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Mimomys savini size evolution in the Early Pleistocene of south-western Europe and possible biochronological implications

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ABSTRACT

Over the course of their evolutionary history, some species of mammals have undergone variations in size, with a general trend towards increased morphometry. This effect can be seen very clearly in the fossil record of rodents because their high rate of reproduction that generates a high fossil record, which allows this phenomenon to be studied in detail. Furthermore, the rapid geographic distribution of rodents means that their evolution can be studied on a continental scale.

If a relationship can be established between the size of individuals and their chronology, and the trend that governs a species' increase in size can be determined, then the chronologies of different sites can be estimated based on the size of the individuals of that species recovered at those particular sites. The correlation between morphometric data of micromammal fossils and age was already used by other authors.

This article studies the rate at which the length of the first lower molar (m1) of *Mimomys savini* (a species of Palearctic arvicoline present in Europe between approximately 1.8 and 0.6 Ma ago) increased over the course of its evolution in Iberian Peninsula (south-western Europe). Because this increase in length occurred at a constant rate, a direct relationship can be established between average length of m1 and chronology, which allows us to set numerical dates to Pleistocene sites containing *Mimomys savini* remains.

1. Introduction

The existence of evolutionary trends has held the interest of the scientific community ever since the theory of evolution was first put forward (Darwin, 1859). An evolutionary trend is essentially a directional change within a single lineage or parallel changes in several lineages or, in other words, a situation in which several lineages undergo the same types of changes. To be considered an evolutionary trend, this directional change has to be maintained over time and may affect one or more taxa within the lineages in which it occurs.

The origin of these evolutionary trends in nature or their causes remains a topic of debate for which there have classically been two different schools of thought: orthogenesis (a biological hypothesis according to which life has an innate tendency to evolve in a unilinear fashion due to some 'guiding force', whether it be internal or external (Marsh, 1874)) and directional selection or orthoselection (a particular modality of natural selection (Simpson, 1944)). In any case, starting from the basic assumption that species evolve in a chain-like fashion and are constantly changing, the existence of evolutionary trends is a completely logical consequence of evolution, and is patently obvious in the fossil record (Simpson, 1944).

The genus *Mimomys* was present in Europe during the Pliocene that disappeared at the beginning of the Middle Pleistocene (about 4 to 0.6 Ma ago [Chaline and Laurin, 1986; Chaline and Sevilla, 1990; Chaline et al., 1993; Agustí, 1995]). The first representative of this genus in Europe was *Mimomys occitanus* and the last was *Mimomys*

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savini (Chaline and Laurin, 1986; Agustí, 1995). Features of the evolution of the lineage include an increase in size, the appearance of cement in the re-entrant angles in molars and a progressive increase in crown height (Agustí, 1995). The last representative of the genus *Mimomys* (*Mimomys savini*) lived from about 1.8 to about 0.6 Ma ago (Fejfar et al., 1998) and exhibits a series of evolutionary trends such as a progressive increase in size (Viriot et al., 1990; Chaline et al., 1999; Lozano-Fernández et al., 2013), a gradual loss of 'mimomyian' traits (mimomys-ridge and enamel islet in m1) and variations in tooth enamel thickness (Koenigswald, 1973, 1982; Heinrich, 1978; Koenigswald and Kolfschoten, 1996; Cuenca-Bescós et al., 1999; Lozano-Fernández et al., 2013).

This work investigates the correlation between size and age of *Mimomys savini* at the Gran Dolina site in order to ascertain whether this trend followed a linear pattern over time and, if so, to evaluate its use as a method for the numerical dating of archaeological sites. If validated, this method would constitute yet another tool with which to study the first human populations in Europe on the Iberian Peninsula (Bermúdez de Castro et al., 1997; Martínez-Navarro et al., 1997; Oms et al., 2000; Carbonell et al., 2008; Toro et al., 2010) during the late Early Pleistocene.

2. Geological and chronological setting

This study was conducted based on data obtained from the *Mimomys savini* remains recovered during the excavation carried out at the Gran Dolina site (Atapuerca, Spain) between levels TD4 and TD6 in the 1990's.

The Sierra de Atapuerca is ~1080 m above sea level, dominating the now-flat landscape of the Castilian grain-growing plains irrigated by the River Arlanzón near the village of Ibeas de Juarros, located 14 km east of the city of Burgos (Fig. 1).

The Gran Dolina is one of the caves of the Railway Trench of the Atapuerca Hill. The Trinchera Dolina represents one of the longest stratigraphic sequences at Atapuerca. It comprises 18–19 m of surface filling which is divided into 11 stratigraphic levels. Nine of these levels (TD3–TD11, numbered from bottom to top) are rich in faunal remains and artefacts (Carbonell et al., 1995, 1999; Bermúdez de Castro et al., 1997; Cuenca-Bescós et al., 2005; Rodríguez et al., 2011).

The archaeological and paleontological excavations in Gran Dolina, or Trinchera Dolina (TD), cave have been conducted every year since 1976, and have revealed a long, culturally and paleontologically rich sequence dated at between ca 1 Ma and 250 Ka ago by means of biostratigraphy, electron spin resonance, electron spin resonance on optically bleached quartz dating, U-series, thermoluminescence, infrared-stimulated-luminescence analysis, and paleomagnetic dating (Cuenca-Bescós et al., 2011; Moreno García, 2011 [Fig. 1]).

3. Material and methods

We studied 372 lower first molars (m1), all of them from adult individuals (Table 1). In other words, these molars all had defined areas free of enamel on the occlusal plane and fully developed roots (Fig. 2). In other published works, both variations in the length and the width of the occlusal plane of the m1 have been used as a reflection of size-related changes among individuals from different paleontological populations (Viriot et al., 1990; Chaline et al., 1999; Lozano-Fernández et al., 2013). The size of the individuals in this

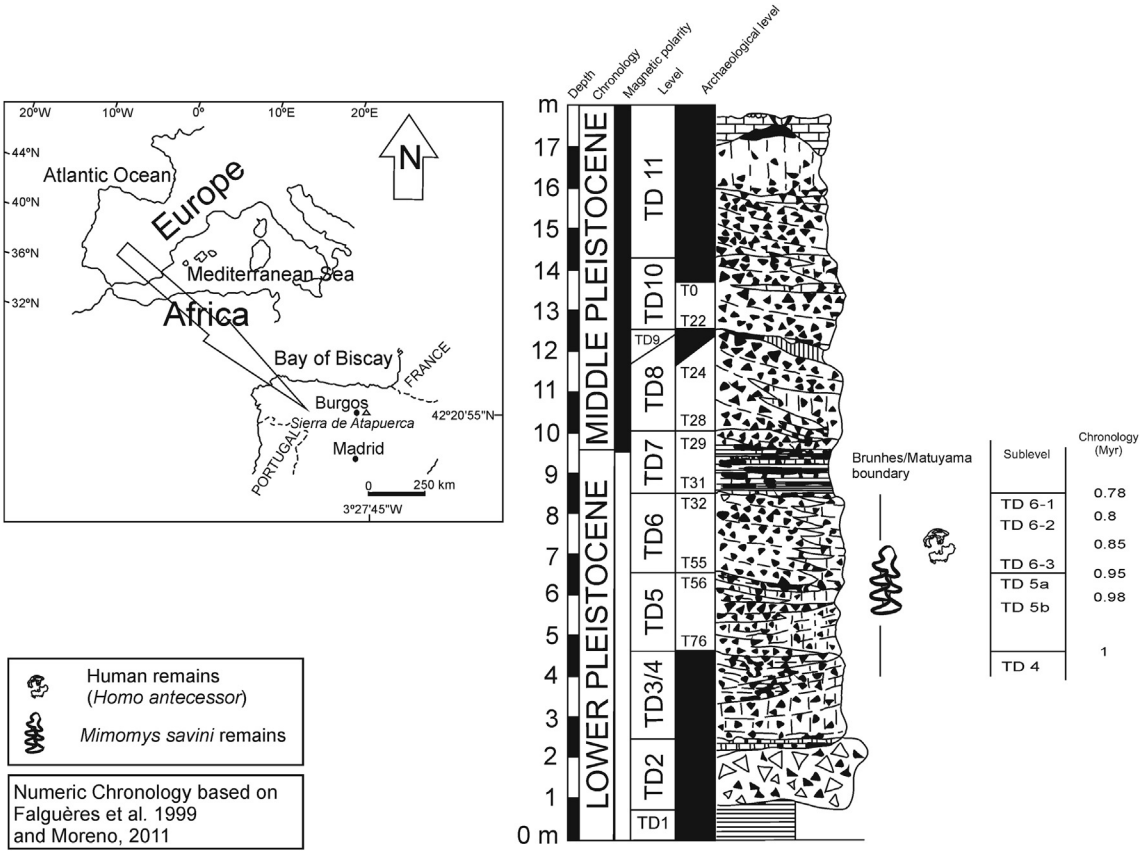

Fig. 1. Geographical location of the Sierra de Atapuerca archaeological sites complex, and Stratigraphic log of Gran Dolina (Modified from Parés and Pérez-González, 1995).