



Geological context and micromammal fauna characterisation from the karstic infilling of La Pedrera (Albaida, Valencia, E Spain)

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Fagoaga, A., Molina, F.J., Crespo, V.D., Laplana, C., Marquina, R. & Ruiz-Sánchez, F.J. 2017. Geological context and micromammal fauna characterisation from the karstic infilling of La Pedrera (Albaida, Valencia, E Spain). [Contexto geológico y caracterización de la fauna de micromamíferos del relleno kárstico de La Pedrera (Albaida, Valencia, E España)]. *Spanish Journal of Palaeontology*, 32 (2), 241-260.

Manuscript received 10 December 2016

Manuscript accepted 1 March 2017

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ABSTRACT

La Pedrera is a new palaeontological site located south of the province of Valencia, between the Betic and Iberian Ranges, in a cavity filled with sediments inside a tufa formation. Roughly 260 fossil remains, corresponding to 14 taxa, have been recovered and studied from Unit III. Six rodents (*Microtus* sp., *M. sp. gr. M. (Terricola) duodecimcostatus-lusitanicus*, *Microtus* sp. gr. *M. brecciensis-cabrerae*, *Arvicola sapidus*, *Eliomys quercinus*, and *Apodemus* sp. gr. *sylvaticus-flavicollis*), one lagomorph (*Oryctolagus* cf. *cuniculus*), three insectivores (*Soricinae* indet., *Crocidura* sp., and *Talpa* cf. *europaea*) and four bats (*Myotis blythii*, *Rhinolophus* cf. *ferrumequinum*, *Myotis bechsteinii*, and *Rhinolophus euryale*) have been identified. The relative chronology obtained by means of the identified species and geological information suggests that this part of the cavity was filled with sediments during the Late Pleistocene or the beginnings of the Holocene. Furthermore, Mutual Ecogeographic Range method and

RESUMEN

La Pedrera es un yacimiento paleontológico localizado en el sur de la provincia de Valencia, entre las Cordilleras Bética e Ibérica, en una cavidad rellena con sedimentos dentro de una formación tobácea. Se han estudiado cerca de 260 fósiles, correspondientes a 14 taxones, procedentes de la Unidad III. Han sido identificados seis roedores (*Microtus* sp., *M. sp. gr. M. (Terricola) duodecimcostatus-lusitanicus*, *M. sp. cf. M. brecciensis-cabrerae*, *Arvicola sapidus*, *Eliomys quercinus* y *Apodemus* sp. gr. *sylvaticus-flavicollis*), un lagomorfo (*Oryctolagus* cf. *cuniculus*), tres insectívoros (*Soricinae* indet., *Crocidura* sp. y *Talpa* cf. *europaea*) y cuatro murciélagos (*Myotis blythii*, *Rhinolophus* cf. *ferrumequinum*, *Myotis bechsteinii* y *Rhinolophus euryale*). La cronología relativa obtenida a través de las especies identificadas y la información geológica apuntan a un relleno de esta parte de la cavidad durante el Pleistoceno Superior o inicios del Holoceno. El método *Mutual Ecogeographic Range* (Rango

Habitat Weighting method show colder and wetter conditions than in Albaida (Valencia, Spain) nowadays.

Keywords: Biochronology, palaeoenvironment, palaeoclimate, Mutual Ecogeographic Range method, Habitat Weighting method.

Ecogeográfico Mutuo) y el método de la Ponderación de los Hábitats muestran condiciones más frías y húmedas que las que se dan en Albaida (Valencia, España) en la actualidad.

Palabras Clave: Biocronología, paleoambiente, paleoclima, Rango Ecogeográfico Mutuo, Método de la Ponderación de los Hábitats.

1. INTRODUCTION

The Late Pleistocene (ca. 128-11.2 ka) is a period of time characterized by several climatic, faunistic and cultural changes (Heinrich, 1988; Bond *et al.*, 1997; Cacho *et al.*, 1999; Sánchez-Goñi & d'Errico, 2005; Cuenca-Bescós *et al.*, 2010). The climatic history of the Late Pleistocene has been inferred from a wide range of evidences (deep-sea and lake sediments, ice cores, glacial landforms, coral reefs, ancient groundwater, cave records, overconsolidated sediments, loess deposits, fossil pollen, and relative sea-level reconstructions (Marshall, 2009 and references therein)). Especially, results derived from several oceanographic campaigns of the International Marine Global Change Study (IMAGES), around the Iberian margin, have contributed hugely to the knowledge of the response of the Iberian Peninsula ecosystems to climate changes in the last 140.000 years (Sánchez-Goñi & d'Errico, 2005).

Micromammals, especially rodents, constitute a valuable tool for biostratigraphy due to their cosmopolitan distribution and their high rates of evolution (Chaline, 1972; van der Meulen, 1973; Agustí, 1986; Fejfar & Heinrich, 1989; Fejfar *et al.*, 1998; Maul & Markova, 2007; Cuenca-Bescós *et al.*, 2010). Small mammals also represent a valuable proxy for the reconstruction of past environments (Andrews, 1990) as they are closely linked to environmental variations and present high ecological exigencies (Delany, 1976; Stoddart, 1979). Therefore, such species are a good instrument to study and reconstruct the history of the different moments represented on palaeontological and archaeological sites (Chaline, 1988; Andrews, 1999; Cuenca-Bescós *et al.*, 2009).

In this work, we want to introduce La Pedrera site, a previously unknown locality discovered in 2002 by local people who immediately contacted with the competent authorities who prospected the area and catalogued the site. Its name comes from the traditional stone extraction areas near the site, exploited since Middle Ages to modern times. This work analyzes this site for the first time, presenting the geological context of the karstic infilling in the tufa formation as well as the information derived from systematic palaeontology, biochronology,

palaeoenvironmental and palaeoclimatic reconstruction through the study of the micromammal content of Unit III of this site.

2. GEOLOGICAL SETTING

The studied area is located in the synclinal basin of Vall d'Albaida (Valencia, Spain), between the Betic and Iberian Ranges, south of the province of Valencia. This valley is filled with Neogene limestone and marls, and is limited to the north by the Cretaceous anticlines of Sierra Grossa, La Solana and Macizo de Marxuquera, and to the south by those of Benicadell, La Filosa and La Cuta (Fig. 1).

During the Pleistocene, several tufa formations and hydromorphic soils were deposited in the basin (Estrela *et al.*, 1993; García *et al.*, 1979). La Pedrera site is located in one of these formations, between the city centre of Albaida and the base of Sierra de Benicadell. That formation has been cited in several scientific publications (Pulido, 1979; Vázquez-Navarro *et al.*, 2014, among others) but it has not been extensively studied. It was formed during an interstadial period (González Martín & Fidalgo, 2015), in a flat geomorphologic context, over the limestone and marls of Serravallian (middle Miocene) age (Fig. 2). Carbonated water came from the karstic surge located on the headwaters of the Albaida River. Tufa formation spreads over 25 ha, with a length of 1.5 km from the distal to the proximal part of the river, and a maximum thickness of 15 m (Figs. 2a-2b). It presents a flat surface until its distal part where several gradient progradation fronts appear with lots of cavities.

The age of the tufa building can be inferred from the geomorphological evolution of the drainage basin of Albaida River. Geomorphological studies points to the preservation of three levels of alluvial terraces dated as the Pleistocene (Estrela *et al.*, 1993; Carmona *et al.*, 1993; García *et al.*, 1979). The lower terrace, originated during Holocene (García *et al.*, 1979), is located at +10 m and over Neogene marls. The middle terrace at +20 m alternate with high frequency hydromorphic soils, red soils and tufa formations, pointing to periods of morphogenetic stability

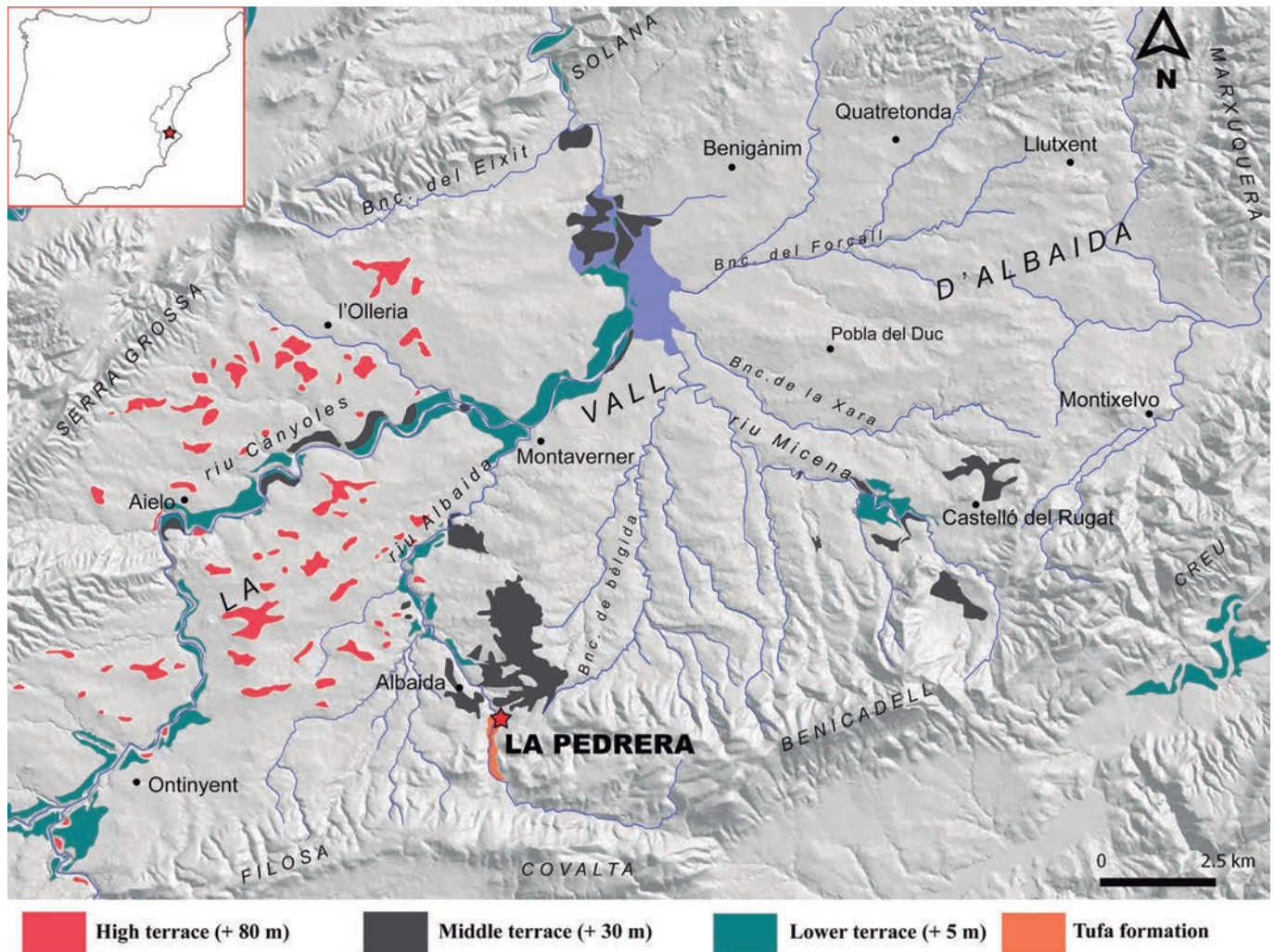


Figure 1. Quaternary set of terraces associated to Canyoles and Albaida rivers with location of the palaeontological site of La Pedrera (Vall d'Albaida, Valencia, Spain).

with lacustrine environments. Comparing with other fluvial basins, the middle terrace ranges from the final moments of the Middle Pleistocene and the beginnings of the Late Pleistocene. Then, another level of terrace, formed by detrital deposits, which is the highest one, documented at +50 m.

According to the data cited above, the tufa formation of Albaida could be morphologically placed between the upper and the middle terraces. The distal part of the building remains nowadays 30 m above the actual river. The middle terrace can be observed, connected to the distal part of the building, 20 m over the riverbed.

The successive fills of the Albaida River eroded and partially karstified the tufa building, forming new cavities and enlarging the older ones. Some of the cavities began to fill with external sediment input, consisting on sand, clay and rounded cobbles, and in the case of La Pedrera with macro and micromammal bones, charcoal fragments and snail shells among other remains as well.

The stratigraphic sequence result of the infill process, is composed by four sedimentary levels, from the bottom to the top (Fig. 2c):

- Unit IV (unknown thickness): Marl-sandy sediment with rounded stones of 1-5 cm and tufa fragments. Highly carbonated matrix.
- Unit III (130 cm): Marl-sandy sediment with less carbonate. Percentage of clay rises progressively from the bottom to the top.
- Unit II (25 cm): Carbonated crust of 15 cm.
- Unit I (40 cm): Red decantation clays with abundant oncolites between 0.5-1 cm.

In general, it can be observed that the beginning of the sedimentary infill is carbonated (IV) (Fig. 2c). Afterwards, the clay content of the sediment increases, as it acquires a more reddish hue (III). A carbonated crust was formed at the top of that level which seals the lower levels (II). Overall, the last unit completely fills the cavity, being

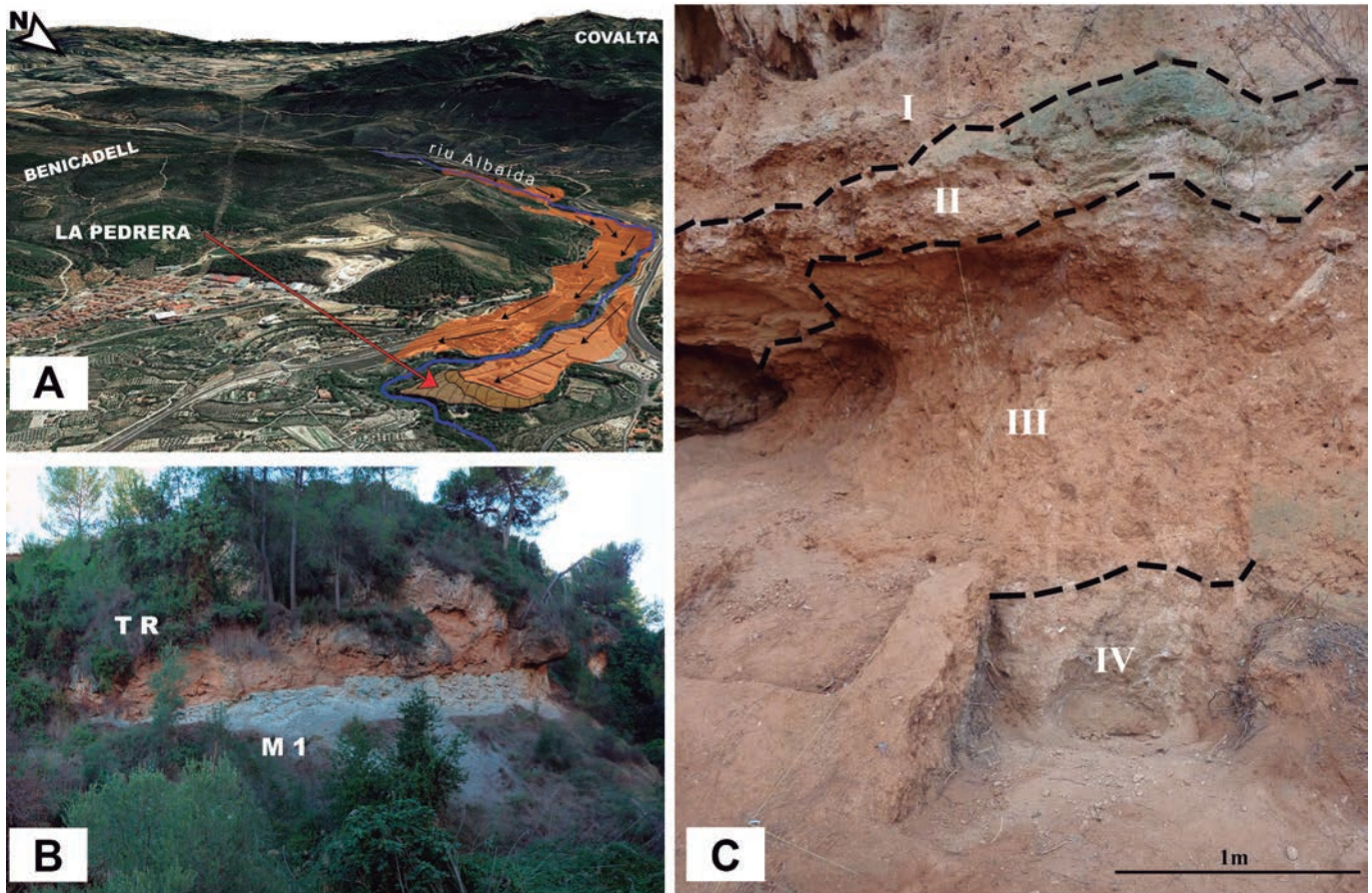


Figure 2. a) Detail of the palaeontological site of La Pedrera (Vall d'Albaida, Valencia, Spain). b) Tufa formation of La Pedrera (Vall d'Albaida, Valencia). M1: Miocene (Serravallian); TR: Travertine. c) Stratigraphic units described at the palaeontological site of La Pedrera (Vall d'Albaida, Valencia).

this unit, composed by clays and oncolites that points to its ponding (I). During the field campaign abundant macromammal remains were found in Units IV and III. These remains will be studied and published in the near future. Micromammal remains are present along the whole sequence.

3. MATERIALS AND METHODS

Approximately 260 small mammal remains have been studied and described in this paper. All of them were recovered from Unit III of La Pedrera karstic infilling. They are temporarily stored at the Universitat de València until their final deposit at the Isurus Paleontological Museum in Alcoi (Alicante). Samples were classified at the Department of Geology (Universitat de València), using a Leica MS5 binocular microscope. Measurements were taken (in mm) on a Leica MZ75 binocular microscope, by means of displacement of a mechanical stage, connected to a Sony Magnescale measuring equipment. Images were

taken with a scanning electron microscope at the Central Support Facility for Experimental Research (SCSIE) of the University of Valencia.

The anatomical nomenclature and measurement methods follow van der Meulen (1973), Rabeder (1981) and Jeannet (2000) for arvicolines, van der Weerd (1976) for murids, Daams (1981) for glirids, Reumer (1984) for soricids, Sevilla (1988) and Fracasso *et al.* (2011) for bats, and ultimately Furió (2007) for talpids. The taxonomic classification follows the one given by Wilson & Reeder (2005).

The abbreviations used throughout the text are: **D**: deciduous; **P**: upper premolar; **p**: lower premolar; **M**: upper molar; **m**: lower molar; **MAT**: Mean annual temperature; **MAP**: Mean annual precipitation; **AW**: anterior width; **BL**: labial length; **L**: Length; **LL**: Lingual length; **PE**: Posterior emargination; **TAW**: Talonid width; **TRW**: Trigonid Width; **W**: Width; **ACC**: Anteroconid Complex; **T**: triangle; **t**: tubercle.

The remains have been counted (NISP) and grouped using the minimum number individuals (MNI) by counting the most highly represented diagnostic element, taking into account laterality.

To reconstruct the palaeoenvironment we use the Habitat Weighting method developed by Whittaker (1948), Rowe (1956) and Gauch (1989), using the MNI calculated for the different taxa. This procedure defines a value, ranging from 0 to 1, for each of the species in every habitat where it is possible to find it. According to Cuenca-Bescós *et al.* (2005), Blain *et al.* (2008) and López-García *et al.* (2010), the habitats used are: Open dry (OD), meadows under seasonal climate change; Open humid (OH), evergreen meadows with dense pastures and suitable topsoil; Woodland (W), mature forest including woodland margins and forest patches, with moderate ground cover; Rocky (R), areas with a suitable rocky or stone substratum; Water (Wa), areas along streams, lakes and ponds. The score for the species identified in each habitat is shown in Table 1.

Table 1. Minimum number of individuals (MNI) and habitat preferences (OD: Open dry; OH: Open humid; Wo: Woodland; R: Rocky; Wa: Water) of the species determined from La Pedrera site (Unit III).

	MNI	OD	OH	Wo	R	Wa
<i>Microtus</i> sp.	1					
<i>M. sp. gr. M. brecciensis-cabrerae</i>	1					
<i>M. (Terricola) sp. gr. M. duodecimcostatus-lusitanicus</i>	3		0.5	0.5		
<i>Arvicola sapidus</i>	1					1
<i>Eliomys quercinus</i>	3			0.5	0.5	
<i>Apodemus sp. gr. sylvaticus-flavicollis</i>	8			1		
<i>Oryctolagus cf. cuniculus</i>	16	0.8	0.2			
<i>Crocidura</i> sp.	2	0.5		0.5		
<i>Talpa cf. europaea</i>	1		0.5	0.5		
Soricinae indet.	1					
<i>Myotis blythii</i>	2	0.25	0.25		0.5	
<i>Rhinolophus cf. ferrumequinum</i>	1			0.8	0.2	
<i>Myotis bechsteinii</i>	1			0.9	0.1	
<i>Rhinolophus euryale</i>	1			0.5	0.5	

Taxonomic composition of the assemblage allows us to evaluate the prevailing climatic conditions at the time of the formation of this Unit (Hernández-Fernández & Peláez-Campomanes, 2005). As an approach to assess the climatic conditions, we have used the Mutual Ecogeographic Range method (MER) (Blain *et al.*, 2009, 2016), which identifies the geographic regions where all the species of the assemblage live nowadays and extrapolate the current mean values for the climatic parameters to our

Unit. Parameters estimated are mean annual temperature (MAT) and mean annual precipitation (MAP). Species distribution was extracted from “El Atlas y Libro Rojo de los Mamíferos terrestres de España” (Palomo *et al.*, 2007) and climatic information from World Clim 1.4 (30 arcseconds resolution grid) (Hijmans *et al.*, 2005), which were both represented on free software GIS. Ecological requirements of the different species determined in the sample have been taken into account, since the areas where some species cannot actually live were removed from the overlapping area (an artificial division without any real ecological base). The results have been compared to the conditions prevailing at the present moment in the municipality of Albaida (16.1°C, 463.47 mm). Climatic parameters have been calculated as described above by using geographic information applications. Despite of being good climate markers (McCoy & Connor, 1980), Chiroptera have been excluded from this study because of their long-distance migrations.

The use of methodologies as Habitat Weighting method and Mutual Ecogeographic Range (MER method) based on actualism, can be justified since all the species identified at the site survived until today (most of them in the same region) and are morphologically similar to their modern representatives (Blain, 2009; López-García *et al.*, 2012). This approach will be tested in future studies using other proxies (study of isotopes in snails or teeth, among others).

4. SYSTEMATIC PALAEOONTOLOGY

Phylum **CHORDATA** Bateson, 1885

Class **MAMMALIA** Linnaeus, 1758

Order **EULIPOTYPHILA** Waddell *et al.*, 1999

Family **Soricidae** Fischer von Waldheim, 1817

Subfamily **Crocidurinae** Milne-Edwards, 1874

Genus *Crocidura* Wagler, 1832

Crocidura sp.
(Fig. 3a)

Material. 2 M1 (CVAI00622, CVAI00623), 1 M2 (CVAI00629) (Table 2).

Description.

M1. The metaloph does not reach the hypocone. There is a well-developed hypoconal flange and a pronounced posterior emargination. The lingual cingulum is small. The hypocone is high and conical, and connected to the

Table 2. Measurements, in millimetres, of the teeth of micromammals at La Pedrera. N: number of specimens measured; Min: Minimum value measured; Max: Maximum value measured; SD: standard deviation.

	N		Min	Max	Mean	SD
<i>Crocidura</i> sp.						
M1	2	AW	1.53	1.64	1.59	0.08
	2	PE	1.12	1.20	1.16	0.06
	2	LL	1.38	1.45	1.42	0.05
	1	BW	-	-	1.41	-
	1	PW	-	-	1.86	-
Soricinae indet.						
M3	1	L	-	-	0.92	-
	1	W	-	-	1.51	-
<i>Talpa</i> cf. <i>europaea</i>						
	1	L	-	-	2.47	-
	1	W	-	-	1.47	-
<i>Rhinolophus euryale</i>						
M2	1	W	-	-	1.51	-
m3	1	L	-	-	1.39	-
	1	TAW	-	-	0.83	-
	1	TRW	-	-	0.96	-
<i>Rhinolophus</i> cf. <i>ferrumequinum</i>						
	1	L	-	-	1.41	-
	1	W	-	-	1.46	-
<i>Myotis bechsteini</i>						
P3	1	W	-	-	0.62	-
M3	1	L	-	-	1.45	-
	1	W	-	-	1.81	-
m1	1	TAW	-	-	1.11	-
m2	1	L	-	-	1.51	-
	1	TAW	-	-	1.10	-
	1	TRW	-	-	0.98	-
<i>Myotis blythii</i>						
P4	1	L	-	-	2.05	-
	1	W	-	-	1.66	-
M3	1	L	-	-	1.91	-
C	1	L	-	-	1.30	-
	1	W	-	-	1.36	-
p2	1	W	-	-	1.07	-
	1	L	-	-	0.94	-
p4	1	L	-	-	1.53	-
	1	W	-	-	1.23	-
m1	1	TRW	-	-	1.82	-
m3	1	L	-	-	2.12	-
	1	TAW	-	-	0.91	-
	1	TRW	-	-	1.53	-
<i>Oryctolagus</i> cf. <i>cuniculus</i>						
p3	12	L	2.25	3.37	2.90	0.33
	12	W	2.42	3.18	2.78	0.25
<i>Arvicola sapidus</i>						
M1	1	W	-	-	1.64	-
M2	1	L	-	-	2.72	-
	1	W	-	-	1.49	-
<i>Microtus</i> sp.						
m2	1	L	-	-	1.49	-
	1	W	-	-	0.86	-
m3	1	L	-	-	1.19	-
	1	W	-	-	0.68	-
<i>M. sp. gr. brecciensis-cabrerae</i>						
M2	L	1	-	-	1.59	-
	W	1	-	-	1.18	-
m2	L	2	1.55	1.79	1.67	0.17
	W	2	1.11	1.29	1.20	0.13
m3	L	1	-	-	1.52	-
	W	1	-	-	1.07	-
<i>M. (Terricola) sp. gr. duodecimcostatus-lusitanicus</i>						
M3	3	L	1.35	1.63	1.54	0.16
	3	W	0.88	0.98	0.94	0.05
m2	3	L	1.49	1.64	1.56	0.08
	2	W	0.89	1.04	0.97	0.10
m3	2	L	1.34	1.65	1.51	0.16
	1	W	-	-	0.68	-

	N		Min	Max	Mean	SD
<i>Apodemus</i> sp. gr. <i>sylvaticus-flavicollis</i>						
M1	12	L	1.79	2.36	2.06	0.16
	13	W	1.17	1.42	1.33	0.07
M2	9	L	1.29	1.47	1.38	0.14
	9	W	1.19	1.29	1.25	0.13
M3	5	L	0.91	0.99	0.95	0.03
	5	W	0.84	0.94	0.88	0.04
m1	12	L	1.82	1.98	1.89	0.05
	13	W	1.09	1.25	1.14	0.05
m2	14	L	1.27	1.37	1.31	0.03
	13	W	1.09	1.26	1.15	0.04
m3	12	L	0.95	1.21	1.06	0.07
	12	W	0.77	1.00	0.91	0.07
<i>Eliomys quercinus</i>						
D4	3	L	1.04	1.39	1.21	0.18
	3	W	1.24	1.73	1.55	0.27
M1,2	7	L	1.37	1.64	1.47	0.11
	7	W	1.76	2.06	1.87	0.11
m1,2	2	L	1.21	1.35	1.28	0.10
	2	W	1.48	1.54	1.51	0.04

Table 2. (Continued)

crest of the hypocone. The preprotocrista is in contact with the paracone. The parastyle and mesostyle are angulous. The mesostyle is continuous. The paracrest is the shortest crest in the ectoloph. The paramesocrest is longer than the postmesocrest. The metastyle is long. The posterior cingulum is well developed and ends down to the metastyle. The metacone and the protocone are higher than the paracone. The ectoloph is very asymmetric.

M2. A fragment of a tooth, with the metacone and part of the posterior cingulum preserved.

Remarks. This taxon is characterized in La Pedrera by the absence of pigmentation and because the upper molars are extended labio-lingually, both characters typical of the genus *Crocidura* (Furió, 2007). This genus is the only crocidurine found in Europe during the Pleistocene (Butler, 1998; Rofes & Cuenca-Bescós, 2011). However, the lack of more diagnostic material prevents us from giving a more specific classification.

Subfamily Soricinae Fischer von Waldheim, 1817

Soricinae indet.
(Fig. 3b)

Material. 1 M3 (CVAI00624) (Table 2).

Description.

M3. The anterior cingulum is well developed and ends near to the parastyle. The cusp is integrated in the paracrest. The paracone is red. The protocone joins the anterior cingulum. The mesostyle is continuous. The postmesocrest is long and straight and ends in front of a well-developed and independent lingual cingulum.

Remarks. Only one tooth of red-toothed shrew has been found in the site of La Pedrera. This material is not diagnostic, but the presence of pigmented tooth allows us to classify it within the Soricinae (Furió, 2007).

Family **Talpidae** Fischer von Waldheim, 1817

Subfamily Talpinae Fischer von Waldheim, 1817

Genus *Talpa* Linnaeus, 1758

Talpa cf. *europaea* Linnaeus, 1758
(Fig. 3c)

Material. 1 m1 (CVAI00647) (Table 2).

Description.

m1. The trigonid is narrower than the talonid and both are about the same length. The paralophid is curved; the protoconid-metaconid crest is short. Thus, the trigonid valley has an U-shaped. The oblique cristid ends against the middle of the protoconid-metaconid crest. The talonid basin is wide and closed by a small cingulum; the reentrant valley is small, and closed by a small curved cingulum. The entostylid is well developed.

Remarks. Scarce material of this taxon has been found in the site of La Pedrera. The m2 is bigger than *Talpa occidentalis* Cabrera, 1907 described by van Cleef-Rodgers & van den Hoek Ostende (2001), and fall inside of the variation of *T. europaea* described by these authors. In addition, the trigonid of the m1 in *T. europaea* is bigger than *T. occidentalis* as it occurs in our material (van Cleef-Rodgers & van den Hoek Ostende, 2001). A new

current species recently described in the south of France and North of Spain, *Talpa aquitania* Nicolas, Martínez-Vargas & Hugot, 2016, is quite similar both in size and morphology to *T. europaea*, but there are hardly any data on its dental morphology, preventing us the comparison. So, the characteristics observed allow us to ascribe the material as *Talpa cf. europaea*.

Order **CHIROPTERA** Blumenbach, 1779

Family **Rhinolophidae** Gray, 1825

Genus *Rhinolophus* Lacépède, 1799

Rhinolophus euryale Blasius, 1853
(Figs. 3d-e)

Material. 1 M2 (CVAI00648), 1 m1 (CVAI00625), 1 m3 (CVA00620) (Table 2).

Description.

M2. Subrectangular tooth. The parastyle is set at a right angle with the preparacrista. The paracingulum is in contact with the parastyle. A short precingulum is present on the anterior side of the protocone. The ectoloph is symmetric. The metacone and the metastyle are broken. The paraloph, metaloph, hypocone, paraconule and metaconule are absent. The talon is developed as a rounded projection directed posteriorly, with a small basin enclosed by a well-developed cingulum. The postprotocrista is connected to the metacingulum, which is curved.

m1. Fragment of tooth, only conserves an 'open V'-shaped trigonid. The paraconid is well developed. The paralophid and metalophid are angular.

m3. Nyctalodont tooth, with a 'V' shaped paralophid. The protoconid is the highest cusp of the trigonid. The paraconid and the metaconid are aligned in occlusal view; the entoconid is displaced lingually. The hypoconulid is labially displaced respect to the entoconid. The entocristid is curved. The lingual cingulum is narrow and closes the trigonid basin. The labial cingulum connects the base of the paraconid to the hypoconulid, and it is narrower in the labial side and straight in lateral view.

Remarks. The size of this medium sized rhinolophid is similar to that of *Rhinolophus hipposideros* (Bechstein, 1800) and *R. euryale*, but the second species has a more robust dentition and a curved metacingulum as our material (Sevilla, 1988; Horáček *et al.*, 2013).

Rhinolophus cf. ferrumequinum (Schreber, 1774)
(Fig. 3f)

Material. 1 p4 (CVAI00641) (Table 2)

Description.

p4. A quadrate tooth, with a narrow cingulum surrounding it, except in the postero lingual side. This cingulum has a small protuberance in its postero lingual side.

Remarks. A big sized p4 has been found in La Pedrera site. This tooth is characterized by has a narrow cingulum and a big size, typical of this species (Sevilla, 1988). Although the scarcity of material and the lack of more diagnostic features prevent us the certainly assignation to this species.

Family **Vespertilionidae** Gray, 1825

Genus *Myotis* Kaup, 1829

Myotis bechsteini (Kuhl, 1817)
(Figs. 3g, 3i)

Material. 1 P3 (CVAI00634), 1 M3 (CVAI00649), 1 m1 (CVAI000632), 1 m2 (CVAI00645), 1 trigonid from a fragmented lower molar (CVAI00630) (Table 2).

Description.

P3. Subtriangular small tooth with a wide cingulum surrounding it, except in the anterolabial side.

M3. Subtriangular tooth. The parastyle is well developed and displays a right angle. The paracingulum is wide and connects to the protocone and the parastyle. The precingulum is very small. The paraloph and paraconule are well developed. The metacone is reduced. Both the metastyle and the postmetacrista are absent. The postprotocrista is short and it is not connected to the metacone. The talon is reduced to a small cingulum.

m1. Fragment of myotodont tooth, only conserves the talonid. The entocrestid is straight. The hypoconulid is lingually placed and is smaller than the entoconid. The postcrestid has a V-shaped. The cingulum is narrow.

m2. Myotodont tooth, with an open angle shaped paralophid. The protoconid is the highest cusp of the trigonid. The paraconid, the metaconid and the entoconid are aligned in occlusal view. The hypoconulid is labially displaced respect to the entoconid. The entocristid is straight. The lingual cingulum is small and closes the trigonid basin. The labial cingulum is wide and starts in the base of the paraconid, but finishes near to the hypoconulid. In lateral view this cingulum is narrow and irregular.

Remarks. It is a common middle sized *Myotis*, similar to *Myotis nattereri* (Kuhl, 1817). *M. nattereri* and *M. bechsteini* can be separated by the M3, because *M. bechsteini* has more angular upper molars and the M3, which is less reduced, presents a paraloph and paraconule (Sevilla, 1988).

Myotis blythii (Tomes, 1857)
(Fig. 3h)

Material. 2 P4 (CVAI000628, CVAI00643), 1 M3 (CVAI00644), 1 c (CVAI00638), 1 p2 (CVAI00637), 1 p4 (CVAI00642), 1 m1 (CVAI00627), 1 m3 (CVAI00621) (Table 2).

Description.

P4. The principal cusp is well developed. The cingulum is narrow and surrounds the tooth except in the metastyle, which is curved and well developed. The talon is small.

M3. Broken tooth, with a posterior part very reduced. The parastyle is well developed. The paracingulum is narrow and is connected to the protocone and the base of the parastyle. The cingulum of the paraflex is well developed. The metacone is reduced to a crest. Both the metastyle and the postmetacrista are absent.

c. Subrectangular tooth, with a principal cusp. The cingulum is well developed and surrounds the tooth except in the anterior side. A small cusplule is present in posterolingual side.

p2. Rounded tooth, with a wide cingulum surrounding it. It has a small protruding in its anterior and postero lingual side.

p4. Subrectangular tooth, with only one principal cusp. The cingulum is well developed, and it is narrow in its labial side. Two cusplules are present in the anterolingual and posterolabial side.

m1. Fragment of tooth that only preserves an 'open-V' shaped trigonid. Paraconid and metaconid have a similar size. The cingulum is wide.

m3. Myotodont tooth with an 'U' shaped paralophid. The protoconid is the highest cusp of the trigonid. The paraconid is slightly in lingual position than the metaconid in occlusal view; the entoconid is displaced lingually. The hypoconulid is slightly labially displaced respect the entoconid. The talonid is very reduced. The entocristid is straight. The lingual cingulum is very small. The labial cingulum is wide and connects the base of the paraconid to the hypoconulid, and it is narrower in the talonid and wide and slightly irregular in lateral view.

Remarks. This species is the best-represented bat in La Pedrera. This material of La Pedrera has a big size, being in the range of *Myotis myotis* (Borkhausen, 1797) and the upper part of the range of *Myotis blythii*, but the relation between trigonid and talonid of the m3 is over 0.45 (specifically 0.59), typical feature of the second species (Sevilla, 1988).

Order **LAGOMORPHA** Brandt, 1855

Family **Leporidae** Fischer von Waldheim, 1817

Genus *Oryctolagus* Linnaeus, 1758

Oryctolagus cf. cuniculus (Linnaeus, 1758)
(Fig. 3q)

Material. 11 I (CVAI00654 to CVAI00664), 28 i (CVAI00686 to CVAI00693, CVAI00736 to CVAI00755), 14 p3 (CVAI00667 to CVAI00670; CVAI00672 to CVAI00681), 11 p4 (CVAI00672 to CVAI00680, CVAI00684, CVAI00685), 10 m1 (CVAI00672 to CVAI00678, CVAI00680, CVAI00684, CVAI00685), 7 m2 (CVAI00672 to CVAI00676, CVAI0067, CVAI00684, CVAI00685), 2 m3 (CVAI00672, CVAI00673) (Table 2).

Description.

p3. The anteroconids, lingual and vestibular, are very similar in size and shape, well developed and rounded.

i1. The anterior lobes have a strong convexity and the mesial one is ledge and rounded.

Remarks. Regarding lagomorphs, upper incisors and third lower premolars are the diagnostic elements (Callou, 1997). However, third lower premolar is the dental remain with a major morphological differentiation and is usually abundant in the fossil record (De Marfà *et al.*, 2006). In the locality of La Pedrera, it has been possible to determine 16 p3. Anteroconids are very similar, contrary to what it's seen on hares, which are dissymmetric (Donard, 1982). However, the morphology of p3 tends to vary very much and that is why its biometric measures have been taken into account. The analysis that relates length versus weight shows that values fall within the values of modern *Oryctolagus cuniculus* (De Marfà *et al.*, 2009). The rounded and ledge character of the upper incisors is typical of the genus *Oryctolagus*, instead of the low rounded shape presented on hares.

Those characters point us to identify the remains as belonging to the genus *Oryctolagus*. Only one species of this genus is present in the Late Pleistocene of the Iberian Peninsula, *O. cuniculus*. In the absence of more diagnostic elements, we ascribe the remains to *Oryctolagus cf. cuniculus*.

Order **RODENTIA** Bowdich, 1821

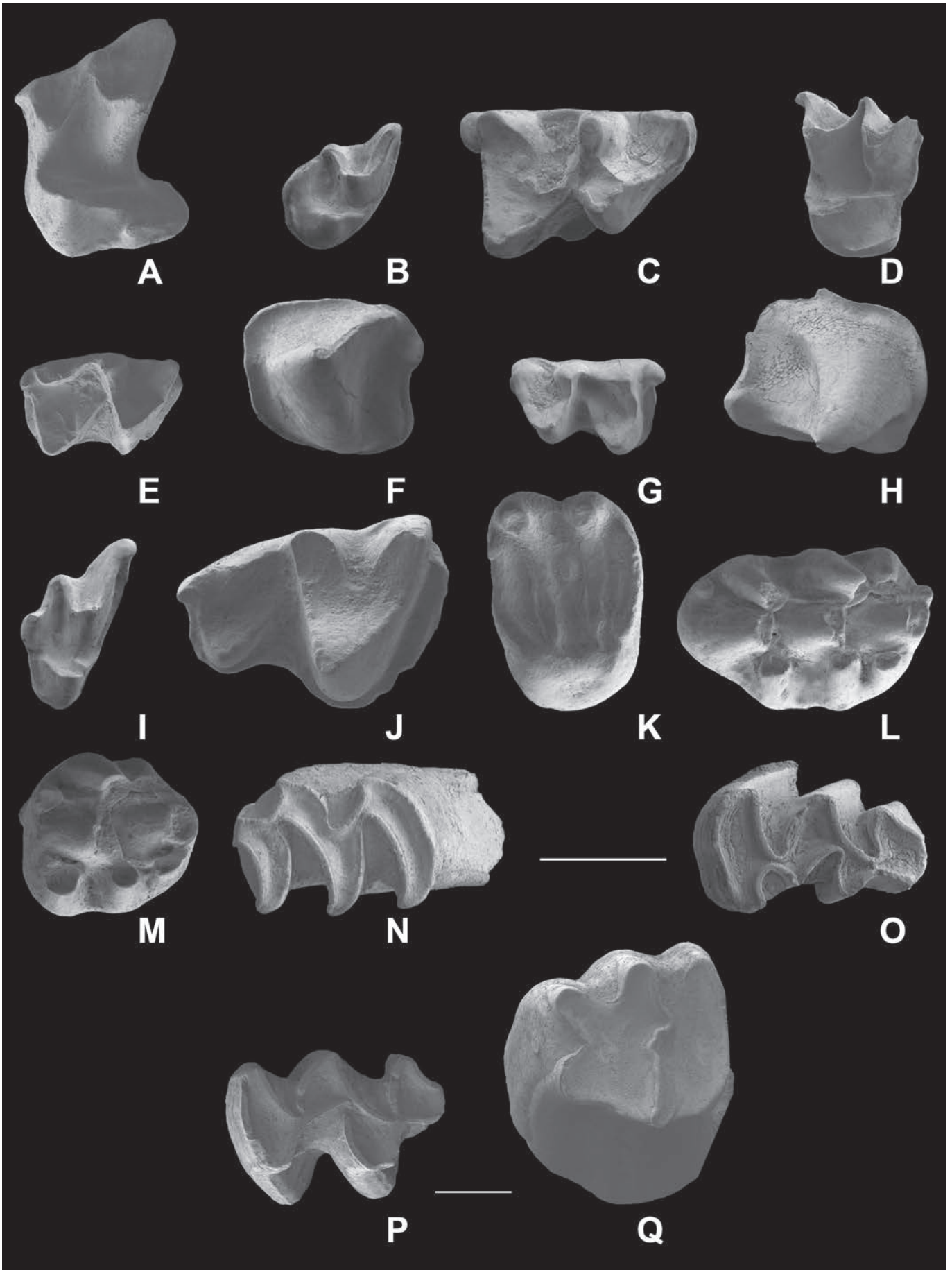
Family **Muridae** Fischer von Waldheim, 1817

Subfamily Arvicolinae Gray, 1825

Genus *Arvicola* Lacépède, 1799

Arvicola sapidus (Miller, 1908)
(Fig. 3p)

Material. 1 M1 (CVAI00583), 1 M2 (CVAI00587) (Table 2).



Description.

M1 and M2. The teeth are big, hypsodont, with no roots and with cement on the reentrant triangles. The enamel is differentiated, being thicker on the anterior triangles.

Remarks. Only two specimens have been recovered from this site. The big size of the molars and the thick enamel is a typical trait of the genus *Arvicola*. The thicker enamel in the anterior triangles (upper molars) allow us ascribe the material to *Arvicola sapidus* (López-Martínez, 1980).

Genus *Microtus* von Schrank, 1798

Microtus sp.

Material. 2 M1-2 (CVAI00586, CVAI00605), 1 m2 (CVAI00598) (Table 2).

Description.

M1-2. The teeth are broken. The triangles are rounded and not confluent.

m2. The triangles are rounded and not confluent.

Remarks. The specimens determined as *Microtus* sp. are very scarce and poorly preserved. However, the typical morphology of this genus could be seen. The triangles are rounded and not connected. In the absence of more diagnostic elements we prefer to maintain this material under open nomenclature.

Microtus sp. gr. *Microtus brecciensis* (Forsyth Major, 1905) *cabreræ* (Thomas, 1906)
(Fig. 3n)

Material. 1 M1 (CVAI00602), 1 M2 (CVAI00597), 1 M3 (CVAI00588), 3 m1 (CVAI00593, CVAI00603, CVAI00606), 2 m2 (CVAI00596, CVAI00600), 1 m3 (CVAI00610), (Table 2).

Description.

m1. The teeth are broken, hypsodont and with no roots. The reentrant angles have cement. There is a big asymmetry of the ACC. Presence of a hint of BRA4. LRA 3 and BRA 3 alternate. T4 and T5 are not confluent. The triangles are acute.

m2. The teeth are hypsodont with no roots. The reentrant angles have cement. There is a big labio-lingual asymmetry, being the lingual salients markedly longer in a lateromedial direction and more acute than the labials.

m3. The teeth are hypsodont with no roots. Reentrant angles with cement. There is a big labio-lingual asymmetry. First and second triangles are almost confluent as morphotype II from Ayarzagüena & López-Martínez (1976).

M2. The teeth are hypsodont with no roots. The reentrant angles have cement.

M3. The teeth are hypsodont with no roots. The reentrant angles have cement.

Remarks. The marked anterioposterior compression of the molars, especially in m1, and the sharpness of the salient triangles are characteristic of the subgenus *Iberomys* (Chaline, 1972). The different morphotypes in m1 and m3 can be used to differentiate *Microtus* (*Iberomys*) *brecciensis* from *Iberomys* (*Iberomys*) *cabreræ* (Ayarzagüena & López Martínez, 1976). However, those authors pointed the variability for those elements and noted the different proportions of each morphotype from each character in the studied populations. In the absence of more specimens with a better conservation and visible diagnostic characters, we ascribe the elements to the subgenus *Iberomys*. The presence of the primitive species *M. (I.) huescarensis* at La Pedrera can be excluded because the absence of confluence between triangles T4 and T5 on m1, which is a diagnostic feature for the species *M. brecciensis* and *M. cabreræ*. Taking into account the absence of more diagnostic elements, we identify this material as *Microtus* sp. gr. *M. brecciensis-cabreræ*.

Microtus (*Terricola*) Niethammer & Krapp, 1978

Figure 3. (a-q) Some of the small mammal remains recovered from Unit III from La Pedrera (Albaida, Spain). **a)** CVAI00623, left M1, *Crociodura* sp. **b)** CVAI00624, right M3, Soricinae indet. **c)** CVAI00647, right m1, *Talpa* cf. *europaea*. **d)** CVAI00648, left M2, *Rhinolophus euryale*. **e)** CVAI00620, right m3, *Rhinolophus euryale*. **f)** CVAI00641, left p4, *Rhinolophus* cf. *ferrumequinum*. **g)** CVAI00645, left m2, *Myotis bechsteini*. **h)** CVAI00642, right p4, *Myotis blythii*. **i)** CVAI00649, right M3, *Myotis bechsteini*. **j)** CVAI00621, right m3, *Myotis blythii*. **k)** CVAI00499, left M1, *Eliomys quercinus*. **l)** CVAI00517, left M1, *Apodemus* sp. gr. *sylvaticus-flavicollis*. **m)** CVAI00540, left M2, *Apodemus* sp. gr. *sylvaticus-flavicollis*. **n)** CVAI00610, right m3, *Microtus* sp. gr. *Microtus brecciensis-cabreræ*. **o)** CVAI00589, right M3, *Microtus* (*Terricola*) sp. gr. *M. duodecimcostatus-lusitanicus*. **p)** CVAI00587, left M2, *Arvicola sapidus*. **q)** CVAI00669, right p3, *Oryctolagus* cf. *cuniculus*. Scale bars = 1 mm.

Microtus sp. gr. *Microtus (Terricola) duodecimcostatus*
(De Selys-Longchamps, 1839)-*lusitanicus* (Gerbe, 1879).
(Fig. 3o)

Material. 2 M2 (CVAI00584, CVAI00607)
5 M3 (CVAI00589 to CVAI00592, CVAI00611), 3
m2 (CVAI00594, CVAI00595, CVAI00601), 3 m3
(CVAI00609, CVAI00612, CVAI00615) (Table 2).

Description.

M2. It has no roots. The teeth are hypsodont, with cement on the reentrant triangles. The angles are not sharp.

M3. No roots. The teeth are hypsodont, with cement on the reentrant triangles. The T2 and T3 are confluent and the salient angle of the T2 is always shorter than previous and posterior angle.

m2. It has no roots. The teeth are hypsodont, with cement on the reentrant triangles. T3 and T4 are confluent and the angles are not sharp.

m3. It has no roots. The teeth are hypsodont, with cement on the reentrant triangles. T3 and T4 are confluent and the angles are not sharp. Big labiolingual asymmetry.

Remarks. The morphology described for the specimens, including the confluence on the cited triangles and their rounded tips, let us ascribe the elements to the subgenus *Terricola*. The length of the salient angle of the T2 on M3 allow us to identify the specimens as *Microtus* sp. gr. *M. (Terricola) duodecimcostatus-lusitanicus*. Giving the absence of the first lower molar, a more precise identification is no longer possible (Brunet-Lecomte *et al.*, 1987).

Subfamily Murinae Illiger, 1811

Genus *Apodemus* Kaup, 1829

Apodemus sp. gr. *sylvaticus* (Linnaeus, 1758)-*flavicollis*
(Melchior, 1834)
(Figs. 3l-m)

Material. 15 M1 (CVAI00509 to CVAI00523), 9
M2 (CVAI00539 to CVAI00547), 5 M3 (CVAI00543b,
CVAI00563 to CVAI00566), 15 m1 (CVAI00524 to
CVAI00538), 15 m2 (CVAI00548 to CVAI00562), 14 m3
(CVAI00567 to CVAI00580) (Table 2).

Description.

M1. The t1bis is present in five of twelve specimens. The t2bis is present in eight of eleven specimens. There is a spur in t1 in only two out of fourteen specimens and almost every t3 have a spur, eleven out of thirteen. There is a well-developed t7. The t4 and t7 are variable. The t12 is well developed.

M2. Both t1 and t3 are big and isolated. T9 is well developed. There are four roots.

M3. The t1 is large and isolated. The t3 is absent. The t4, t5, t6, t8 and t9 are connected.

m1. The tma is well developed. The anteroconid is symmetric and linked to the metaconid by a narrow crest. The labial cingulum is well developed and it has a large round c1 and one or two accessory cuspids. Big round or oval posterior heel shifted towards the lingual side of the molar. Two roots.

m2. The antero-labial part is large and oval. The labial cingulum is poorly developed. The posterior tubercle is big, round or oval and shift towards the lingual side. Two roots.

m3. The anterolabial cuspid is absent. Two out of fourteen have an accessory cuspid.

Remarks. Differentiation between the species of the genus *Apodemus* is complicated due to the similarity between the morphology and the measurements of the dentition. However, studying living populations the discrimination is possible (Michaux & Pasquier, 1974). The relative length of the m2 (length/width) and the percentage of M2 with a reduced t9 (Michaux & Pasquier, 1974; Arrizabalaga *et al.*, 1999) are the characters, which led to differentiate between both species.

The length/width ratio of the m2 of the specimens from La Pedrera is high (1.14), being higher than the values of extant *Apodemus sylvaticus* (Linnaeus, 1766), and consistent with the values of *A. flavicollis* (Michaux & Pasquier 1974). However, the population from La Pedrera has a well-developed t9 in M2, which is a typical morphology of *A. sylvaticus*. The connection between t4 and t7 in M1 is variable.

Giving the difficulties in discriminating both species with the material studied, we ascribe those specimens from La Pedrera site to *Apodemus* sp. gr. *sylvaticus-flavicollis* until more material of this taxon are recovered from this site.

Family **Gliridae** Muirhead, 1819

Genus *Eliomys* Wagner, 1840

Eliomys quercinus (Linnaeus, 1766)
(Fig. 3k)

Material. 3 D4 (CVAI00494, CVAI00500, CVAI00501),
4 M1 (CVAI00495, CVAI00497, CVAI00499, CVAI00503),
2 M1-2 (CVAI00498, CVAI00502), 1 M2 (CVAI00496) 5
m1-2 (CVAI00504, CVAI00506, CVAI00508) (Table 2).

Description.

D4. Only two specimens (CVAI00500, CVAI00500), have been described because of the high level of occlusal

wear of the third (CVAI00494). The D4 has a sub-triangular outline. Protocone is the highest cusp. The anteroloph is short and connected at a low level to the paracone. The protoloph is clearly discontinuous in one specimen. No centrolophids. Metaloph is continuous. The posteroloph is low and lingually connected to the protocone.

M1. The outline is subrectangular. The anteroloph is connected basally to the paracone in three specimens and connected at medium height in another four. The paracone is the highest cusp, separated from metacone, also high. The protoloph and metaloph are continuous. The precentroloph has medium length in two out of four specimens and short length in another two. The postcentroloph is absent in one specimen, short in two specimens and long in another. There are three roots.

M2. The outline is trapezoidal. The anteroloph is high connected to the paracone. The paracone is the highest cusp, separated from metacone, also high. The protoloph and metaloph are continuous. There is no precentroloph and there is a short postcentroloph. There are three roots.

m1-2. All of the specimens present high level of crown wear and no one of them have been able to describe.

Remarks. *Eliomys quercinus*, *Glis glis* and *Muscardinus avellanarius* (Linnaeus, 1758) are the species of glirids recorded in the Iberian Peninsula during the Late Pleistocene. The morphology observed in the specimens from La Pedrera is very similar to *Eliomys quercinus*. The surface is clearly concave and presents well developed cusps, low number of transverse ridges and any accessory crests in the lower molars. According to Ruiz Bustos *et al.* (1982) and Paunescu & Abbassi (2002), these morphologies are diagnostic features of the species *E. quercinus*.

5. RESULTS AND DISCUSSION

5.1. Small mammal assemblage

Unit III of La Pedrera site has provided a NISP of 264 that corresponds to 14 taxa and a total MNI of 42. Six rodents (*Microtus* sp., *M. sp. gr. M. (Terricola) duodecimcostatus-lusitanicus*, *M. sp. gr. M. brecciensis-cabrerae*, *Arvicola sapidus*, *Eliomys quercinus*, and *Apodemus* sp. gr. *sylvaticus-flavicollis*), one lagomorph (*Oryctolagus* cf. *cuniculus*), three insectivores (Soricinae indet., *Crocidura* sp., and *Talpa* cf. *europaea*) and four bats (*Myotis blythii*, *Rhinolophus* cf. *ferrumequinum*, *Myotis bechsteinii*, and *Rhinolophus euryale*) have been identified.

The most represented species in the assemblage are *Apodemus* sp. gr. *sylvaticus-flavicollis* with a MNI of

8 and *O. cf. cuniculus* with an MNI of 16. The rest of the identified species have a similar representation: *Eliomys quercinus* and *Microtus* sp. gr. *M. (Terricola) duodecimcostatus-lusitanicus* a MNI of 3; *Crocidura* sp. and *Myotis blythii* a MNI of 2; *Microtus* sp., *M. sp. gr. M. brecciensis-cabrerae*, *Arvicola sapidus*, Soricinae indet., *Rhinolophus* cf. *ferrumequinum*, *Myotis bechsteinii*, *Rhinolophus euryale* and *Talpa* cf. *europaea* poorly represented, with a MNI of 1 (Table 1).

5.2. Biochronology

Regarding the biochronological inferences, *Microtus* sp. gr. *M. duodecimcostatus-lusitanicus* is the most outstanding taxon for La Pedrea site. *Microtus lusitanicus* appeared in the Iberian Peninsula in the Late Pleistocene (Sesé, 2005; López-García *et al.*, 2011) while *Microtus duodecimcostatus* has been recorded at Cueva del Agua (López-Martínez & Ruiz-Bustos, 1977) and Cuesta de la Bajada (Santonja *et al.*, 2014) during Middle Pleistocene. However, representatives of the subgenus *Terricola* are absent in the Mediterranean zone until the Late Pleistocene (Guillem, 1995; López-García *et al.*, 2008, 2012). They have not been recorded in Middle Pleistocene sites of the same region as Bolomor and Cova Negra (Fernández Peris *et al.*, 1994; Guillem, 1996, 2009). On the other hand, the faunal association recovered from the site is compatible with the fauna present before the entrance to the Iberian Peninsula of the genera *Mus*, *Rattus* or *Suncus* facilitated by human dispersion (Cucchi *et al.*, 2005). Regarding the species *M. blythii*, in the Iberian Peninsula, it has been identified only at the Bronze Age levels of Cova de la Sarsa (Sevilla, 1988) and at the end of the Late Pleistocene at Cova Colomera (López-García, 2011), suggesting short chronological range for this species in this geographical realm. However, from the Early Pleistocene onwards there are numerous samples attributed to the group of species *Myotis myotis-blythii* in which it has not been possible to determine if only one of the two species of the group were present, or if both were present at the same time (Sevilla, 1988). For this reason, it cannot be dismissed that the presence of *M. blythii* in the Iberian Peninsula is much older, and this species cannot be used as a marker for the Late Pleistocene-Holocene.

All the available biochronological information, together with the chronological context derived from the geologic study, points to a Late Pleistocene to early Holocene age for the studied assemblage. The remaining species represented in the faunal association appeared in the Iberian Peninsula before the beginning of the Late Pleistocene and are present during that period (Agustí *et al.*, 2011; Donard, 1982; Sesé & Sevilla, 1996; Cuenca-Bescós *et al.*, 2010) (Fig. 4).

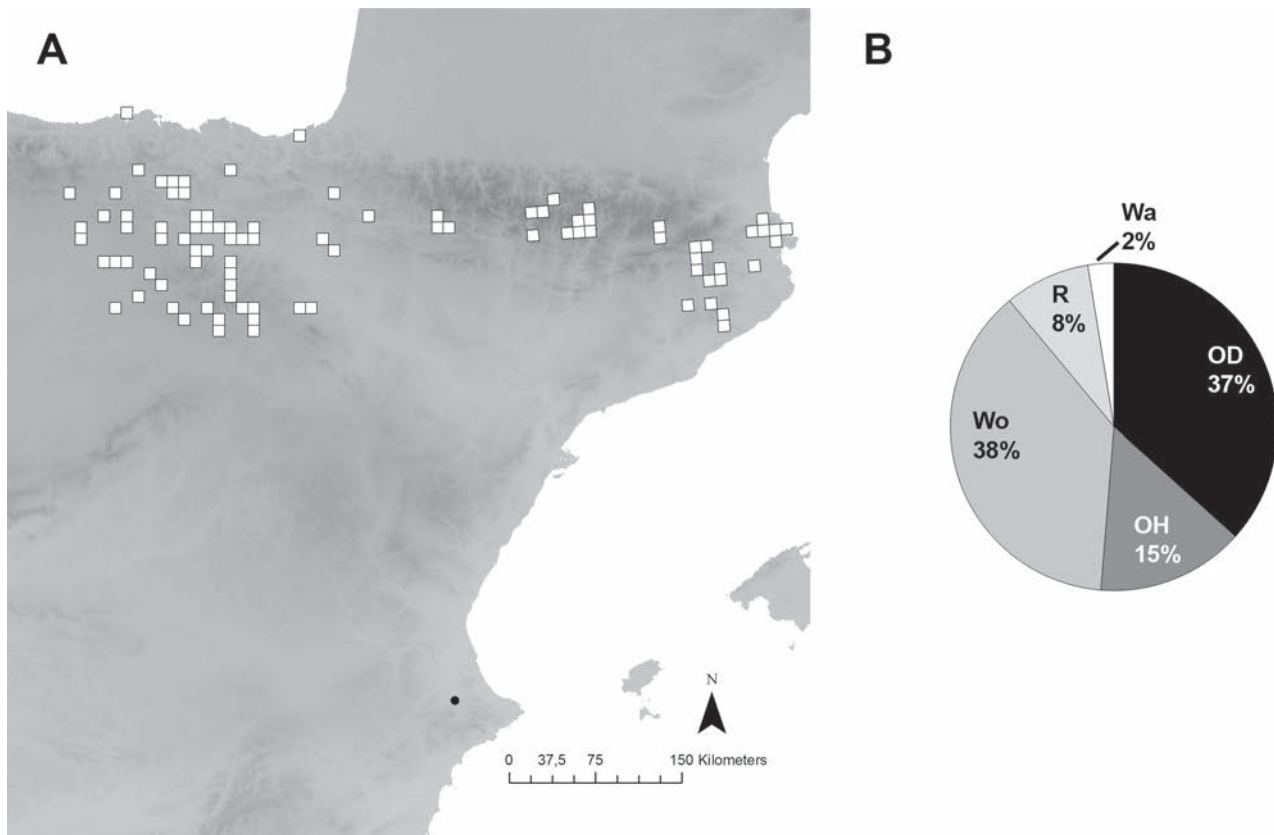


Figure 5. a) Current overlapping area of the small mammals (without bats) identified in Unit III from La Pedrera (Albaida) (white squares) with the location of the palaeontological site (black dot) over the raster of MAT values. b) Reconstruction of the landscape in Unit III from La Pedrera obtained by applying the Habitat Weighting method on the small mammal remains. OD: Open dry; OH: Open humid; Wo: Woodland; R: Rocky; Wa: Water.

ACKNOWLEDGEMENTS

This work has been possible thanks to the Sociedad Española de Paleontología who has funded this project. Also, the authors want to thank the reviewers Carmen Sesé and Juan Manuel López García for the corrections and the constructive comments.

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