

## PALEOENVIRONMENTAL AND PALEOCLIMATIC APPROACH TO THE UPPER PLEISTOCENE SITE OF ARTAZU VII (ARRASATE, NORTHERN IBERIAN PENINSULA) USING SMALL VERTEBRATES

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# PALEOENVIRONMENTAL AND PALEOCLIMATIC APPROACH TO THE UPPER PLEISTOCENE SITE OF ARTAZU VII (ARRASATE, NORTHERN IBERIAN PENINSULA) USING SMALL VERTEBRATES

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**Abstract.** The Artazu VII site (Arrasate, northern Iberian Peninsula) is a fossiliferous deposit that was discovered unsystematically at the Kobate Quarry in 2012. During the following year, all the vertebrate remains attributed to the upper Pleistocene (~ 93 ka) were recovered in an emergency excavation project. Here, we describe, for the first time, the small vertebrate assemblage (amphibians, reptiles, and small mammals) recovered from the site, as well as the environmental and climatic results estimated from the paleoecological affinities of the studied taxa. More than 50,000 microvertebrate elements were recovered, comprising 24 taxa of which seven belong to the Order Rodentia; five, to the Order Eulipotyphla; one, to the Order Chiroptera; seven, to the Order Anura; and four, to the Order Squamata. Considering the environmental attributions and the relative abundance of each taxon, the paleoenvironmental and paleoclimatic conditions were reconstructed and the sequence was divided into three phases. Although woodland mass is present in the whole sequence, expansion and regression changes can be observed. Thus, the stratigraphic sequence begins with a landscape with open spaces. Higher up the stratigraphic column, woodland expands and reaches its maximum development in the second phase. Finally, the woodland environment declines and reaches similar values to those of the initial situation. These forestry biotopes were related to temperate and humid conditions comparable to those of the modern landscape. It was also concluded that a watercourse existed near the site.

**Key words.** Upper Pleistocene. Iberian Peninsula. Cantabrian Range. Paleoenvironment. Paleoclimate. Small vertebrates.

**Resumen.** APROXIMACIÓN PALEOCLIMÁTICA Y PALEOAMBIENTAL DEL YACIMIENTO DEL PLEISTOCENO SUPERIOR DE ARTAZU VII (ARRASATE, NORTE DE LA PENÍNSULA IBÉRICA) A PARTIR DE MICROVERTEBRADOS. El yacimiento de Artazu VII (Arrasate, norte de la Península Ibérica) se descubrió accidentalmente en el año 2012 en la cantera de Kobate y fue vaciado en una excavación de emergencia durante el siguiente año. Los restos de vertebrados fueron atribuidos al Pleistoceno superior (~ 93 ka). En este trabajo se describen, por primera vez, la asociación de microvertebrados (anfibios, reptiles y micromamíferos) recuperados en el yacimiento y la reconstrucción paleoambiental para cada uno de los niveles estudiados. Se han recuperado más de 50.000 elementos óseos de microvertebrados, componiéndose la asociación de 24 taxones, correspondiendo siete de ellos al Orden Rodentia, cinco al Orden Eulipotyphla, uno al Orden Chiroptera, siete al Orden Anura y cuatro al Orden Squamata. Teniendo en cuenta la abundancia relativa y los requisitos ecológicos de cada taxón, se ha procedido a la reconstrucción paleoambiental y paleoclimática de todos los lechos estudiados. De esta manera, se han identificado tres diferentes fases a lo largo de la secuencia estratigráfica. Aunque las evidencias de la presencia de bosques está presente a lo largo de toda la columna estratigráfica, pueden observarse cambios en su extensión. La secuencia comienza con un ambiente dominado por espacios abiertos. A medida que se sube estratigráficamente la masa boscosa va aumentando, alcanzando su máximo momento de desarrollo en la segunda fase. Finalmente, el biotopo forestal disminuye hasta alcanzar los valores de la primera fase. En todo momento el entorno agreste se desarrolla en un entorno cálido y húmedo, comparable al actual en el País Vasco e infiriendo la existencia de un curso de agua en las inmediaciones del yacimiento.

**Palabras clave.** Pleistoceno superior. Península Ibérica. Cornisa cantábrica. Paleoambiente. Paleoclima. Microvertebrados.

THE Artazu VII Cave (Arrasate, northern Iberian Peninsula) was located 351 m.a.s.l, on the southwest side of Mount Artazu (UTM coordinates; X=538241, Y=4769155; datum

WGS84 and Zone 30 T; Suárez-Bilbao *et al.*, 2016; see Fig 1.1). This area is part of the Upper Deba Valley, surrounded by three mountain ranges: the first one is formed by the

peaks of Udalaiz (1090 m), Tellamendi (830 m) and Murugain (775 m); the second one, by Atzabal (1168 m) and Karraskagain (400 m); and the third one, by Anboto (1268 m) and Kurtzebarri (1155 m). The cave was situated on a hillside (Suárez-Bilbao *et al.*, 2016) surrounded by woodland.

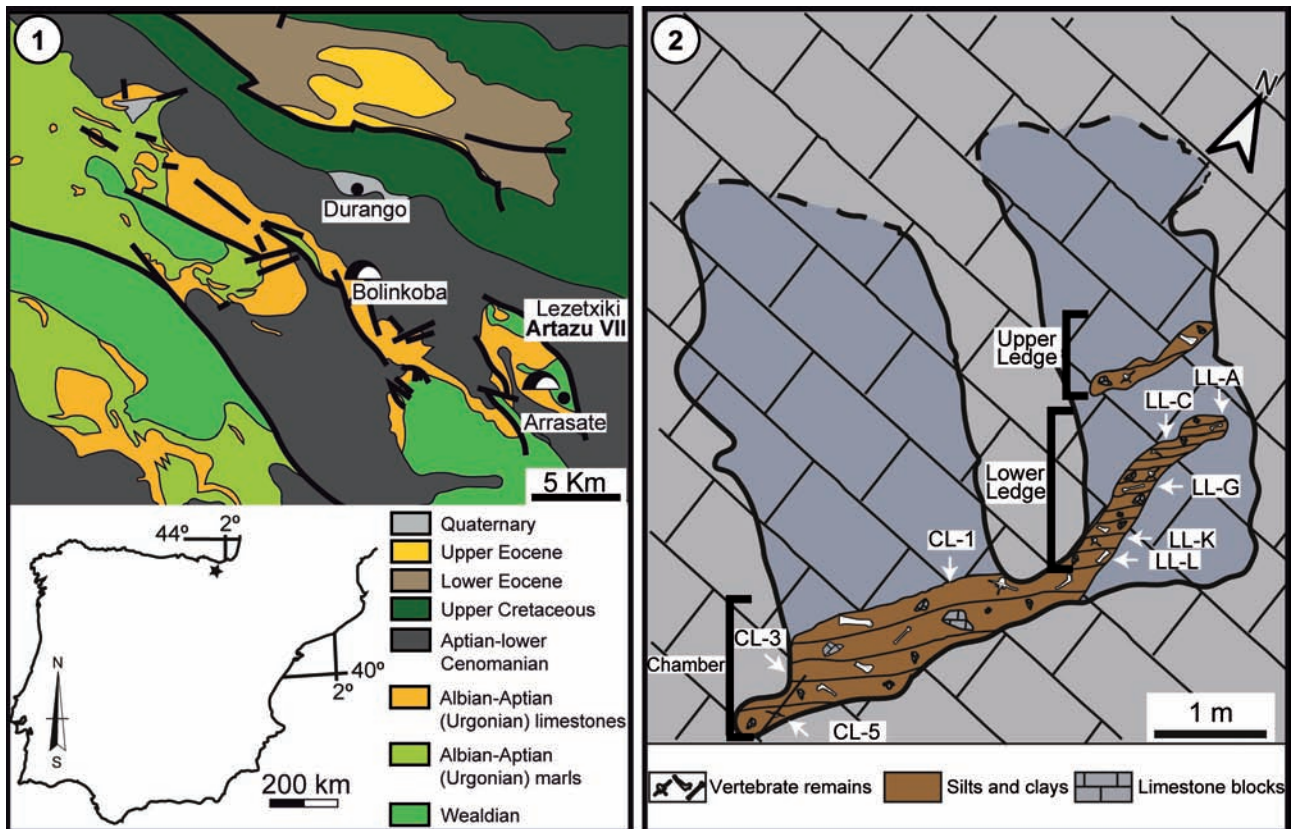
Geologically, Artazu VII was located in a karst complex with anticlinal and synclinal structures in a NW-SE direction (Fig 1.1). This karst system developed in Cretaceous limestones characterized by abundant Aptian–Albian rudists and corals.

Artazu VII was in an area where numerous Quaternary sites of important archaeological and paleontological fill, such as Bolinkoba (Fig 1.1) (Iriarte-Chiapusso and Arrizabalaga, 2012), Arlanpe (Rios-Garaizar *et al.*, 2015), Askondo (Garate and Rios-Garaizar, 2011), and Lezetxiki and Lezetxiki II (Barandiarán, 1965; Altuna, 1972), among others, were discovered. The latter complex is remarkable for the south

western most record of *Sicista betulina* (Rofes *et al.*, 2012) and the identification of the first Quaternary record of *Muscardinus avellanarius* in the Iberian Peninsula (García-Ibaibarriaga *et al.*, 2015a).

**Artazu VII site**

Artazu VII was discovered in 2012 during a blasting in the Kobate Quarry and was the object of a rescue excavation performed in 2013 by María-José Iriarte and Alvaro Arrizabalaga. Although a large part of the site was destroyed during the blasting, it was possible to collect some *in situ* material (Suárez-Bilbao *et al.*, 2016). Three different areas, but no levels, were differentiated in the structure of the site. They were named, from top to bottom, ‘Upper Ledge’, ‘Lower Ledge’ and ‘Chamber’ (Fig 1.B). Two panther (*Panthera pardus*) teeth samples collected from Lower Ledge K and L, and belonging to the middle of the stratigraphic se-



**Figure 1.** 1, Geographic position of Artazu VII (Arrasate, Gipuzkoa, north Iberian Peninsula). The Artazu VII Cave is marked with a star. 2, Artazu VII stratigraphic sequence. The levels studied in this work are: LL-A, Lower Ledge A; LL-C, Lower Ledge C; LL-G, Lower Ledge G; LL-K, Lower Ledge K; LL-L, Lower Ledge L; CL-1, Chamber Layer 1; CL-3, Chamber Layer 3 and CL-5, Chamber Layer 5.

quence, were dated by amino acid racemization (AAR). While the first tooth gave an age of 98.4 ka, the other was dated as 88.5 ka old, with a mean value of 93 ka (Suárez-Bilbao *et al.*, 2016).

Although it was not possible to establish the morphology of the cave due to the partial destruction of the site, the evidence leads us to theorize that Artazu VII acted as a natural trap (Suárez-Bilbao *et al.*, 2016). No signs of carnivore or human activity were identified and most of the large mammal remains were found in anatomical connection. Therefore, the recovered faunal association reflects, more precisely and as it was not biased by any predator hunting preferences, the environment at the time of infilling the site. The vertebrate accumulation at Artazu VII consists of at least 40 different taxa, including macrofauna (ungulates and carnivores) and microfauna (birds, amphibians, reptiles and small mammals). This paper presents the composition of the small vertebrate assemblage (except for birds) and, based on such elements, infers paleoenvironmental changes during the first half of the upper Pleistocene in the surroundings of the upper Deba Valley (northern Iberian Peninsula).

## MATERIAL AND METHODS

### *Fieldwork and collecting techniques*

The sampling was carried out by sections from which seventeen 7–15 cm thick samples were recovered. As the fieldwork was conducted in three different areas, the designation of the spits was different. Thus, the two samples from the Upper Ledge were ordered by depth (from 0 to 15 cm) while the 12 spits from the Lower Ledge were sorted alphabetically (from A to L) and the five samples from the Chamber were numbered (from 1 to 5) (Suárez-Bilbao *et al.*, 2016) (Fig 1.2). These samples were processed with the water-screening method, using two sieves of 0.5 and 2 mm of mesh size. Subsequently, the material was separated and photographed using a Nikon SMZ 1500 stereomicroscope at 10× magnification in the Stratigraphy and Palaeontology Department of the University of the Basque Country (UPV/EHU).

The specimens here studied are housed at Gordailua (Cultural Heritage Center of Gipuzkoa, Irun, Spain); see supplementary information for further details.

### *Systematic attribution and quantification*

The taxonomy of the small mammals follows Wilson and Reeder (2005), while Speybroeck *et al.* (2010) is followed for amphibians and reptiles. Additionally, the vertebrate remains were identified following the criteria in: Van der Meulen (1973), Pasquier (1974), Heinrich (1982), and Claudio (2013), for rodents; Reumer (1984) and Furió Bruno (2007), for eulipotyphlans; and Szyndlar (1984), Bailon (1991, 1999), and Blain (2009) for amphibians and reptiles.

Specific attributions were made mainly for the most diagnostic cranial and/or postcranial elements for each case: teeth for rodents (first lower molars for Arvicolinae, and any molar for Murinae and *Pliomys lenki*); mandibles, maxillae and isolated teeth for Soricinae and Erinaceinae; vertebrae for newts, lacertids and snakes; vertebrae, dental material and osteoderms for *Anguis fragilis*; and the humerus, the ilium and the scapula for the anurans.

In Artazu VII, the small vertebrates were quantified according to the Minimal Number of Individuals (MNI), taking into account the position of the cranial or/and postcranial element in the skeleton (right and/or left), and by the Number of Identified Specimens (NISIP). In the case of amphibians, the sex was taken into account whenever possible.

### *Habitat types and climate categories*

All the microfauna recovered from Artazu VII are extant taxa with the exception of *Pliomys lenki* and, therefore, species-habitat correlations are highly reliable. To establish the paleoenvironmental reconstruction of this site, the ecological characteristics of each taxon and their relative proportions were taken into account. On the one hand, this is based on their modern counterparts (actualism). Then again, to determine the ecology and habitat requirements of the extinct species, phylogenetic relationships and biogeographical criteria were used. Nevertheless, this classification in some species is limited since transitions between biotopes are gradual and, occasionally, the same taxon can be found associated with more than one environment.

The habitat and climate preferences of each species were established following Pokines (1998), Salvador (1998), Pleguezuelos *et al.* (2002), Palomo *et al.* (2007), Sesé (2005), Cuenca-Bescós *et al.* (2008, 2009) and López-García *et al.* (2011, 2012), among others. It is important to highlight that, in the Northern Iberian Peninsula, relatively warm condi-

tions and increases in humidity are associated with woodland expansion (Iriarte-Chiapusso and Murelaga, 2012). Thus, we compare the abundance ratio of species indicative of deciduous forests that are warmer and moister environments (*Apodemus sylvaticus-flavicollis*, *Erinaceus europaeus*, *Pliomys lenki* and *Talpa* sp.) as well as aquatic environments (*Arvicola amphibius* and *Neomys* sp.), versus other species that can live in more than one habitat, such as both in grasslands and in woodland masses (all the Arvicolinae described in this paper, with the exception of the aforementioned ones). The remaining small mammal taxa [*Sorex (Sorex) araneus-coronatus* and *Sorex (Sorex) minutus*], as well as the amphibian and reptile species, are not particularly significant for the reconstruction of the evolution of the environmental conditions but still provide relevant paleoenvironmental information.

## RESULTS

### *Small vertebrate assemblage*

Due to the large number of remains and the absence of different levels, eight arbitrary spits spanning the whole sequence were selected. The samples analyzed are spits A, C, G, K and L from the Lower Ledge, and 1, 3 and 5 from the Chamber (Fig. 1.2), which represent a total volume of 54.75 L of sediment. Over 50,000 small vertebrate remains (identified and unidentified) consisting of isolated teeth, mandibles, maxillaries, post-cranial elements and fragmented bones were extracted. In fact, 9,644 remains (NISP) corresponding to a minimum number of individuals (MNI) of 732 were identified at the genus or the species level (Tabs. 1–2). The microfaunal assemblage comprises 24 taxa (Figs. 2–3) corresponding to small mammals, amphibians and reptiles: six Arvicolinae [*Arvicola amphibius*, *Arvicola sapidus*, *Microtus (Microtus) agrestis*, *Microtus (Microtus) arvalis*, *Microtus (Terricola)* sp. and *Pliomys lenki*], one murine (*Apodemus sylvaticus-flavicollis*), one erinaceid (*Erinaceus europaeus*), three soricids [*Sorex (Sorex) araneus-coronatus*, *Sorex (Sorex) minutus* and *Neomys* sp.], one talpidae (*Talpa* sp.), one bat (Chiroptera indet.), two salamandrids (*Salamandra salamandra* and *Triturus* sp.), five ranids (*Alytes obstetricans*, *Discoglossus* sp., *Hyla arborea*, *Bufo bufo* and *Rana temporaria-iberica*), two saurians (Lacertidae indet. and *Anguis fragilis*) and two snakes (*Coronella girondica* and *Vipera* sp.).

As mentioned above, all the species that were identified in Artazu VII are extant except for *P. lenki*. According to Cuenca-Bescós *et al.* (2010) and having been recorded in the Magdalenian levels at the site of El Mirón, this species survived until the upper Pleistocene in the Iberian Peninsula. Additionally, the absence of *Crocidura russula*, *Eliomys quercinus*, *Glis glis* and *Microtus (Alexandromys) oeconomicus* in the stratigraphic sequence is noteworthy. The first three species are associated with benign conditions of temperate climates (Chaline, 1970; Rzebik-Kowalska, 1995; Sesé, 2005), whereas the latter taxon is related with the coldest climate stages (Chaline, 1970; Pemán, 1985; Laplana *et al.*, 2016).

### *Taphonomic remarks*

The taphonomy of the small vertebrates from Artazu VII has not been analyzed in detail but some basic points can be given. Accumulations of microfauna in caves commonly tend to be the result of the action of predators and to be formed either from owl pellets or the excreta of small carnivores (Andrews, 1990). This action sometimes causes, to a greater or lesser extent, physical (bites) and/or chemical traces (corrosion by gastric juices) on the bones (Andrews, 1990). In Artazu VII, the bones of the microfauna do not display many digestion traces and bone fragmentation is very low. However, some of the remains exhibit post-depositional fractures so that, after the accumulation was formed and taking into account the shape of the cave, the remains are thought to have been disseminated by some kind of flow (water, mud) that deposited them in the deepest part of the cave. For this reason, even if owls and/or carnivores were potential agents in the accumulation of small vertebrates in the sequence, the main taphonomic agent probably was a tractive watercourse.

### *Small mammalian community changes over spits*

A significant difference between taxonomic and quantitative proportions can be observed in the stratigraphic sequence from Artazu VII (Fig. 4; Tab. 1). The samples from the Upper Ledge were not considered because of their scarcity in bone remains. Thus, only the samples from the Lower Ledge and Chamber were studied. In this way, different small mammalian taxa were recorded in Chamber and the Lower Ledge. The three spits in Chamber yielded a total MNI

TABLE 1 – Number of identified specimens (NISP) and minimum number of individuals (MNI) of small mammal species from Artazu VII (Arrasate, Gipuzkoa, northern Iberian Peninsula), organized by spits.

	LL-A		LL-C		LL-G		LL-K		LL-L		CL-1		CL-3		CL-5	
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
<i>Arvicola amphibius</i>	6	3			3	1			10	5	3	2	9	5	10	8
<i>Arvicola sapidus</i>	1	1	4	3	1	1			1	1						
<i>Microtus (Microtus) agrestis</i>	14	10	9	5	4	2	2	1	17	10	4	3	27	15	43	30
<i>Microtus (Microtus) arvalis</i>	13	8	7	5	1	1	1	1	1	1	2	1	3	2	29	2
<i>Microtus (Terricola) sp.</i>	6	3	6	5	7	3	9	7	11	8	3	2	12	7	19	15
<i>Apodemus sylvaticus-flavicollis</i>	39	6	54	12	33	6	28	4	45	14	49	8	29	7	122	16
<i>Pliomys lenki</i>					2	1			1	1	3	1	11	3	7	4
<i>Chiroptera indet.</i>													1	1	2	2
<i>Erinaceus europaeus</i>															1	1
<i>Neomys sp.</i>			3	1	1	1			3	2	3	2	8	3	8	3
<i>Sorex (Sorex) araneus-coronatus</i>	38	8	50	14	49	15	34	7	64	21	72	17	97	30	161	66
<i>Sorex (Sorex) minutus</i>	17	7	23	7	15	6	7	2	22	6	32	12	26	7	24	11
<i>Talpa sp.</i>			14	2	4	2	1	1	2	2	6	1	8	1	2	1

Abbreviations: LL-A, Lower Ledge A; LL-C, Lower Ledge C; LL-G, Lower Ledge G; LL-K, Lower Ledge K; LL-L, Lower Ledge L; CL-1, Chamber Layer 1; CL-3, Chamber Layer 3; CL-5, Chamber Layer 5.

TABLE 2 – Number of identified specimens (NISP) and minimum number of individuals (MNI) of reptile and amphibian species from Artazu VII (Arrasate, Gipuzkoa, northern Iberian Peninsula), organized by spits.

	LL-A		LL-C		LL-G		LL-K		LL-L		CL-1		CL-3		CL-5	
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI
<i>Salamandra salamandra</i>			1	1			5	1	10	1	1	1	14	1	7	1
<i>Triturus sp.</i>	2	1					5	1								
<i>Alytes obstreticans</i>							1	1	1	1	1	1	1	1	1	1
<i>Discoglossus sp.</i>													1	1	3	1
<i>Hyla arborea</i>	4	1														
<i>Bufo bufo</i>	2	1	2	1	20	2	13	2	32	3	130	9	165	12	214	15
<i>Rana temporaria-iberica</i>	7	1	7	2	32	3	44	3	53	4	191	11	143	9	189	11
<i>Lacertidae indet.</i>	641	13	650	13	302	4	228	4	242	3	30	1	130	3	765	23
<i>Anguis fragilis</i>	33	1	16	1	407	1	299	1	48	1	113	2	1286	1	1131	23
<i>Coronella girondica</i>							8	1	9	1	65	1	47	1	6	1
<i>Vipera sp.</i>	13	1	17	1	11	1	11	1	36	1	89	1	142	1	56	1

Abbreviations: LL-A, Lower Ledge A; LL-C, Lower Ledge C; LL-G, Lower Ledge G; LL-K, Lower Ledge K; LL-L, Lower Ledge L; CL-1, Chamber Layer 1; CL-3, Chamber Layer 3; CL-5, Chamber Layer 5.

of 286, with a clear predominance of *S. (S.) araneus-coronatus* followed by *A. sylvaticus-flavicollis* and *M. (M.) agrestis* in Chamber 5 and 3, and *S. minutus* and *A. sylvaticus-flavicollis* in Chamber 1. It is remarkable that the only appearance of *E. europaeus* occurs in Chamber 5, where no presence of *Neomys* sp. is recorded. Moreover, Chiroptera indet. disappears in Chamber 1 (Fig. 4; Tab. 1). The Lower Ledge assemblage is formed by a minimum of 233 individuals and some changes, especially in the relative abundance of taxa, can be noticed in this sequence. In Lower Ledge L and as the proportion of shrews decreases and that of the Muri-

nae increases, the most abundant species is *S. (S.) araneus-coronatus*, which is followed by *A. sylvaticus-flavicollis* and *M. (M.) agrestis*. Lower Ledge K displays the poorest taxonomic paleodiversity, with just seven small mammal taxa. It is the only spit in which the sum of the Arvicolinae does not reach 15% of the sample. When comparing Chamber K with the previous spits, no presence of Arvicolinae, *Neomys* sp. and *P. lenki* is detected. *Sorex araneus-coronatus* and *M. (Terricola) sp.*, accompanied by *A. sylvaticus-flavicollis*, prevail in the sample and constitute almost 80% of the individuals (Fig. 4; Tab. 1). In both Chamber G and Chamber C, the most

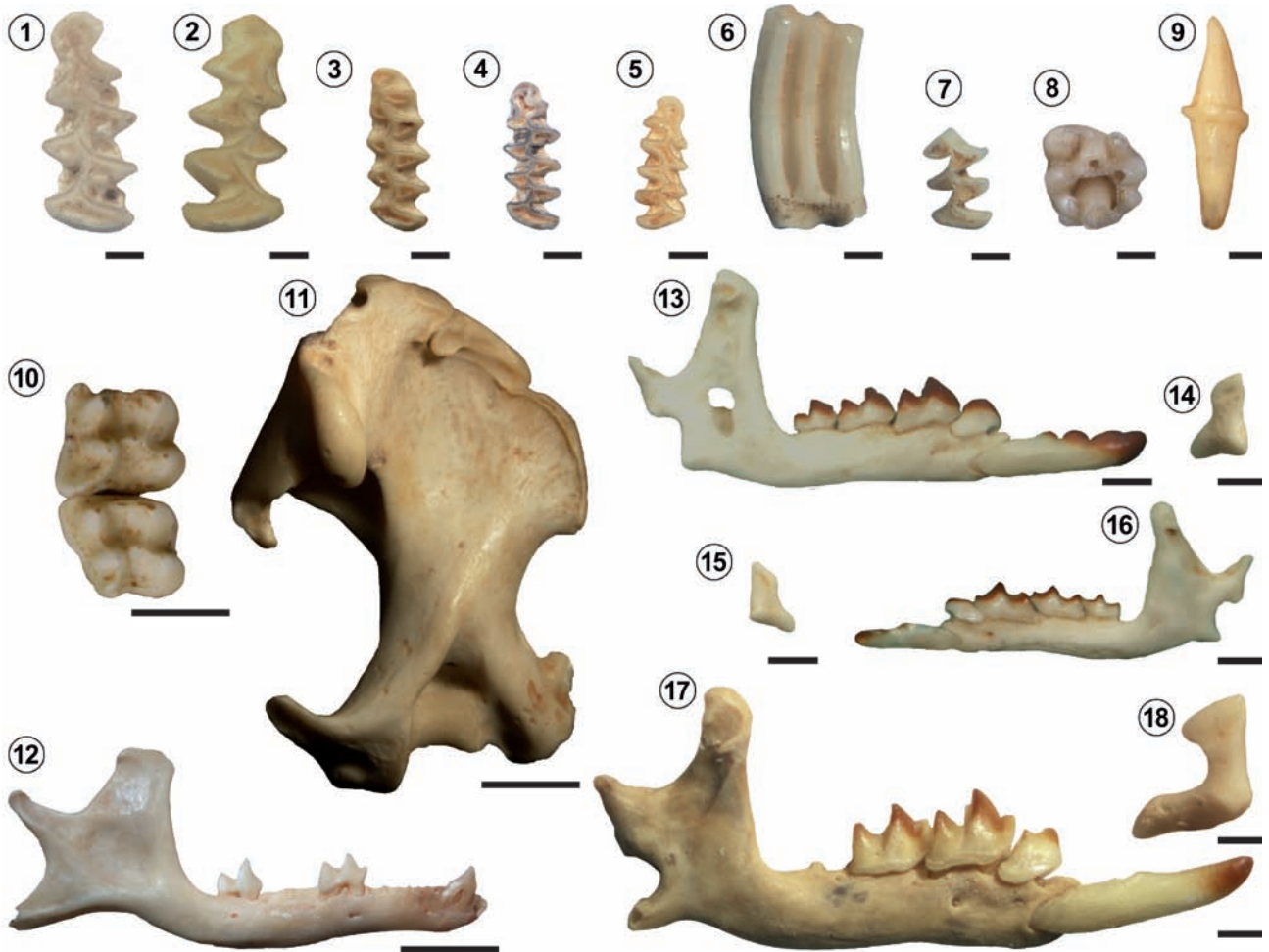


Figure 2. Small mammal remains from the Artazu VII site (Arrasate, Gipuzkoa, north of Iberian Peninsula) in occlusal view (except 6, 9, 11, 12, 13 and 17, in labial view, and 14, 15, 16, and 18, in posterior view). 1, *Arvicola amphibius* left m1; 2, *Arvicola amphibius* right m1; 3, *Microtus (Microtus) agrestis* right m1; 4, *Microtus (Microtus) arvalis* left m1; 5, *Microtus (Terricola) sp.* right m1; 6-7, *Pliomys lenki* left m3; 8, *Apodemus sylvaticus-flavicollis* left M2; 9, Chiroptera indet.; 10, *Erinaceus europaeus* right M1-M2; 11-12, *Talpa* sp. left humerus and right mandible; 13-14, *Sorex (Sorex) araneus-coronatus* right mandible; 15-16, *Sorex (Sorex) minutus* left mandible; 17-18, *Neomys* sp. right mandible. Scale bars= 0.5 mm (1-9), 5 mm (10-12), 1 mm (13-18).

abundant species is *S. (S.) araneus-coronatus*, followed by *A. sylvaticus-flavicollis* and *S. minutus*. Even so, differences can be appreciated among them. Thus, in Chamber C, *A. amphibius* and *P. lenki* disappear and the relative proportion of the remaining Arvicolinae increases. Lower Ledge A, as well as Lower Ledge K, are relatively impoverished. The taxonomic biodiversity comprises eight species, with the absence of *Neomys* sp., *P. lenki*, and *Talpa* sp., among others, and is dominated by *M. (Terricola)* sp. followed by *M. (M.) arvalis* and *S. araneus-coronatus* (Fig. 4; Tab. 1). Finally, differences between the two deposit areas exist. While *A. sapidus* does not appear in the Chamber area, Chiroptera indet. and *E. europaeus* are observed only in the Lower Ledge.

### Amphibian and reptile community changes over spits

Differences between the assemblages from Chamber and the Lower Ledge are prominent. In general, paleodiversity decreases upwards the stratigraphic column. Yet, some exceptions can be observed, as in Lower Ledge A, where paleodiversity grows again. The most important differences are found between the two structural zones. First of all, Chamber displays greater abundance of individuals than the Lower Ledge, as the minimum number of individuals is approximately twice as high (134 in the Chamber and 79 in the Lower Ledge). Moreover, although a similar number of species (nine in the Chamber and 10 in the Lower Ledge) was recorded, the taxonomy and the relative abundance of

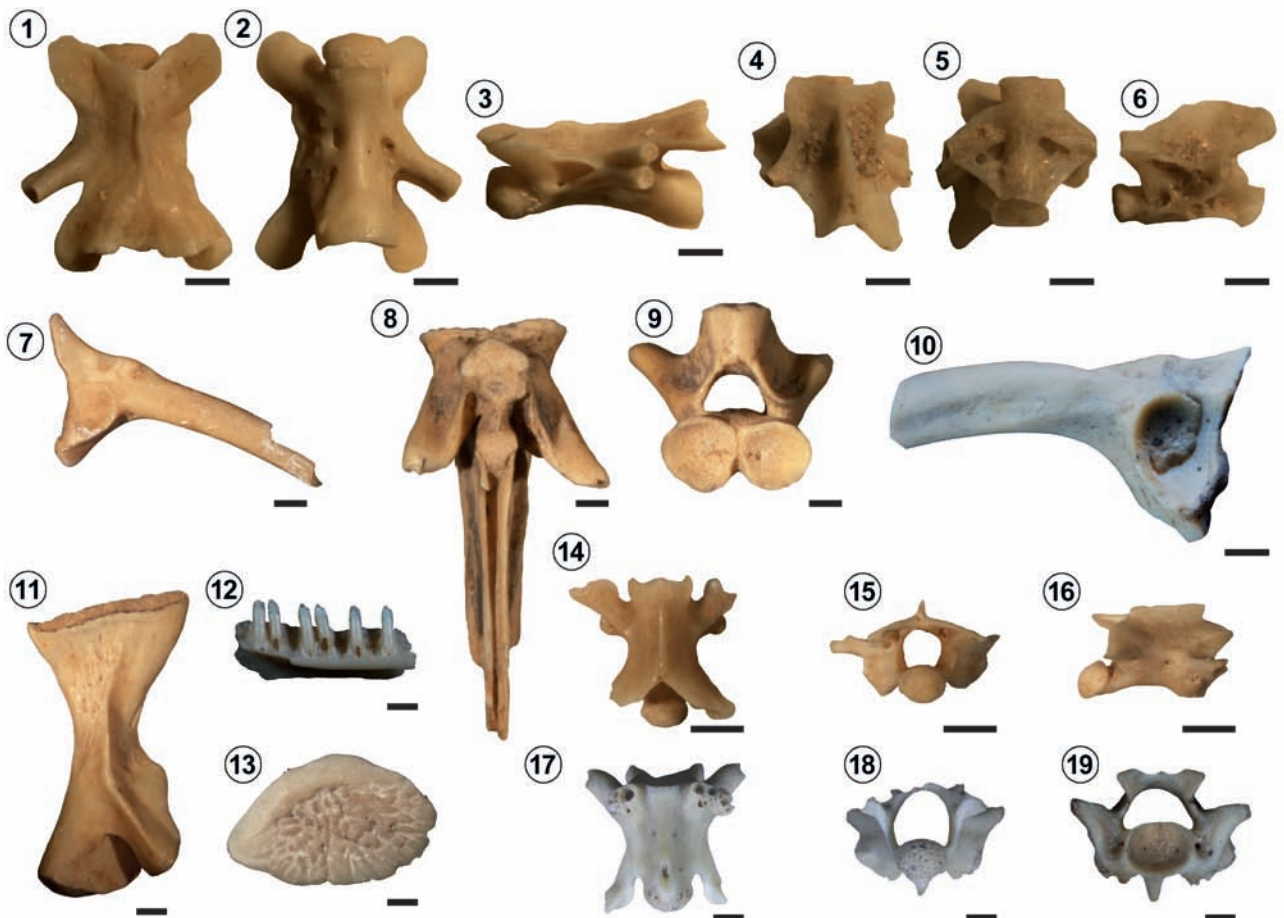


Figure 3. Some amphibian and reptile remains from the Artazu VII site (Arrasate, Gipuzkoa, northern Iberian Peninsula). 1–3, *Salamandra salamandra* trunk vertebrae, dorsal view, ventral view, left lateral view; 4–6, *Triturus* sp. trunk vertebrae, dorsal view, ventral view, right lateral view; 7, *Alytes obstetricians* right ilium, lateral view; 8–9, *Discoglossus* sp. urostyle, dorsal view, anterior view; 10, *Bufo bufo* left ilium, lateral view; 11, *Rana temporaria-iberica* right scapula, ventral view; 12, Lacertidae indet. incomplete left dentary, medial view; 13, *Anguis fragilis* osteoderm, external view; 14–16, *Coronella girondica* trunk vertebrae dorsal view, posterior view, right lateral view; 17–19, *Vipera* sp. trunk vertebrae dorsal view, posterior view, anterior view. Scale bars= 1 mm (1–9, 11–19), 0.5 mm (10).



each are very different (Fig. 5; Tab. 2). In the three samples from Chamber, the most abundant species are *B. bufo* and *R. temporaria-iberica*. While, in Chamber 1, this abundance is followed by *A. fragilis*, in Levels 5 and 3, *B. bufo* and *R. temporaria-iberica* are accompanied by Lacertidae. It is also remarkable that, in the whole stratigraphic sequence, *DiscoGLOSSUS* sp. appears exclusively in Chambers 5 and 3 (Fig. 5; Tab. 2). In the Lower Ledge, major species concentration changes occur. In the Lower Ledges L and K, eight and nine taxa are represented, respectively, with *R. temporaria-iberica*, Lacertidae and *B. bufo* being the most numerous in

descending order. The best represented taxa are repeated in Lower Ledge G but, in this case, the absence of *C. girondica*, *S. salamandra*, and *A. obstreticans* is observed, and thus this is the least diverse spit (Fig. 5; Tab. 2). Finally, in Lower Ledges C and A, the most abundant taxon is, by far, family Lacertidae, with a representation of around 70% in both cases, followed by *R. temporaria-iberica* in the first case. It is equally important to highlight the existence of *H. arborea* in Chamber 3 and in the uppermost level, and the appearance of *Triturus* sp. only in the uppermost level and in Lower Ledge K.

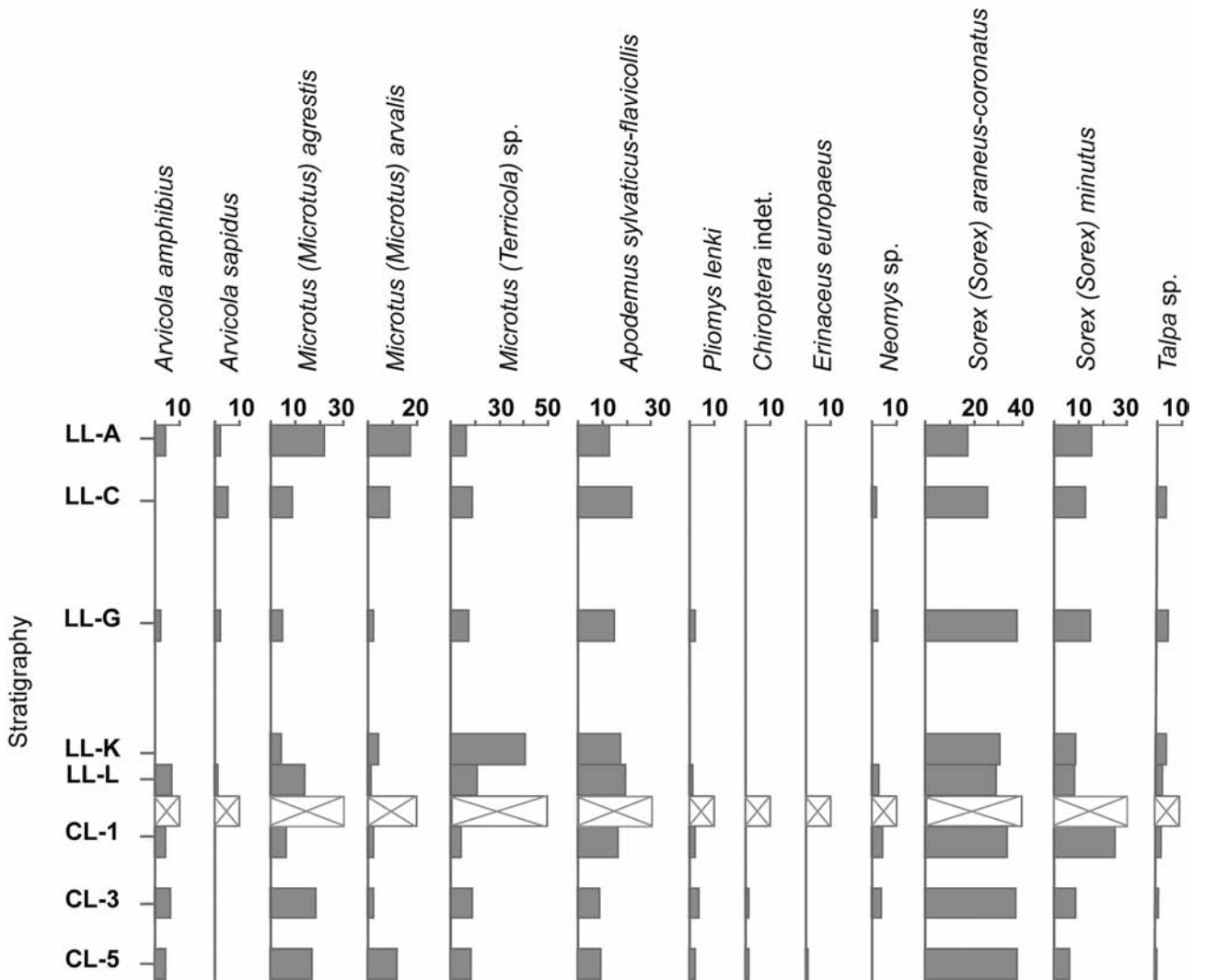


Figure 4. Relative variations in small mammal abundance across sampled levels at Artazu VII (Arrasate, Gipuzkoa, northern Iberian Peninsula), expressed as the percentage of the minimum number of individuals (MNI). Stratigraphy key as in Figure 1.

DISCUSSION

Paleoenvironment evolution

Most of the small vertebrate taxa are associated with a specific biotope and precise ecological conditions, quickly adapting to environmental changes. Therefore, according to the number of taxa (Figs. 4–6; Tabs. 1–2) and their environment requirements, paleoecological and paleoenvironmental data is inferred from the small vertebrates in Artazu VII, as can be seen in Figure 6. Given the large number of small vertebrates in this site, all the spits were considered for the paleoenvironmental reconstruction. The presence of *M. (M.) agrestis*, *M. (M.) arvalis* and *M. (Terricola) sp.* throughout the section can be representative of grassland with a

herbaceous cover or/and woodland zones. Additionally, *A. sapidus* generally moves in meadow biotopes in the presence of *A. amphibius* but can also be found in forest biotopes too. Therefore, the appearance of *A. sapidus* (only identified in the Lower Ledge area) supports this affirmation. Based only on stenoic species, woodland biotopes and relatively warm environments are represented throughout the sequence by *A. sylvaticus-flavicollis* and, in some spits, also by *E. europaeus*, *P. lenki*, and *Talpa sp.* though never in more than 25% (Fig. 6). Thus, species that indicate grassland areas are clearly predominant as they represent more than 60% of the species in all cases. Also, the record of the two species of *Sorex* genus and the *M. (Terricola)* subgenus indi-

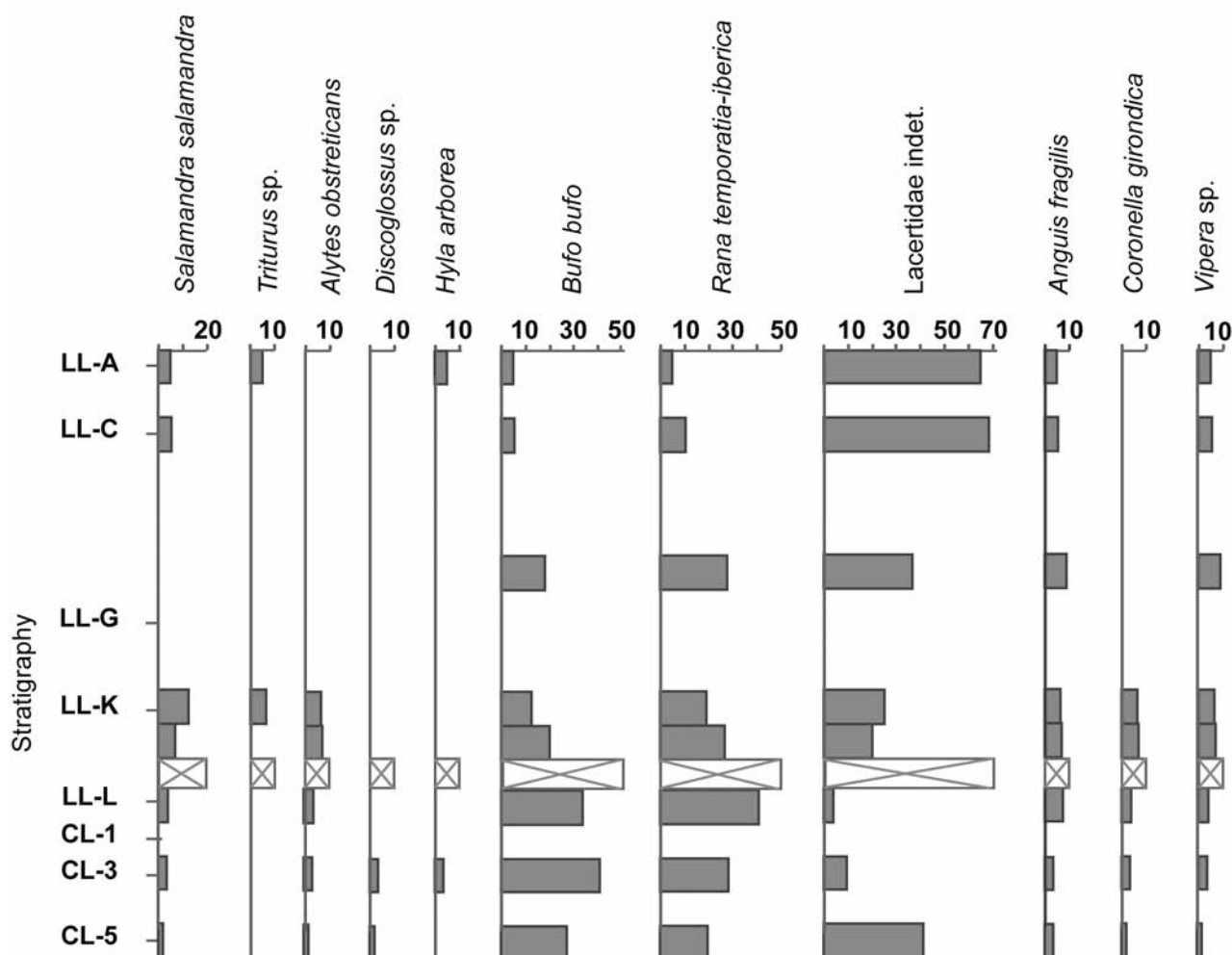


Figure 5. Relative variations in reptile and amphibian abundance across sampled levels at Artazu VII (Arrasate, Gipuzkoa, northern Iberian Peninsula), expressed as the percentage of the minimum number of individuals (MNI). Stratigraphy key as in Figure 1.

cates humid environmental conditions. Both taxa can be observed in the whole stratigraphic sequence, considering that *S. (S.) araneus-coronatus* and *S. (S.) minutus* are representative of atmospheric humidity while *M. (Terricola)* sp. is an indicative of humidity in the ground by their need to dig burrows. In this way, Chamber 5 begins at a time of lesser forest development, around 12% (Fig. 6). From Chamber 5 to the Lower Ledge L, paleoenvironmental conditions slightly improve, and the woodland biotope reaches its maximum of almost 24% biotope while humidity progressively increases (Fig. 6). From then to Lower Ledge C, the percentage of forest environment species remains more or less constant, with values of around 23%. A small descent in woodland development can be appreciated in Lower Ledge K (Fig. 6). In contrast, humidity conditions behave differently. Lower Ledge K shows an absence of species indicative of dry environmental conditions. Subsequently, in Lower Ledge G, a

small rise immediately followed by another slight descent, in Lower Ledge C, can be observed. Finally, in Lower Ledge A, a significant decrease of forest cover and a moderate increase in moisture occurs again. With only a 13% of representation, this level is the least indicative of woodland in the whole stratigraphic sequence (Fig. 6).

Similar conclusions were reached regarding the herpetological remains identified at Artazu VII. The dominant taxa (Lacertidae indet., *R. temporaria-iberica* and *B. bufo*) are inhabitants of areas with a certain plant cover, mainly broadleaf and mixed forests, near almost permanent sources of water. The presence of species associated with woodlands (*A. fragilis*, *S. salamandra* and *A. obstetricans*) is exiguous although relatively constant throughout the stratigraphic sequence. Levels 3 and 5 in Chamber would represent the moment of greatest expansion of the forest and, therefore, the warmest moments. However, the type of

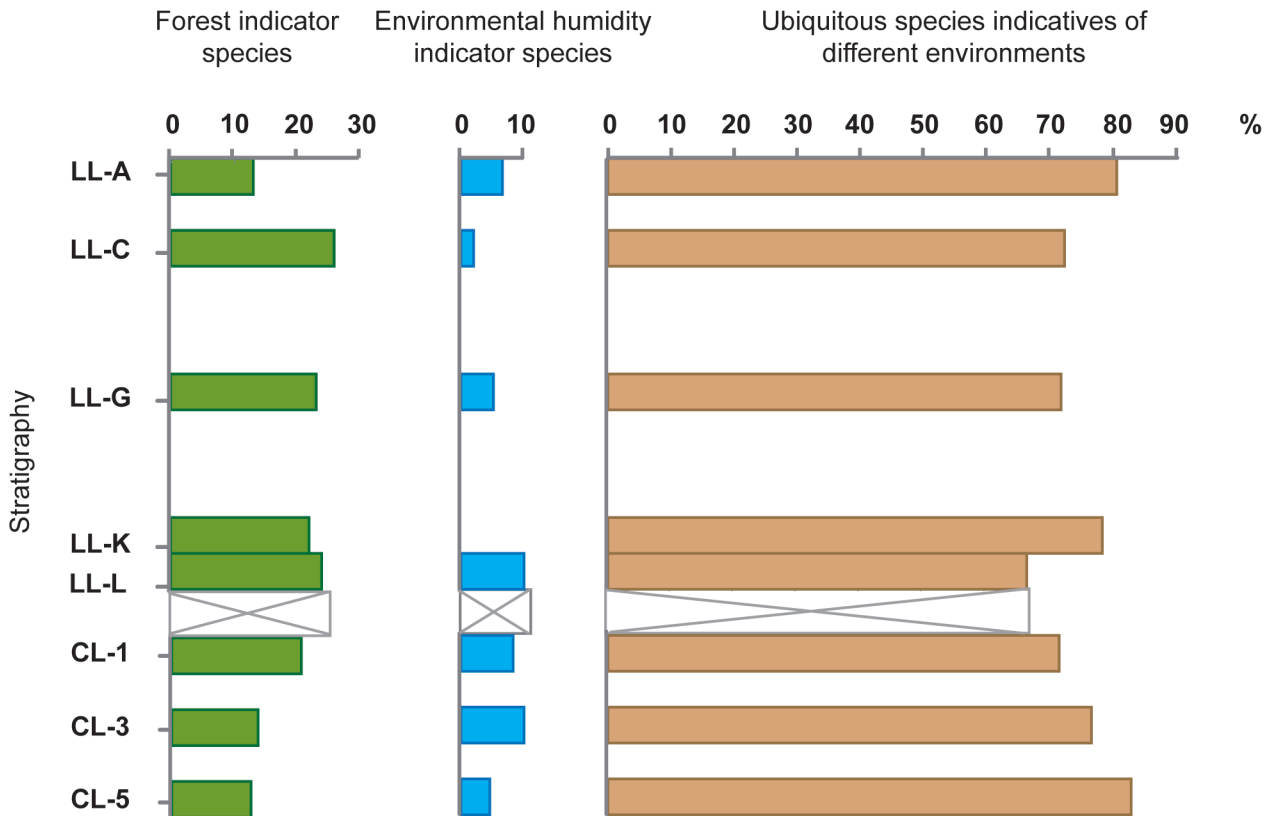


Figure 6. Paleoenvironmental reconstruction at Artazu VII (Arrasate, Gipuzkoa, northern Iberian Peninsula) based on the abundance ratio of rodent species indicative of deciduous forest compared with species indicatives of other terrains. Stratigraphy key as in Figure 1.

landscape dominant in the surroundings of the site would have been grasslands, especially humid meadows, since the majority of the identified species require environmental humidity even in the presence of permanent water sources.

To summarize, considering that the proportion of stenothermal species that indicate forest environments and relatively warm temperatures is between 12% and 26% throughout the sequence and taking into account the continuous presence of species indicating a certain degree of humidity and a watercourse (with the exception of Lower Ledge K), we can conclude that a woodland mass existed in the surroundings of Artazu VII with at least a 13% of development (Fig. 6). Even so, the vegetation was probably a mixture of grassland and forest. In addition, given the absence of species like *C. russula*, *G. glis* and *E. quercinus* that are associated with benign environmental conditions, and the absence of taxa that are indicative of the coldest stages, such as *M. (A.) oeconomicus*, the climate around Artazu VII would have been neither very warm nor very cold but relatively temperate, similar to today.

### **Comparison with other paleoenvironmental reconstructions with small mammals in the Cantabrian Range**

Many prehistoric caves with sedimentary fill containing vertebrates are known in the Cantabrian Mountain Range: at the western end, A Valina (Fernández-Rodríguez, 1989), Cova Eirós (Grandal D'Anglade, 1993) and Liñares (López, 2003); in the central sector, the best-known deposits are La Parte and Jou Puerta (Álvarez-Lao, 2014) in Asturias, and El Mirón (Cuenca-Bescós *et al.*, 2009), Peña Cabarga and Pico del Castillo (Castaños *et al.*, 2012) in Cantabria; finally, at the eastern end, Lezetxiki (Altuna, 1972), Punta Lucero (Castaños, 1988), Labeko Koba (Altuna and Mariezkurrena, 2000), Ventalaperra (Murelaga *et al.*, 2007), Lezika (Castaños *et al.*, 2009), Peña Larga (Murelaga *et al.*, 2009), Lezetxiki II (Castaños *et al.*, 2011), Kiputz IX (Castaños *et al.*, 2014), Santimamiñe (Rofes *et al.*, 2014) and Askondo (García-Ibaibarriaga *et al.*, 2015b), in the Basque Country. However, most of these deposits are younger than Artazu VII. In addition, sites like Artazu VII, which acted as a natural trap without human intervention and for which no detailed paleoenvironmental studies using small vertebrates have been carried out, are even scarcer.

In this way, and even despite not having the same

chronology of ~93 ka, Artazu VII can be compared with relatively warm levels in the nearest sites of the Northern Iberian Peninsula, like Ventalaperra (Murelaga *et al.*, 2007), Santimamiñe (Rofes *et al.*, 2014) and Askondo (García-Ibaibarriaga *et al.*, 2015b). Ventalaperra (Karrantza, Bizkaia) is dated in the second half of the upper Pleistocene at 25900 ± 2157 BP and represents from the early upper Paleolithic to the Mousterian (Murelaga *et al.*, 2007). The paleoenvironment inferred from both levels at Ventalaperra indicates that, in the thanatocoenosis process, a temperate and humid environment with woodland mass existed. The proportion of *A. sylvaticus-flavicollis* in the level attributed to the upper Paleolithic is almost 35% and, in the case of the Mousterian level, 20% (Murelaga *et al.*, 2007). Askondo (Mañaria, Bizkaia) has a chronocultural sequence from the middle Paleolithic to the Bronze Age (García-Ibaibarriaga *et al.*, 2015b). In levels related with climate improvement and therefore relatively warmer and moister climate conditions, the fossil record is dominated by *A. sylvaticus-flavicollis*, followed in descending order of MNI by *M. (M.) agrestis*, *A. amphibius*, and *S. (S.) araneus-coronatus*. In addition, levels attributed to woodland areas always display a relative abundance of between 20% and 30% of *Apodemus* genera (García-Ibaibarriaga *et al.*, 2015b). The stratigraphic sequence at Santimamiñe (Kortezubi, Bizkaia) includes a record over 20,000 years long, from the latest upper Pleistocene to the middle Holocene and representing both cold and warm climate periods (Rofes *et al.*, 2014). Levels with an abundance of 12% or more of *A. sylvaticus-flavicollis* are related with a general warming that parallels a slight advance in grasslands and the reappearance of woodlands, as can be seen in the upper Magdalenian (Level Almp; Rofes *et al.*, 2014). The tendencies described in those other deposits can also be observed at Artazu VII, considering that the *A. sylvaticus-flavicollis* representation is of between 12% and 26% throughout the sequence, and the taxa *S. (S.) araneus-coronatus* and *M. (M.) agrestis* are well recorded. There is, therefore, no doubt about the presence of a woodland mass with relatively temperate and humid conditions.

### **CONCLUSIONS**

The Cave of Artazu VII (Arrasate, northern Iberian Peninsula) is one of the better-suited deposits for the reconstruction of the upper Pleistocene paleoenvironment,

not only in the Cantabrian Region but in the whole of the Iberian Peninsula, given it acted as a natural trap with no human intervention and owing to its high biodiversity and exceptional conservation. The small vertebrate assemblage (mammals, amphibians, and reptiles) from this site enabled the reconstruction of the paleoenvironment in the surroundings at the time of infill. Eight spits representing the whole stratigraphic sequence were studied. Skeletal remains ascend to 9,644 corresponding to a minimum of 732 individuals and 24 taxa were identified. The paleoenvironmental reconstruction based on small vertebrates shows, in general, a mixture of woodland and grassland throughout the stratigraphic sequence with a certain degree of humidity in the environment (except in Lower Ledge K). It can be concluded that a continuous woodland mass with a watercourse nearby existed in the area. Moreover, the climate at the time of the formation of the deposit was neither very warm nor very cold but relatively temperate, like today. Three main phases during the upper Pleistocene were differentiated in the conditions inferred by observing the small mammals in Artazu VII. Thus, the first stage begins with the moment of the least forest development. Later, in the second phase, the woodland biotope progressively reaches its maximum expansion. Finally, woodland development declines again until it reaches a similar extension to the that of the first stage. Moreover, the correlation of this site with other paleoenvironmental reconstructions using small mammals in the same region supports this conclusion. Therefore, considering that Artazu VII is attributed to the first half of the late Pleistocene and the inferred environment is relatively warm, we propose that the deposit would correspond to a warm moment in the MIS 5c sub-stage.

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