lower part of the Katata Formation including the Hiraen Clay, and considered that it was deposited in the littoral zone of a shallow lake.

Eighteen volcanic ash layers intercalated in the Katata Formation play an important role as marker beds (Figure 3). Among them, the Kisen and B Volcanic Ash Layers in the Kisen Clay Member, and the E Volcanic Ash Layer in the Ryuge Sand and Gravel Member are correlated with the Azuki, Sayama and Kasuri Volcanic Ash Layers in the Osaka Group, respectively (Ishida and Yokoyama, 1969; Hayashi, 1974; Yoshikawa, 1983). The Azuki and Kasuri Volcanic Ash Layers were dated at $0.87 \pm 0.07$ Ma and $0.37 \pm 0.04$ (or $0.38 \pm 0.03$) Ma, respectively by fission track (Nishimura and Sasajima, 1970). On the other hand, Suzuki (1988) determined the ages of the Sayama and Kasuri Volcanic Ash Layers as $0.77 \pm 0.31$ Ma and $0.42 \pm 0.08$ Ma, respectively by the same method. Additionally, a fission track age of $0.7 \pm 0.14$ Ma was obtained from the Biotite I Volcanic Ash Layer in the Kisen Clay Member by Nishimura and Yokoyama (1975). On the other hand, Hayashida et al. (1976) designated the Brunhes-Matuyama geomagnetic boundary to the horizon about 10 m above the Biotite I Volcanic Ash Layer in the section of the Kisen River. On the basis of these chronological data, the horizon of the murid molar is estimated as about 0.65 to 0.7 Ma in age.
### Biostratigraphic consideration

Proboscideans and artiodactyls are reported from the Katata Formation in the Katata Hills (Naumann, 1881; Hiki, 1915; Matsumoto and Ozaki, 1959; Ikebe et al., 1966; Kamei, 1966; Okazaki and Matsuoka, 1979; Tamura et al., 1982; Taruno et al., 1983; Kamei, 1984 etc.). The murid specimen is the first record of micro-mammal in the formation. The stratigraphic position of these mammalian remains is summarized in Figure 3. The murid specimen occurs at the lowest horizon among them.

Kamei et al. (1988) proposed a mammalian biozonation of the Late Neogene and Quaternary sediments in the Japanese Islands. They divided the Middle Pleistocene into three biozones, QM3 (0.73 to 0.5 Ma), QM4 (0.5 to 0.3 Ma) and QM5 (0.3 to 0.12 Ma). The faunal contents of QM4 and QM5 are abundant, but that of QM3 is almost un-
known. Only two forms, *Mammuthus* cf. *armeniacus* and *Bison* sp., were reported from QM3. Accordingly the present specimen is an important addition to the mammalian fauna of this biozone.

**Systematic description**

Descriptive terminology and method of measurements are given in Figure 4. The specimen described here is stored in the Department of Geology and Mineralogy, Faculty of Science, Kyoto University.

Order Rodentia Bowdich, 1821  
Family Muridae Gray, 1821  
Genus *Apodemus* Kaup, 1829  
*Apodemus argenteus* (Temminck, 1844)

*Figure 5*

Mus argenteus* Temminck, 1844, p. 51, pl. 15, fig. 1.  
Other synonyms are given in Kawamura (1989).

**Material.**—1 isolated M1 (KUJC 100718).  
**Locality.**—Kurihara, Shiga-cho, Shiga-gun, Shiga Prefecture (135°54'13"E; 35°9'37"N).

**Horizon.**—Hiraen Clay Member, Katata Formation, Kobiwako Group.  
**Age.**—Early Middle Pleistocene (ca. 0.65 to 0.7 Ma).

**Description.**—The crown is as high as those of the living species of *Apodemus*, but somewhat higher than those of *Micromys* (B and C of Figure 5). In occlusal view, it has an oval outline, and comprises three chevron-shaped cusp rows (anterior, middle and posterior chevrons), which are the basic pattern of murid M1. The buccal cusps (labial anterocone, paracone, metacone and posterior cingulum) and central cusps (lingual anterocone, protocone and hypocone) are inclined to the front, while the lingual cusps (antero-style, enterostyle and posterostyle) are almost erect. The central cusps are larger than other cusps.

The dentine fields of the three cusps of the anterior chevron are well confluent with each other. Neither precingulum nor prestyle are recognized. The occlusal surface of the labial anterocone is considerably anterior to that of the anterocone. The posterior spur of the former cusp is well defined, while that of the latter cusp is indistinct. The anterior chevron is clearly separated from the middle chevron by a deep transverse valley. No accessory cusps are observed at the lingual or buccal entrance of the valley.

The dentine fields of the three cusps of the middle chevron are also confluent. Moreover, that of the paracone is continuous with that of the metacone in the posterior chevron. The occlusal surfaces of the paracone and enterostyle are approximately set in the same transverse line. The transverse valley between the middle and posterior chevrons is deep, but opens only lingually.

The dentine fields of the four cusps of the posterior chevron are confluent with each other. The morphology of this chevron is of the "argenteus type" as discussed by Kawamura (1989). Namely, the posterior cingulum is well developed and strongly connected to the metacone and hypocone. Furthermore, the hypocone is directly connected to

the metacone. The valley between the hypocone and posterior cingulum is distinct, but becomes a slender closed pit. The posterostyle is well developed and elongate antero-posteriorly.

A root below the lingual anterocone is preserved. It extends antero-superiorly. It is thick and has an antero-posteriorly elliptical cross section.

**Measurement.**—The specimen was measured by a profile projector (Nikon V-12) with an electric digital counter (Nikon CM-65). The measurements of the comparative living materials (Figure 6) were also obtained by the same instrument.

Length of crown (L)......1.77 mm
Width of crown (W)......1.08 mm

**Comparison and discussion.**—The present specimen was compared with the actual molars of six living murid genera known from Japan (*Apodemus, Diplothrix, Micromys, Mus, Rattus* and *Tokudaia*), and with the descriptions and illustrations of the molars of 46 living murid genera (*Abditomys, Anonymomys, Archboldomys, Bandicota, Batomys, Berylnys, Bullimus, Bunomys, Carpsomys, Celaenomys, Chiromyscus, Chiropodomys, Chiromys, Crateromys, Cremnomys, Crunomys, Dacnomys, Diomys, Echiorthix, Eropeplus, Golunda, Hadromys, Haeromys, Hapalomys, Kadarsanomys, Lenomys, Lenothrix, Leopoldomys, Limnomys, Margartamys, Maxomys, Melamothrix, Millardia, Nesokia, Niviventer, Palawanomys, Paruromys, Phloemys, Pithecheir, Rhynchomys, Srilankamys, Sun-

As the result, it is strongly suggested that the morphological characters of the specimen are best coincident with those of Apodemus, to which the specimen is undoubtedly assigned.

The genus Apodemus comprises many living and fossil species. The following species are representatives of the genus:

- A. mystacinus (Danford et Alston)
- A. jeanteti Michaux
- A. flavicollis (Melchior)
- A. sylvaticus (Linnaeus)
- A. dominans Kretzoi
- A. microps Kratochvil et Rosicky
- A. argenteus (Temminck)
- A. speciosus (Temminck)
- A. peninsulae (Thomas)
- A. giliacus (Thomas)
- A. draco (Barrett-Hamilton)
- A. latronum Thomas
- A. semotus Thomas
- A. agrarius (Pallas)

Kawamura (1989) distinguished three morphotypes in the posterior chevrons of M¹ and M² of Apodemus. In the “speciosus type”, the posterior cingulum is absent, or forms a weak projection of the hypocone. In the latter case, it is never connected to the metacone, but the hypocone is connected to the metacone by a strong ridge, which is separated from the posterior cingulum. In the

![Figure 6. Scatter diagram showing the relationship between the length and width of crown for the present specimen and M¹ of the Japanese living Apodemus.](image-url)
"gillicus type", the posterior cingulum is situated on the ridge between the metacone and hypocone. The "argenteus type" is characterized by a well-developed posterior cingulum which is connected to the hypocone and metacone, but separated from the ridge between the last two cusps.

Among the above-listed species, *A. mystacinus*, *A. jeanteti*, *A. flavicollis*, *A. sylvaticus*, *A. dominans*, *A. microps*, *A. speciosus*, *A. peninsulæ*, *A. gillicus*, *A. semotus* and *A. agratius* are different from the present specimen in having M1 with the posterior chevron of the *speciosus* or *gillicus* type. Moreover, M1 of these species except *A. microps* are larger than the present specimen. Although available information on the dental morphology of *A. draco* and *A. latronum* is poor, M1 of these two species seem to be larger than the specimen.

M1 of the remaining species, *A. argenteus*, strongly resembles the specimen in outline and height of crown, arrangement and morphology of each cusp (especially the posterior chevron with the pattern of the *argenteus* type) and size. As shown in Figure 6, the length and width of the specimen plot in the center of the cluster of the living *A. argenteus*. Because no significant differences are found between the specimen and M1 of *A. argenteus*, the specimen can be referred to *A. argenteus*.

Kawamura (1989) described many specimens of *A. argenteus* from middle Middle Pleistocene to Holocene localities in the Japanese Islands. These are very similar to the present specimen in the morphology of crown and size. He also pointed out that *A. argenteus* remained almost unchanged in these characters from the middle Middle Pleistocene to Holocene. The present specimen indicates that such an unchanged condition can be traced back to the early Middle Pleistocene. Therefore, it is inferred that *A. argenteus* originated from its ancestral species in or prior to the Early Pleistocene.

The Early Pleistocene fossil records of *Apodemus* in China are very important for considering the ancestry of *A. argenteus*. Unfortunately, they are very few. *A. cf. sylvaticus* from Huaiyu (Teilhard, 1940) is the only comparable form. However, this form is considerably different from *A. argenteus* (Kawamura, 1989). Furthermore, as mentioned above, the Early Pleistocene and Pliocene fossil species from Europe such as *A. jeanteti* and *A. dominans* also differ from *A. argenteus*. Consequently, the ancestry of *A. argenteus* remains unknown. As pointed out by Kawamura (1989), this species seems to have evolved along an independent lineage from the other known species of *Apodemus*.

**Conclusion**

The murid molar found in the Hiraen Clay Member of the Kobiwako Group is undoubtedly referred to M1 of *Apodemus*. The comparisons with many species of the genus show that the morphology and size of the molar are best compared with those of *A. argenteus*, an endemic species of the present Japanese Islands. Because the geological age of the molar is estimated to be 0.65 to 0.7 Ma, it is concluded that the biostratigraphic range of *A. argenteus* extends back to QM3, and this species already inhabited in the islands in the early Middle Pleistocene. The occurrence of the molar strongly supports the opinion of Kawamura (1989) that *A. argenteus* arose from its ancestral species in or prior to the Early Pleistocene.

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Hiraen 比良園, Huaiyu 灰裕, Kamiogi 上仰木, Kataa 坚田, Kisen 喜撰, Kitahama 北浜, Kobiwako 古獰琶湖, Kurihara 栗原, Nijigaoka 両ケ丘, Otani 大谷, Ryuge 龍華, Sakawa 佐川, Sayama 斎山, Shiga-cho 志賀町, Shiga-gun 滋賀郡, Takashiro 高城, Yamasaka 山下。

古獰琶湖層群から産出した中期更新世前期の齧歯目ネズミ科の臼歯化石：古獰琶湖層群の比良園給土層から産出した齧歯類の上頜第1大臼歯は、ネズミ科の化石としては日本列島最古のものである。この化石は、現在の日本列島の固有種であるヒメネズミ *Apodemus argentipes* と同定される。このことは、本種が中期更新世前期の0.65–0.7 Maまでに種分化していたことを示している。さらに日本では、中期更新世前期に相当する哺乳動物化石帯のQM3帯（0.5 Maから0.73 Ma）の動物相の内容が現在はほとんど知られていなかったことから、今回の化石は日本列島の哺乳動物相の変遷史を考える上で重要である。

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