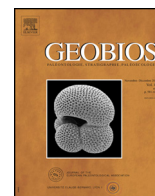




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Original article

Latest Miocene insectivores from Eastern Spain: Evidence for enhanced latitudinal differences during the Messinian[☆]



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ABSTRACT

The fossil insectivores from Turolian sites (latest Miocene) in Spain are poorly studied, usually limited to the description of a few new species, or restricted to non-detailed faunal lists. For the first time, the insectivore fossil contents from several Turolian localities at different latitudes from the eastern area of the Iberian Peninsula have been thoroughly studied, and appropriate descriptions, measurements and photographs have been provided. The systematic characterisation of these small mammal assemblages reveals a difference between northern and southern localities, the latter including a lower number of species than the former ones. The identifications carried out are in good agreement with the previous faunal lists of Turolian insectivores, thus reinforcing the model of southward diversity decrease already noticed for older Miocene insectivore assemblages from Spain, and weakening the possibility of a sampling or a taphonomic bias. This pattern is linked to the latitudinally prevailing climatic and environmental conditions; it has not been found hitherto in any other region from Europe, Western Asia or northern Africa.

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1. Introduction

The European eulipotyphlan assemblages acquired their present-day characteristics after the extinction of the dimylids, plesiosoricids and heterosoricids during the late Miocene, *ca.* 9 Ma. For the first time, the group was only represented in Europe by the extant families Erinaceidae, Soricidae and Talpidae. Subsequent climatic conditions influenced their relative and absolute abundances. For instance, the rather warm and humid environments during the early Pliocene enhanced the diversity of shrews (Reumer, 1995), whereas the following glacial-interglacial Pleistocene dynamics decimated their accumulated diversity. Burrowing moles, desmans and uropsilines also experienced changes in their abundance and distribution, and so it happened within the erinaceines. Therefore, the present-day eulipotyphlan communities in Europe can be considered as the result of an initial stock of late Miocene insectivores influenced by the Plio-Pleistocene climatic and environmental dynamics.

The vertebrate faunas of the latest part of the Miocene are especially well represented in the Iberian Peninsula, where their excellent fossil record deserved the description of the “Turolian” and “Ventian”, two continental stages making reference to the Spanish province of Teruel (Crusafont-Pairó, 1965) and the locality of Venta del Moro (Morales et al., 2013), respectively. Moreover, Spain is of special interest because its geographical placement encompassed different ecotopes. During most of the Miocene, the Iberian Peninsula clearly reflected its peculiar character as a transitional area, from the rather moist and colder zones at its northern part to the drier and warmer ones at the southern zones. A remarkable latitudinal gradient is well reflected in the European fossil assemblages, the insectivores being one of the groups most influenced by related external factors (Furió et al., 2011a; Van den Hoek Ostende et al., 2016). Not by chance, this group has been confirmed to be amongst the most sensitive mammals to the environmental conditions (Hernández-Fernández, 2001).

Unfortunately, the latest Miocene insectivore assemblages from Spain have remained poorly studied, limited to either a few publications of isolated taxa or, more frequently, preliminary identifications in general faunal lists (e.g., Mein et al., 1978; Mein et al., 1990; Agustí et al., 1981; Agustí et al., 2006c; Castillo et al., 1990; Sesé, 1991; Adrover et al., 1993; Van Dam, 1997; Van Dam

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et al., 2001; García-Alix et al., 2008; Minwer-Barakat et al., 2009). A general overview on how eulipotyphlan communities were structured during this timespan was still missing. This is especially important for the last two m.y. of the Miocene, a key moment immersed in a global cooling trend (Zachos et al., 2001), a seasonality increase in Europe (Eronen et al., 2009; Bruch et al., 2011), and repeated episodes of desiccation of the Mediterranean Sea during the Messinian Salinity Crisis (Roveri et al., 2014) allowing some faunal exchanges between the Iberian Peninsula and the African continent (Agustí et al., 2006a; Gibert et al., 2013; García-Alix et al., 2016). In the present work, we describe these assemblages from some localities of the latest Miocene from Spain at different latitudes, from the northern intramontane ones of La Cerdanya Basin in the Pyrenees to the southern ones of the Fortuna Basin in Murcia, and we discuss them within the late Miocene European context.

2. Localities

2.1. Can Vilella

This locality belongs to the Cerdanya Basin, at the NE of the Iberian Peninsula (Fig. 1). The fossil vegetation and mollusk assemblage are indicative of a distal alluvial fan environment with lacustrine areas (Agustí and Roca, 1987). According to Agustí et al. (2006b), the small mammal assemblage of level 1 includes *Epimeriones* aff. *austriacus*, *Kowalskia* aff. *lavocati*, *Apodemus gudrunae*, *Eozapus* aff. *intermedius*, *Muscardinus* aff. *vireti*, *Glirulus* aff. *lissiensis*, and *Prolagus michauxi*. The other two levels with insectivores, CV-0B and CV-3B, have only provided fossils of *E.* aff. *austriacus* and *A. gudrunae*, respectively.

2.2. Romanyà d'Empordà

This locality belongs to the Empordà Basin, which is placed more to the East than the Cerdanya Basin (Fig. 1). Its geological traits are indicative of an alluvial fan, and its fossil fauna is characteristic of moist environments and wooded areas (Llenas et al., 2002). The small mammal association (J.A., pers. obs.) of level 1B includes *Muscardinus* aff. *heintzi*, *Occitanomys* sp., *Rhagapodemus* aff. *lissiensis*, *Ruscinomys lasallei*, *Apocricetus alberti*, *Pseudocricetus* aff. *polgardi*, *Kowalskia* sp., *Paraethomys* aff. *miocaenicus*, *Apodemus gudrunae*, *Blackia* sp., *Pliopetaurista* aff. *bressana*, and *Dipoides problematicus*. The level 1C includes (J.A., pers. obs.) *Muscardinus* aff. *heinzi*, *Paraglrulus* aff. *lissiensis*, *Apocricetus alberti*, *Occitanomys* sp., *Stephanomys ramblensis*, *Apodemus gudrunae*, and *Rhagapodemus* aff. *lissiensis*. In both levels, some large mammal remains and gastropods have also been found.

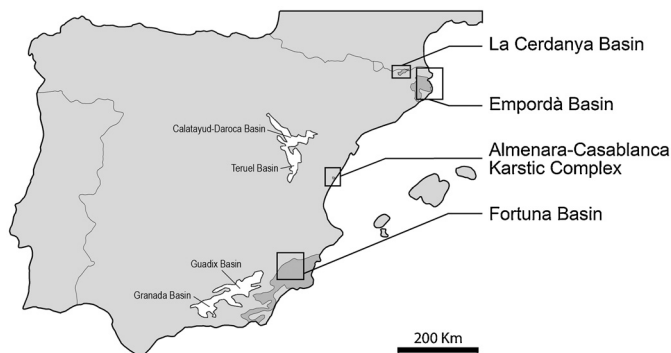


Fig. 1. Geographic location of the four main source areas of the fossils studied in this work. Other important inner basins with Turolian insectivores frequently referenced throughout the text are indicated in smaller case.

2.3. Bàscara Superior

This locality also belongs to the Empordà Basin; it is stratigraphically placed a few meters above the classical site of Bàscara referenced in Agustí et al. (1990). The geological traits of the section are indicative of an alluvial fan (Llenas et al., 2002). The small mammal assemblage, according to Llenas et al. (2002), includes *Apodemus* cf. *gudrunae*, *Occitanomys* aff. *adroveri*, *Apocricetus alberti*, and *Ruscinomys* aff. *lasallei*.

2.4. Almenara-Casablanca M

This locality is a karstic infilling in the province of Castelló (eastern Spain). Geologically, the karstic complex, including this site belongs to coastal end of Serra d'Espadà range, at the eastern sector of the Iberian range (Fig. 1). According to Agustí et al. (2011), the small mammal assemblage of this locality includes *Apodemus gudrunae*, *Occitanomys* cf. *adroveri*, *Castillomys crusafonti*, *Paraethomys meini*, *Stephanomys ramblensis*, *Ruscinomys lasallei*, *Apocricetus alberti*, *Blancomys* sp., *Eliomys truci*, *Myocricetodon jaegeri*, *Calomyscus* sp., *Debruijnimys almenarensis*, and *Pseudomeriones abbreviatus*.

2.5. Sifón de Librilla Section

This section belongs to the Fortuna Basin (Murcia Province), in southeastern Spain (Fig. 1). All the geological layers are typical of alluvial sediments, and the fossiliferous levels are associated to lacustrine environments developed at the distal zones (Agustí et al., 2006a). Two levels have provided Turolian faunas with insectivores: Sifón 52 and Sifón 2B. According to Agustí et al. (2006c), the small mammal assemblage for both of them includes *Apodemus gudrunae*, *Stephanomys ramblensis*, *Occitanomys* sp., *Apocricetus alberti*, *Ruscinomys* sp., *Eliomys truci*, *Muscardinus vireti*, and *Prolagus michauxi*.

2.6. El Chorrico – Salinas de Molina Section

This composite section also belongs to the Fortuna Basin (Fig. 1), but is placed 22 km SW to the Sifón de Librilla Section. The only Turolian level included in this section is Chorrico 2B. The small mammal assemblage of this site includes *Apodemus gudrunae*, *Stephanomys ramblensis*, *Occitanomys* sp., *Apocricetus alberti*, *Ruscinomys* sp., *Eliomys truci*, *Muscardinus vireti*, and *Prolagus michauxi* (J.A., pers. obs.). Two other isolated sites in the nearby area, Romerales 2B and Romerales 2C, show quite a similar faunal assemblage. However, they are considered to be somewhat younger than Chorrico 2B, but older than the arrival of *Paraethomys*. Their insectivore contents have been included in the present study because of their strategic location, but they are discussed in further detail in another study (Piñero et al., in press).

3. Material and methods

3.1. Field work

The fossil material was collected during the 1990s and the 2000s by the second author (J.A.) during different field seasons. In the case of the material from Romanyà d'Empordà and Bàscara Superior, the sediments were originally collected and water-screened by Manel Llenas (ICP), as part of a geological survey of the Girona province (NE Spain). The precise geographic and stratigraphical position of each locality studied in this work has not been detailed to protect and avoid inadequate visitors. However, this information is reposted at the ICP databases, and it can be provided for research purposes to any qualified person contacting

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