Quaternary Research 79 (2013) 158–167

Contents lists available at SciVerse ScienceDirect

Quaternary Research

journal homepage: www.elsevier.com/locate/yqres

# Paleoenvironmental reconstruction of the early Neolithic to middle Bronze Age Peña Larga rock shelter (Álava, Spain) from the small mammal record

Juan Rofes [a,*], Mari Cruz Zuluaga [b], Xabier Murelaga [a], Javier Fernández-Eraso [c], Salvador Bailon [d], María José Iriarte [c], Luis Ángel Ortega [b], Ainhoa Alonso-Olazabal [b]

[a] *Universidad del País Vasco UPV/EHU, Facultad de Ciencia y Tecnología, Departamento de Estratigrafía y Paleontología, Apartado 644, E-48080, Bilbao, Spain*
[b] *Universidad del País Vasco UPV/EHU, Facultad de Ciencia y Tecnología, Departamento de Mineralogía y Petrología, Apartado 644, E-48080 Bilbao, Spain*
[c] *Universidad del País Vasco UPV/EHU, Facultad de Letras, Departamento de Geografía, Prehistoria y Arqueología, E-01006 Vitoria-Gasteiz, Spain*
[d] *UMR 7209–UMR 7149, CNRS Département Ecologie et Gestion de la Biodiversité (EGB), MNHN Bâtiment d'Anatomie Comparée CP55, 55 rue Buffon, 75005, Paris, France*

ARTICLE INFO

*Article history:*
Received 27 February 2012
Available online 13 December 2012

*Keywords:*
Cantabrian cordillera
Chalcolithic
Collective burials
Small vertebrates
Relative abundance
Climate
Habitat

ABSTRACT

The Peña Larga site, a rock shelter on the southern slopes of the Cantabrian cordillera (north Spain), is an archeological deposit covering nearly 4000 years, from the early Neolithic to the middle Bronze Age (Atlantic/Subboreal chronozones). It was used both as a household and as a stable, with a hiatus in the Chalcolithic when it was used as a collective sepulcher. Nearly twenty-eight thousand small vertebrate elements were recovered from its seven stratigraphic units, of which 2553 items were identified to the genus and/or species levels. The assemblage is composed of mammals, birds, reptiles, and amphibians. Of these, small mammals were used for paleoenvironmental reconstruction since they are very sensitive to climatic conditions, the sample sizes are large, and their preservation is good. Their distributions over time, measured in terms of relative abundance, serve as reliable proxies of habitat and climate change. The reconstruction of Peña Larga's past environments based on small mammals roughly coincides with the pollen and the amphibian/reptile records on the local scale, and with that of an ice core from Central Greenland on the global scale. This makes it a valuable tool for comparative purposes both in the regional and continental scales.

## Introduction

Due to its peculiar environmental and geologic conditions, prehistoric archeological sites on the Cantabrian range (northern Iberian Peninsula) are usually set in caves and rock shelters. Most of them had different uses over time, alternatively showing evidence of being temporary hunting camps, long-term occupations, and/or stabling sites. During unoccupied periods, some sites were even occasionally used as collective sepulchers (e.g., Armendáriz and Etxebarría, 1983; Carnicero, 2006; Etxebarría and Herrasti, 2007; Ruíz-Cobo et al., 2008).

Most of the large mammal remains at these cave sites are derived from human consumption, revealing for instance the hunting techniques, carcass treatment, and feeding preferences of past inhabitants. Stockbreeding is a practice largely documented as beginning in the Neolithic (Utrilla et al., 1998; Zilhao, 2001; Rojo et al., 2006), and the gradual process from a hunting to a farming economy has been recorded at many caves across the Iberian landscape (e.g., Martí et al., 1980; Zilhao, 2001; Castaños, 2004; Carretero et al., 2008; Vergès et al., 2008; Marín-Arroyo, 2010). Peña Larga (Cripán, Álava), an archeological rock shelter deposit covering nearly 4000 years of history (from the early Neolithic to the middle Bronze Age; Atlantic to Subboreal chronozones), is no exception in any of the above mentioned aspects, as extensively documented by Castaños (1997) and Fernández-Eraso (1997).

In contrast, the accumulation of small vertebrate remains in archeological sites is inversely proportional to human occupation. The presence of people scares away the predators producing the microvertebrate tanatocenosis, usually nocturnal birds of prey and/or small carnivores. Periods when caves and/or rock shelters are used for burial purposes, with scarce or null human occupation, are particularly propitious for those animals to nest at the entrances or to build burrows inside. Therefore, the digestion sub-products of birds of prey (e.g., owl pellets) and small carnivores are the main sources for microvertebrate deposition in caves (Andrews, 1990).

Unlike large mammal remains (most of them product of human selection), microvertebrate accumulations better reflect local biocenosis, despite unavoidable biases due to specific predators (Andrews, 1990). Moreover, small mammals are particularly sensitive to habitat and climatic changes and can be successfully used for the reconstruction of past environments (e.g., Bertolini et al., 1996; Pokines, 1998;

---

* Corresponding author.
*E-mail addresses:* juan.rofes@ehu.es (J. Rofes), mcruz.zuluaga@ehu.es (M.C. Zuluaga), xabier.murelaga@ehu.es (X. Murelaga), javier.fernandeze@ehu.es (J. Fernández-Eraso), salvador.bailon@mnhn.fr (S. Bailon), mariajose.iriarte@ehu.es (M.J. Iriarte), luis.ortega@ehu.es (L.Á. Ortega), ainhoa.alonso@ehu.es (A. Alonso-Olazabal).

0033-5894/$ – see front matter © 2012 University of Washington. Published by Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.yqres.2012.11.002

Repenning, 2001; Cuenca-Bescós et al., 2005; Sesé, 2005; Cuenca-Bescós et al., 2009; López-García et al., 2010, 2012).

By distributing the different small mammalian species (in terms of relative abundance) according to their current habitat and climate requirements, and plotting them against time, the aim of this paper is to propose a reconstruction of past environments of the landscape around the Peña Larga rock shelter, and to compare the results with other paleoenvironmental records on the local, regional and global scales.

## The site

The rock shelter of Peña Larga (Cripán, Álava, Spain) is located in Oligocene conglomerates on the southern slopes of the Cantabrian cordillera (Fig. 1). It lies nearly 900 m above sea level and is roughly 15 m wide by 4.30 m high, with a depth ranging between 3 and 6 m (Fig. 2A). The site was casually discovered by Cripán villagers in 1984. Five seasons of fieldwork (led by Javier Fernández-Eraso), were conducted between 1985 and 1989 (Fernández-Eraso, 1997). In addition, a small-vertebrate sampling campaign was carried out in 2008.

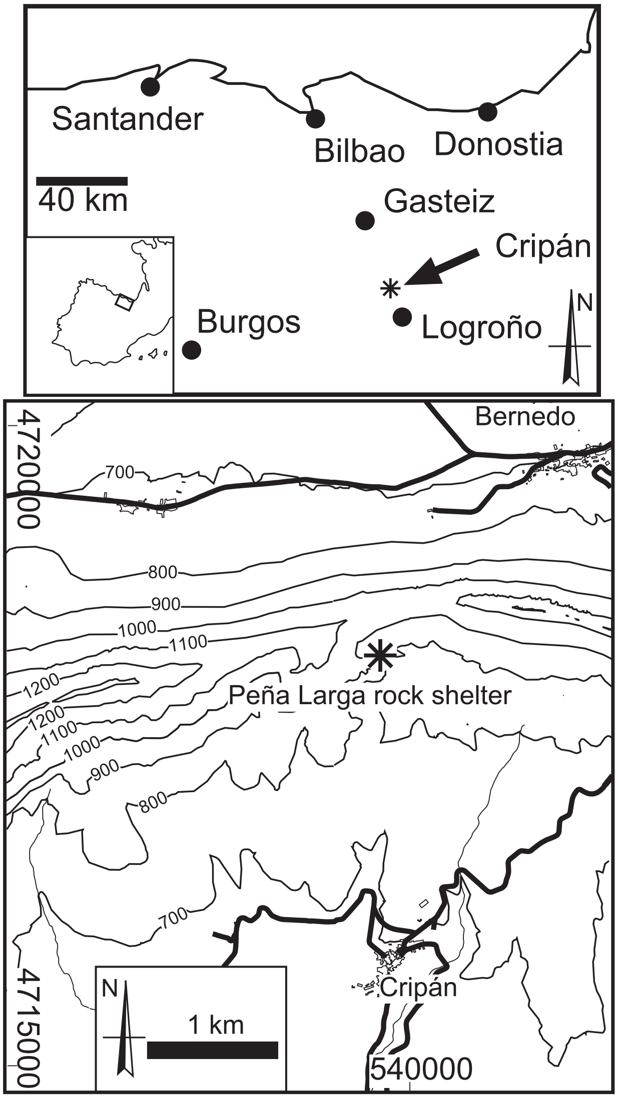

**Figure 1.** Location of the Peña Larga rock shelter in the Iberian Peninsula (up), and near the village of Cripán, Álava, Spain (down).

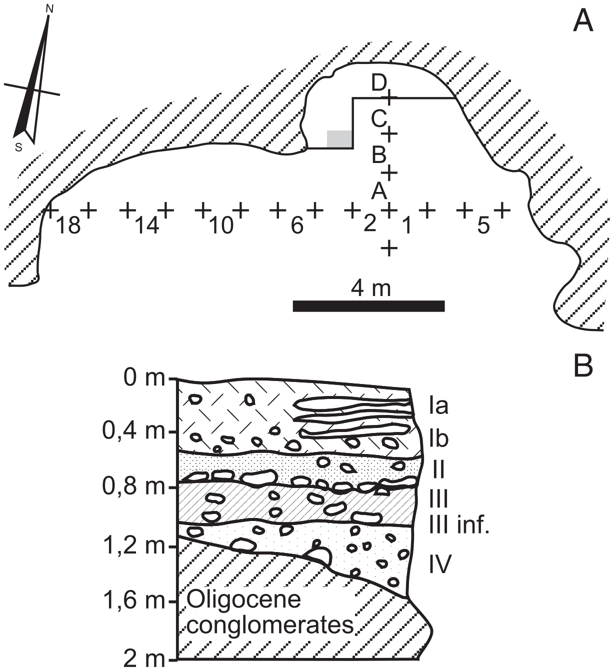

**Figure 2.** Plan view (A) and stratigraphic sequence (B) of Peña Larga (Cripán, Álava, Spain). Gray square in A is the area from where the small vertebrates were obtained.

Six chrono-cultural levels were distinguished in the ca. 166 cm stratigraphic sequence of the site on the basis of their different lithology, color, and archeological content (Fig. 2B). As lithology was extensively described in Fernández-Eraso (1997, 2007–2008), and Fernández-Eraso et al. (2010), we present here only a brief synopsis of the chronology and cultural filiations. Date calibration was accomplished using the IntCal09 data set (Reimer et al., 2009) and OxCal4.10 calibration software (Bronk Ramsey, 2009).

From bottom to top, the six stratigraphic levels of Peña Larga are: Base level, Level IV, Level Lower-III, Level III, Level II, and Level I, subdivided in Ia and Ib (Fig. 2B). The base level is sterile and it lies directly on the bedrock of the cave. Various radiocarbon assays dated Level IV to 5738–5485 cal yr BP [4890 ± 50 $^{14}$C yr BP (Beta-242781)] in its upper part (taken from a cattle molar), 6634–6412 cal yr BP [5720 ± 40 $^{14}$C yr BP (Beta-242782)] in its middle section (taken from a fragment of ovicaprid metapodial), and 7665–7509 cal yr BP [6720 ± 40 $^{14}$C yr BP (Beta-242783)] in its lowermost part (another fragmentary metapodial of ovicaprid). Culturally, it corresponds to the early and middle Neolithic, having cardiale pottery associated.

Evidence of a hearth containing human bones (which probably come from the overlying level) was recovered from Level Lower-III, together with pottery fragments and pieces of worked flint; this level can be attributed to the late Neolithic. Level III, mainly used for anthropic burials, was culturally assigned to the early Chalcolithic period. The radiocarbon date for this level, obtained from an indeterminate large mammal bone sample, is 5288–4881 cal yr BP [4450 ± 40 $^{14}$C yr BP (Beta-299948)]. Level II exhibits several large alternating lenses, some reddish, some whitish, which probably correspond to the occasional burning of barns or areas occupied by animals. A domestic cattle molar was dated to 4789–4418 cal yr BP [4040 ± 40$^{14}$C yr BP (Beta-242780)], and this level could be attributed to the late Chalcolithic.

Level I is of early and middle Bronze Age filiations. Two sublevels (Ia, Ib) were distinguished. Sublevel Ia yielded artifacts both from modern times (glazed ceramics, coins) and prehistoric periods (handmade pottery, flint flakes, bone awls, etc.). Sublevel Ib is much more compact and finer grained than Ia. Among the artifacts found in this unit, a flint fragment from a sickle deserves special attention.

The large mammalian assemblage of Peña Larga is composed of both wild and domestic species (Castaños, 1997): *Equus ferus* and/or *Equus caballus*, *Bos taurus*, *Capra hircus*, *Ovis aries*, *Cervus elaphus*, *Capreolus capreolus*, *Sus domesticus*, *Sus scrofa*, *Canis familiaris*, *Vulpes vulpes*, *Felis silvestris*, *Lynx pardina*, and *Martes* sp.

The unequal distribution of the macromammal remains in different levels of the site evidences a change in the economic strategies of its various dwellers. Peña Larga was used both as a household and as a stable from the early Neolithic to the middle Bronze Age, with a hiatus during the Chalcolithic when it was used as a collective sepulcher. The exploitation of animal resources tends more and more to a livestock economy and a progressive decrease in hunting (Castaños, 1997), as recorded in many other cave sites from the Iberian Peninsula covering the same time span (see Introduction).

## Material and methods

### *Collecting techniques*

To obtain the small vertebrate sample, an area of 0.33 $m^2$ was specifically excavated throughout the entire stratigraphic sequence during the 2008 field campaign. The sampled area corresponds to sectors 6 and 9 of the B4 square in the archeological grid (Fig. 2A). A sediment volume of 0.412 $m^3$ was initially obtained. After removal of clods, clasts, and gravel, the remaining 0.264 $m^3$ was washed and sieved using 0.5-mm and 250-μm sieves. The small vertebrates were collected from residue coarser than 0.5 mm. Fossils were sorted, classified, and studied with the aid of a binocular microscope (7×, 20×, and 40× magnifications). Most elements are isolated mandibles, skull fragments, teeth, and long bones.

### *Taphonomic remarks*

Small terrestrial predators hunted the territory near the rock shelter, providing an accurate view of the local environment, whereas larger avian predators might have transported prey longer distances to the site. Little breakage, and the light to moderate digestion observed in the arvicoline teeth, indicate that the bones were likely accumulated by an avian predator of category 1 (sensu Andrews, 1990) such as the barn owl (*Tyto alba*), which is an opportunistic rather than a selective hunter. However, there are certain exceptional cases of great to extreme modification, which means Categories IV to V on Andrews' scale (1990). In these cases, the agents of deposition were most probably small mammalian carnivores such as foxes, wildcats, and mustelids (Andrews, 1990; Matthews, 2006), all of them present in the large mammal assemblage of Peña Larga.

### *Systematic attribution and quantification*

More than 27,800 fossil items were sorted, of which 2553 were identified to the genus and/or species levels following the general criteria of small-vertebrate paleontology. Specific attributions rest mainly on diagnostic elements: first lower molars for the Arvicolinae; mandibles and isolated teeth for the Soricidae, Chiroptera and Lagomorpha; mandibles and humeri for the Talpidae; isolated teeth for the Sciuridae, Gliridae and Murinae; forelimb elements for birds; skull elements for the Lacertidae; teeth, vertebrae and osteoderms for the Anguidae; trunk vertebrae for the Colubridae; humeri and ilium for the

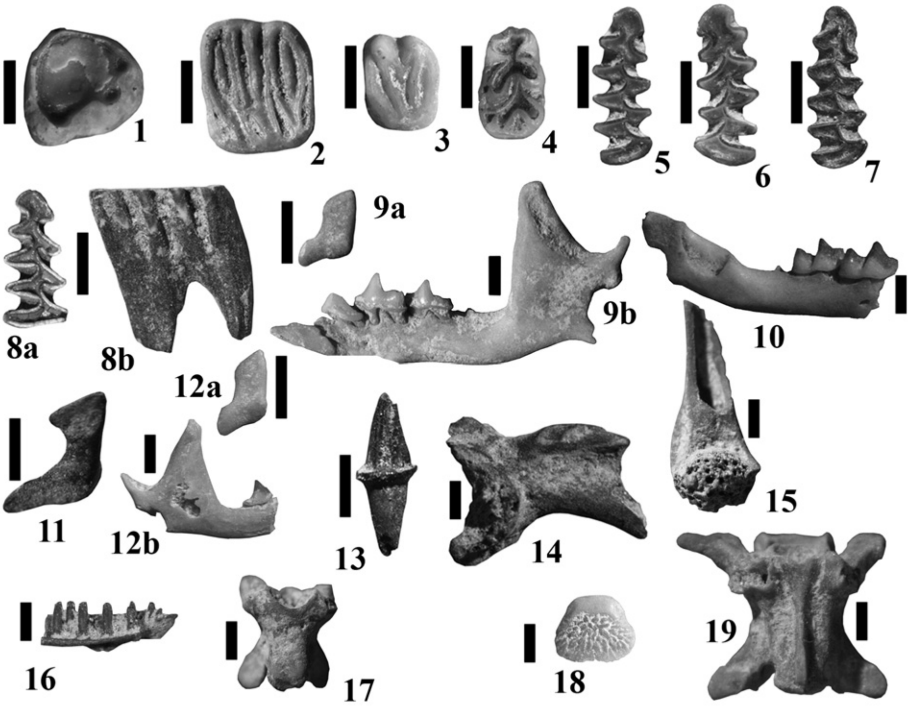

**Figure 3.** Selected specimens of small vertebrates from Peña Larga (Cripán, Álava, Spain). *Sciurus vulgaris* (1) right p4 in occlusal view; *Glis glis* (2) left M1 or M2 in occlusal view; *Eliomys quercinus* (3) left M1 or M2 in occlusal view; *Apodemus sylvaticus* (4) left m1 in occlusal view; *Microtus (M.)* gr. *arvalis-agrestis* (5) right m1 in occlusal view; *Microtus (T.) lusitanicus* (6) left m1 in occlusal view; *Chionomys nivalis* (7) right m1 in occlusal view; *Clethrionomys glareolus* (8a) right m1 in occlusal view, (8b) Idem in lingual view; *Crocidura russula* (9a) right mandibular condyle in posterior view, (9b) left mandible in lateral view; *Sorex* gr. *araneus-coronatus* (10) incomplete right mandible in lateral view; *Neomys* gr. *fodiens-anomalus* (11) right mandibular condyle in posterior view; *Sorex minutus* (12a) right mandibular condyle in posterior view, (12b) incomplete right mandible in lateral view; Chiroptera Indet. (13) canine in lateral view; *Rana* cf. *temporaria* (14) incomplete right ilium in lateral view, and (15) incomplete left humerus in anterior view; Lacertidae Indet. (16) right dentarium in lingual view; *Anguis fragilis* (17) trunk vertebrae in ventral view, and (18) osteoderm; *Natrix* sp. (19) trunk vertebrae in ventral view. Scale bar = 1 mm.

**Table 1**
Stratigraphic distribution of the small mammals MNIs from Peña Larga (Cripán, Álava, Spain).

| Cultural periods | Level | Radiocarbon ages | | *Sciurus vulgaris* | *Glis glis* | *Eliomys quercinus* | *Apodemus sylvaticus* | *Arvicola* sp. | *Microtus (M.) gr. arvalis/agrestis* | *Microtus (T.) lusitanicus* | *Chionomys nivalis* | *Clethrionomys glareolus* | *Sorex* gr. *araneus-coronatus* | *Sorex minutus* | *Neomys* gr. *fodiens-anomalus* | *Crocidura russula* | *Talpa europaea* | Chiroptera Indet. | MNI | No. of species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $^{14}$C yr BP | cal yr BP 2σ | | | | | | | | | | | | | | | | | |
| Bronze/ Modern | Ia | | | 1 | 1 | 1 | 4 | | 1 | | | | 4 | | | | 4 | 1 | 17 | 8 |
| Bronze Age | Ib | | | | | 1 | 3 | | 1 | 1 | | | 2 | | | | | 1 | 9 | 6 |
| | II | 4040 ± 40 | 4789–4418 | | 1 | | 3 | | | 1 | | | 5 | 1 | | | 2 | 1 | 14 | 7 |
| Chalcolithic | III | 4450 ± 40 | 5288–4881 | 1 | 14 | 3 | 80 | | 10 | 6 | 1 | 4 | 4 | 7 | 2 | 11 | 7 | 2 | 152 | 14 |
| | Lower-III | | | 1 | 3 | 1 | 21 | 1 | 1 | 1 | | 1 | 2 | 2 | | 3 | 1 | 2 | 40 | 13 |
| Neolithic | IV | 4890 ± 50<br>5720 ± 40<br>6720 ± 40 | 5738–5485<br>6634–6412<br>7665–7509 | | 1 | 2 | 10 | | | 3 | | 1 | 2 | | | 3 | 7 | 1 | 30 | 10 |

From left to right, columns are: Cultural periods, identified by their archeological content; Level, stratigraphic level; Radiocarbon ages, after Fernández-Eraso et al. (2010), and calibrated at 95.4% confidence intervals; next fifteen columns are the small mammal taxa; MNI is the minimal number of individuals in each level; N. of species is the number of taxa in each level.

amphibians. The taxonomic classification for small mammals follows Wilson and Reeder (2005), and that for amphibians and reptiles follows Speybroeck and Crochet (2007).

Given the taphonomic nature of the deposit (see above), the minimal number of individuals (MNI) per species should be a reasonably good quantitative measure to reconstruct past environments. The MNI of the small vertebrate record was calculated based on the amounts of a specific diagnostic tooth (e.g., first lower molar in arvicolines) or some equally identifiable cranial or post-cranial element for small mammals (rodents, insectivores and chiropterans), birds, reptiles, and amphibians. The low number and lack of precise assignations (i.e., to the species level) of bird, reptile, and amphibian elements from Peña Larga make them unsuitable for paleoenvironmental reconstructions.

There is classical debate on whether the NISP (Number of identified specimens) or the MNI (Minimal number of individuals) is a better method to quantify a given sample (Grayson, 1984). Both measures have advantages and drawbacks (Marshall and Pilgram, 1993), but the most frequently used among scholars dealing with small mammals and paleoenvironmental reconstructions is the MNI, given the inability in attributing some cranial and post-cranial specimens to a specific taxon, i.e., the unrooted teeth different from m1 in medium-sized arvicolines (Pokines, 1998; Cuenca-Bescós et al., 2005, 2009; López-García et al., 2010; Cuenca-Bescós et al., 2011; López-García et al., 2012).

### *Habitat types and climatic categories*

Following Cuenca-Bescós et al. (2009), we assigned Peña Larga's small mammals to six habitat types based on their environmental affinities. Being a relatively recent site, all the Peña Larga fauna is extant, which means there is little doubt in the species–habitat correlations. Nevertheless, this classification lacks sharp boundaries, and, as with many other natural borders, transitions are gradual (ecotones). The habitat types are described below.

1. Forest: woodland, scrub forest, and woodland edges. Mature forest including woodland margins and patchy forest with moderate ground cover.
2. Humid meadow: evergreen meadows with dense pastures and suitable topsoil. It indicates humid conditions.
3. Grassland: grassland or open meadow; that is, meadows under seasonal climatic change. It indicates relatively dry conditions.
4. Rocky: highland and/or alpine, comprising species living in steppe grasslands with rocky substrates, usually above timberline.
5. Water: streams, lakes, ponds and marshes. It indicates abundant surface water, either running or stagnant.
6. Cave: inhabited by cave-dwellers, sporadic or permanent, such as bats.

To evaluate the climatic requirements of the small mammals from Peña Larga, we divided our taxa in two major categories, which are detailed as follows:

1. Cold: It ranges from the severe, steppe climatic conditions typical of the glacial advances (if dominant) to periods of cool or temperate weather (if not dominant). Rocky and humid meadow habitats are, characteristic of this category.
2. Warm: If dominant, it indicates warm, Mediterranean conditions. Forested landscapes and grasslands are typical of this climatic category.

Data on the habitat and climatic preferences of extant species were taken from Janeau and Aulagnier (1997), Pokines (1998), Cuenca-Bescós et al. (2005, 2009), Palomo and Gisbert (2005), Sesé (2005), and Rofes and Cuenca-Bescós (2011).

## Results

### Small vertebrate assemblage

The small vertebrate fauna from Peña Larga was extensively documented elsewhere (Murelaga et al., 2009). Therefore, here we only synthesize the information besides adding some previously omitted species and a few environmental remarks. The small vertebrates from Peña Larga comprise 21 taxa: four soricids (*Sorex minutus*, *Sorex* gr. *araneus-coronatus*, *Neomys* gr. *fodiens-anomalus* and *Crocidura russula*); one talpid (*Talpa europaea*); one sciurid (*Sciurus vulgaris*); two glirids (*Glis glis* and *Eliomys quercinus*); six murids (*Apodemus sylvaticus*, *Microtus* (*Microtus*) gr. *arvalis-agrestis*, *M.* (*Terricola*) *lusitanicus*, *Chionomys nivalis*, *Clethrionomys glareolus*, and *Arvicola* sp.); Chiroptera indet.; one leporid (*Oryctolagus cunniculus*); one amphibian (cf. *Rana temporaria*); three reptiles (cf. *Podarcis*, *Anguis fragilis*, and *Natrix* sp.); and Passeriformes indet. Figure 3 shows selected specimens of nearly all the small vertebrates recovered from Peña Larga.

From the non-mammalian assemblage, it is worth mentioning the ecological requirements of the common frog (*R. temporaria*) and the slow worm (*A. fragilis*). *Rana temporaria* is a species commonly found at Quaternary deposits of Atlantic Europe; beech forests are its main habitat in the Basque Country, where it is continuously active throughout the year (Bea et al., 1986; Pleguezuelos et al., 2004). However, it must be stated that this species lives in a wide variety of habitats along Europe, and, in some cases, it does hibernate during cold episodes (Arnold and Ovenden, 2002).

*A. fragilis* is a humid-condition, cold-tolerant reptile that, along with the common frog, currently inhabits the Eurosiberian region of Iberia. It is active from March to October and is commonly found both in open meadows and seasonal forests (Galán, 2002; Pleguezuelos et al., 2004).

### Small mammals and paleoenvironmental reconstructions

After calculating the MNI (262) of the different species of small mammals, the species were ordered by stratigraphic levels covering the Neolithic, Chalcolithic, Bronze, and Bronze/modern periods. All these data are summarized in Table 1, including radiocarbon dates whenever possible. The NISP is also provided in Table 2. Data on the habitat and climatic preferences of the currently living species found in Peña Larga are summarized in Table 3.

Thirty-one remains of *Oryctolagus cuniculus* were identified in the sample. They are present throughout the sequence except Sublevel Ib, reaching an abundance peak in Level II. Rabbits are not included in Tables 1 and 2 because, unlike other small mammals, they do not provide precise paleoenvironmental information, and their presence at the site (or at least part of it) could be associated with human consumption.

The amount of samples studied and the good preservation of small mammal bones (low digestion traces, moderate breakage, and preserved skeletal elements) suggest that they accumulated naturally, mainly due to owls and to much lesser extent small carnivores. Therefore, the small mammalian assemblage should be a feasible means of reconstructing at least part of the biocenosis around Peña Larga, and small mammals serve as proxies of habitat and climate change due to their sensitivity to environmental conditions (Bertolini et al., 1996; Pokines, 1998; Cuenca-Bescós et al., 2005; Sesé, 2005; Cuenca-Bescós et al., 2009; López-García et al., 2010, 2012).

The number of taxa (species richness) and the MNI percentage per species (relative abundance) are both measures of information abstracted from habitats, in that habitats with extreme climates and poor vegetation tend to be dominated by small numbers of species with high amounts of individuals, whereas more equable habitats with complex vegetation have larger number of species but no single species is dominant; thus, landscape complexity is correlated with

**Table 2**
Stratigraphic distribution of the small mammals NISPs from Peña Larga (Cripán, Álava, Spain).

| Cultural periods | Level | Radiocarbon ages | | *Sciurus vulgaris* | *Glis glis* | *Eliomys quercinus* | *Apodemus sylvaticus* | *Arvicola* sp. | *Microtus (M.)* gr. *arvalis/agrestis*[a] | *Microtus (T.) lusitanicus*[a] | *Chionomys nivalis*[a] | *Clethrionomys glareolus* | *Sorex* gr. *araneus-coronatus* | *Sorex minutus* | *Neomys* gr. *fodiens-anomalus* | *Crocidura russula* | *Talpa europaea* | Chiroptera Indet. | NISP | No. of species |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $^{14}$C yr BP | cal yr BP 2σ | | | | | | | | | | | | | | | | | |
| Bronze/Modern | Ia | | | 1 | 3 | 1 | 46 | | 24 | | | | 8 | | | | 10 | 1 | 94 | 8 |
| Bronze Age | Ib | | | | | 1 | 31 | | 6 | 2 | | | 2 | | | | | 3 | 45 | 6 |
| | II | 4040 ± 40 | 4789–4418 | | 8 | | 33 | | | 26 | | | 9 | 1 | | | 17 | 1 | 95 | 7 |
| Chalcolithic | III | 4450 ± 40 | 5288–4881 | 1 | 161 | 48 | 957 | | 255 | 152 | 4 | 9 | 7 | 11 | 2 | 20 | 148 | 5 | 1780 | 14 |
| | Lower-III | | | 1 | 41 | 12 | 246 | 1 | 22 | 42 | | 1 | 9 | 2 | | 9 | 21 | 6 | 413 | 13 |
| Neolithic | IV | 4890 ± 50<br>5720 ± 40<br>6720 ± 40 | 5738–5485<br>6634–6412<br>7665–7509 | | 1 | 15 | 117 | | | 69 | | 2 | 4 | | | 4 | 35 | 2 | 249 | 10 |

From left to right, columns are: Cultural periods, identified by their archeological content; Level, stratigraphic level; Radiocarbon ages, after Fernández-Eraso et al. (2010), and calibrated at 95.4% confidence intervals; next fifteen columns are the small mammal taxa; NISP is the number of identified specimens in each level; N. of species is the number of taxa in each level.

[a] These numbers were estimated by extrapolating the MNI proportions to the samples of indeterminate small-sized arvicoline unrooted teeth.

**Table 3**
Faunal list of the small mammals studied in this paper.

| Small mammal species | | Habitat | | | | | | Climate | |
|---|---|---|---|---|---|---|---|---|---|
| Scientific names | Common names | Rocky | Humid meadow | Grassland | Water | Forest | Cave | Warm | Cold |
| *Sciurus vulgaris* | Red squirrel | | | | | X | | X | |
| *Glis glis* | Fat dormouse | | | | | X | | X | |
| *Eliomys quercinus* | Garden dormouse | | | | | X | | X | |
| *Apodemus sylvaticus* | Wood mouse | | | | | X | | X | |
| *Arvicola* sp. | Water vole | | X | | X | | | | |
| *Microtus (M.)* gr. *arvalis-agrestis* | Common/Field vole | | | X | | | | X | |
| *Microtus (T.) lusitanicus* | Lusitanian pine vole | | X | | | | | | X |
| *Chionomys nivalis* | Snow vole | X | | | | | | | X |
| *Clethrionomys glareolus* | Bank vole | | | | | X | | X | |
| *Sorex* gr. *araneus-coronatus* | Common/Millet's shrew | | X | | | | | | X |
| *Sorex minutus* | Pygmy shrew | | X | | | | | | X |
| *Neomys* gr. *fodiens-anomalus* | Water shrew | | | | X | | | | |
| *Crocidura russula* | Greater white-toothed shrew | | | X | | | | X | |
| *Talpa europaea* | Common mole | | X | | | | | | |
| Chiroptera Indet. | Bats | | | | | | X | | |

Columns third to eighth are the habitat types; the last two are climatic categories.

high specific diversity and climatic equitability (Cuenca-Bescós et al., 2009, 2011).

### Small mammalian community changes over time

Figure 4 (based on data from Table 1) shows the stratigraphic and quantitative distribution of the Peña Larga small mammals. Following the stratigraphic sequence from bottom to top, in Level IV the association is composed, in descending order of relative abundance (as defined above), most of all by *A. sylvaticus*, *T. europea*, *Microtus* (*Terricola*) *lusitanicus* and *C. russula*, and, to a lesser extent, by *E. quercinus*, *Sorex* gr. *araneus/coronatus*, *Cl. glareolus*, *G. glis*, and Chiroptera. In spite of its three different radiocarbon dates (see Table 1), the small mammal sample from this level is uniform.

In Level Lower-III, the most abundant taxon is by far *Apodemus*, its relative abundance considerably rising from the previous level. Second in abundance are *G. glis* and *C. russula*, closely followed by *S.* gr. *araneus/coronatus*, Chiroptera, and *S. minutus*, the latter species appearing in this level. *Talpa europaea* drastically drops together with *M. (T.) lusitanicus* and *E. quercinus*, the latter two in a lesser extent. *Microtus* (*Microtus*) gr. *arvalis/agrestis*, *Sc. vulgaris*, and *Arvicola* also appear in this level. A first chiropteran peak occurs.

Level III has the highest MNIs of the sequence for ten out of fifteen species (Table 1). *Arvicola* disappears from the record, but *Ch. nivalis* and *Neomys* gr. *fodiens/anomalus* takes its place. In terms of relative abundance, the descending list is as follows: *A. sylvaticus*, *G. glis*, *C. russula*, *M. (M.)* gr. *arvalis/agrestis*, *T. europaea*, *S. minutus*, *M. (T.) lusitanicus*, *S.* gr. *araneus/coronatus*, *Cl. glareolus*, *E. quercinus*, *N.* gr. *fodiens/anomalus*, *Ch. nivalis*, and *S. vulgaris*.

Level II exhibits the most dramatic reduction in species of the entire sequence. *Sciurus vulgaris*, *E. quercinus*, *M.* (*M.*) *gr. arvalis/agrestis*, *Ch. nivalis*, *Cl. glareolus*, *N. fodiens/anomalus*, and *C. russula* disappear from the record. The MNI of the remaining taxa falls notably, with the exception of *S.* gr. *araneus/coronatus* (Table 1). Both proportionally and in the MNI, the most abundant taxon is, for the first time, *S.* gr. *araneus/coronatus*, closely followed by *A. sylvaticus* and *T. europaea*.

In Sublevel Ib the MNIs are still low (Table 1) and *Apodemus* turns to dominate the record. The reappearance of *E. quercinus* and *M. (M.)* gr. *arvalis/agrestis* is remarkable and to the detriment of *S.* gr. *araneus/coronatus*. *Glis glis*, *S. minutus*, and *T. europaea* disappear, and a new chiropteran peak is recorded. In Sublevel Ia a slight recovery in the number of species is observed with the reappearance of *Sc. vulgaris*, *G. glis* and *T. europaea*, although *M. (T.) lusitanicus* disappears. The most abundant taxa are *A. sylvaticus*, *S.* gr. *araneus/coronatus* and *T. europaea*.

The dominant species throughout the entire sequence, with the exception of Level II, is *A. sylvaticus*, and it is also numerically and proportionally the most stable taxon of the assemblage. The next are *S.* gr. *araneus/coronatus* and the chiropterans (both also present along the whole sequence), followed by *T. europaea*, *Microtus* (*T.*) *lusitanicus* and the glirids, especially *G. glis*.

It is evident that Level II marks an inflexion point in species richness, with low values from here on and only a small upturn in the latest level (Ia). Richness peaks, in contrast, are recorded in Levels III and Lower-III (14 and 13 species, respectively). In this sense, a simple linear regression (Grayson, 1984) has been performed to evaluate the relationship between sample size (measured as MNI) and the number of species per level. The resulting bivariate plot is shown in Figure 5. The high value of the coefficient of determination ($R^2 = 0.8649$) means that sample size and species richness are strongly correlated, and that richness is mostly driven by the size of the sample (not environment) along the entire sequence. Therefore, in this case, only the relative abundance of taxa per level must be considered for paleoenvironmental reconstructions.

From a taphonomic perspective, it is very difficult to determine the span of inoccupation periods. We can reasonably state that the inoccupation of Level III was longer than any other, because of both it is the only one with human burials and it is the one with the largest amount of small vertebrates recovered (77% of the identified specimens). However, we cannot discard some other, probably shorter, inoccupation episodes along the rest of the sequence. The modern experience with the accumulation of owl pellets show that, in only 30 years, it is possible to get thousands of owl pellets from an unoccupied house (Gloria Cuenca-Bescós, personal communication).

### Habitat and climate evolution at Peña Larga

Figure 6 (constructed by crossing data from Fig. 4 and Table 3) reconstructs Peña Larga habitat and climate distribution based on changes in the small mammalian community over time. First is the pre-eminence of woodlands and warm conditions throughout the sequence (with the important exception of Level II), both determined by the great representation of wood mouse (*A. sylvaticus*) and glirids (*G. glis*, *E. quercinus*) in the record compared to the other small mammals. Periods of landscape opening and oscillations between temperate/humid meadow and warm/dry meadow (grassland) are given, over all, by the alternation in representation of the red-toothed shrews (*Sorex* gr. *araneus/coronatus*, *S. minutus*) and the white-toothed shrew (*C. russula*), and to a lesser extent by the alternation of two species

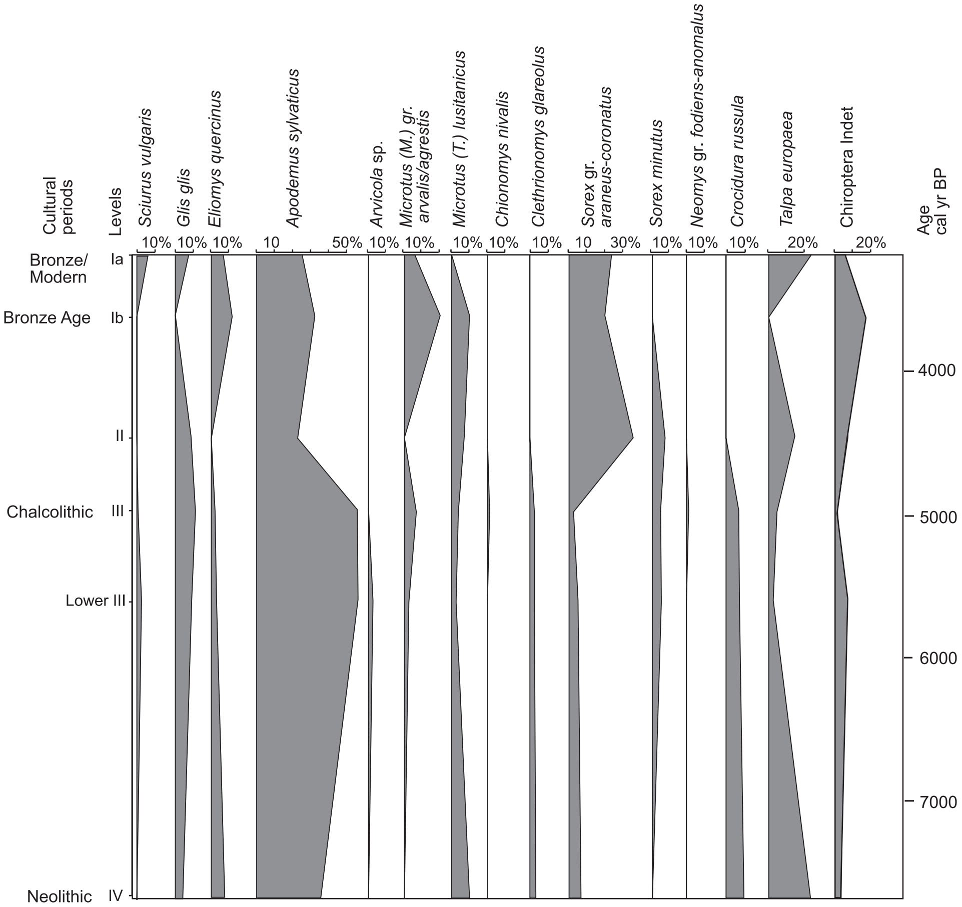

**Figure 4.** Quantitative distribution of the small mammals from Peña Larga (Cripán, Álava, Spain) from the early Neolithic to the middle Bronze Age. From left to right, columns represent the cultural periods defined by their archeological contents, the stratigraphic levels of Peña Larga, the fifteen taxa recorded at the site, and the ages expressed in cal yr BP. Graphics represent the relative species abundances variations through time expressed in terms of the percentage of the minimal number of individuals (MNI) in each level (% of the MNIs given at the top of each column).

of voles: *Microtus* (*T.*) *lusitanicus* and *M.* (*M.*) *arvalis/agrestis* (see Table 3).

*Talpa europaea* is also significant in humid meadow representation. The relative abundance of this species together with those of *Sorex* determines the humid meadow and cold peaks of Level II.

As expected, a rocky habitat (cold and dry) is poorly represented at Peña Larga, with just a few specimens of *Ch. nivalis* in Level III. Also scarce are taxa related to aquatic environments (e.g., *Arvicola*, *Neomys*), only being present in the lower half of the sequence.

Due to their strong relation to the substrate, Cuenca-Bescós et al. (2009) suggest not including chiropterans in any of the main habitat types. However, it is worth noting that their relative abundance peaks in the sequence coincide with advances of forest and warm conditions (Levels Lower-III and Ib).

To summarize, we have a global perspective for the environment of Peña Larga (Fig. 6) that begins during the early and middle Neolithic (Level IV) with a temperate phase in which forest prevails but humid meadows are also important. Towards the end of the Neolithic (Lower-III), conditions became warmer, with woodland reaching its peak to the detriment of humid meadows. At the beginning of the Chalcolithic (Level III), warm conditions persisted and grasslands slightly gained terrain to humid meadows and woodlands. Towards the middle or end of this period (Level II), a relatively cold phase began, with a great advance of humid meadows to the detriment of woodlands and grasslands. The open humid landscape exceeded by far the limit reached during the early/middle Neolithic.

The environmental scenario of Sublevels Ib and Ia is quite different from that observed after the mild phase of Level IV (Levels Lower-III and III), with forest and grassland upturns in Sublevel Ib and a considerable recovering of humid meadows in Sublevel Ia.

The presence of *Ch. nivalis* in Level III is noteworthy as it is the only species representing the rocky habitat in the assemblage. As for El

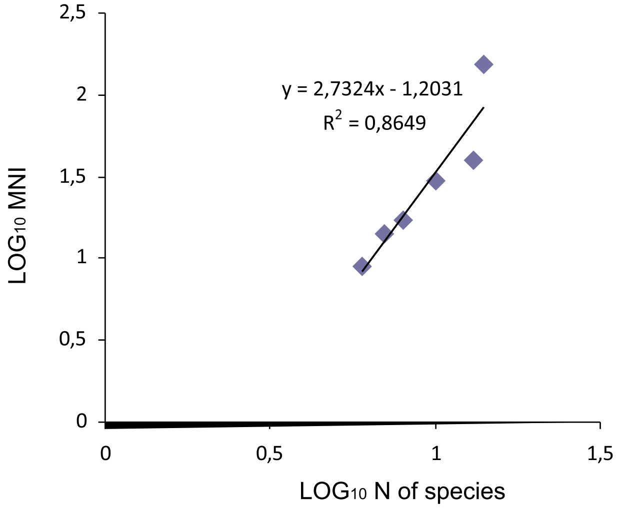

**Figure 5.** Scatter diagram showing the relationship between $\log_{10}$ number of species (x) and $\text{Log}_{10}$ minimal number of individuals (y) per level in Peña Larga. Diamonds are the points of interception between variables, the line is the regression slope, and $R^2$ is the coefficient of determination.

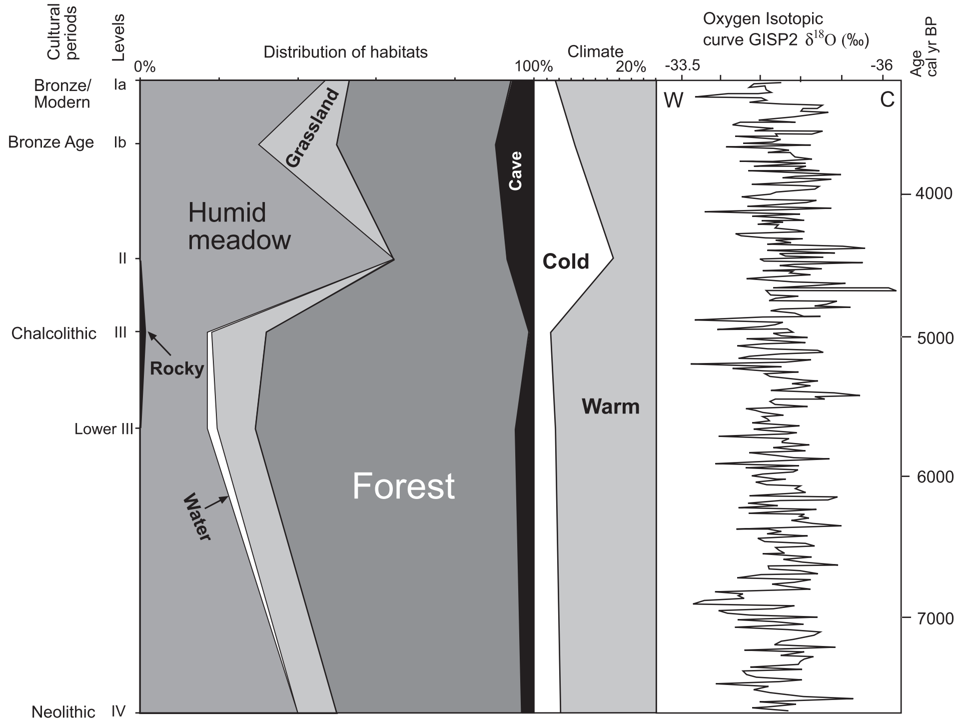

**Figure 6.** Paleoenvironmental evolution of Peña Larga (Cripán, Álava, Spain) based on the distribution of habitat types and climatic oscillations along the stratigraphic sequence. From left to right, columns represent the cultural periods defined by their archeological contents, the stratigraphic levels of Peña Larga, the species grouped by their habitat and climatic requirements, the $\delta^{18}O$ curve obtained from a deep ice core of central Greenland (GISP2, Grootes et al., 1993), and the ages expressed in cal yr BP. Dates for Sublevels Ia–Ib were estimated. W, warm; C, cold.

Mirón (Cuenca-Bescós et al., 2009), this element could anticipate the arrival of the subsequent cold phase (Level II), which coincides with the short "Ice Age" recorded during the Chalcolithic/early Bronze Age transition (Bond et al., 1997, 2001).

Warm conditions and the increase in open landscapes during the early Chalcolithic would have been optimal for the proliferation of open-air households and the use of caves and rock shelters for burial purposes, as in the Peña Larga Level III.

## Discussion

Comparing our results with those obtained from the palynological study of Peña Larga (Iriarte, 1997: Fig. 1 therein), we generally find more coincidences than contradictions.

Iriarte (1997) emphasizes, above all, the importance of spores and filicales at the site, its presence reflecting environmental humidity for the entire sequence. Quantitative evolution of this kind of pollen at levels ranging from the early Neolithic to the middle Bronze Age shows a trend very similar to that of the humid meadow habitat obtained from the small mammal distribution. Likewise, the evolution of the poaceae pollen (herbaceous flora) perfectly correlates with that of grasslands. The same occurs with the arboreal pollen and the forest habitat, which exhibit opposite trends only in Sublevel Ib.

There is no contradiction between pollen and small mammals in the reconstruction of the Peña Larga environment during the Neolithic and Chalcolithic periods (Levels IV to II). The relatively cold and humid phase of Level II is perfectly reflected, with a drastic fall in numbers in the case of small mammals, and a rise in spores and filicales to the detriment of arboreal pollen and poaceae.

It is undeniable that, during the Chalcolithic and the Bronze Age, agriculture and stockbreeding spread drastically on the Iberian Peninsula (Barrios, 2004; Fabián et al., 2006; Cuenca-Bescós et al., 2009). Peña Larga is no exception, and to this could be attributed the decrease in woodland detected in the pollen analysis of Sublevel Ib and below (Iriarte, 1997). From the point of view of the small mammalian association, in this sublevel there is an upturn in forest habitat and warm conditions (compared to Level II), but species amounts remain low. This could be explained either by a climatic change and/or, more likely, by an increase of human activity in the surroundings. We have to bear in mind that the sampling of small mammals accumulated by birds of prey was carried out on a much larger scale than that of pollen, which could generate apparent contradictions.

There are pollen studies reflecting dry conditions for the Chalcolithic/Bronze Age transition on the Iberian Peninsula (e.g., Burjachs and López Sáez, 2003; López-Sáez and López-García, 2003; Fabián et al., 2006). This is probably true for the markedly seasonal North Plateau, where those studies were carried out. However, this conclusion should not be extrapolated to the well-known humid Cantabrian realm (e.g., Pokines, 1998; Cuenca-Bescós et al., 2009).

As stated above, the scarcity of amphibians and reptiles in Peña Largas's archeological record led to the methodological decision of leaving them out of the paleoenvironmental reconstructions. Nevertheless, the presence of both *R. temporaria* and, particularly, of *A. fragilis* further support the predominance of forested and humid habitats throughout the sequence.

On a regional perspective, the Peña Larga's environmental reconstruction roughly coincides with that of the upper part of El Mirón in Cantabria (Cuenca-Bescós et al., 2009), with the predominance of woodland and warm conditions for the Neolithic/Chalcolithic period, and the expansion of humid meadows during the Bronze Age. On the continental and global scales, the Peña Larga sequence reflects a mostly warm period within the Holocene Climatic Optimum.

Deep ice cores from central Greenland provide a long reliable climate record, which extends back to 105 ka (Grootes et al., 1993). We have correlated our data on habitat and climate distribution from Peña Larga with the $\delta^{18}O$ curve obtained from the Greenland Ice Sheet Project 2 (GISP2). We correlated the lower part of the curve with the calibrated radiocarbon ages given in Table 1 (levels IV–II), and the remaining with estimated dates for the early and middle Bronze Age (Sublevels Ia–Ib). The GISP2 $\delta^{18}$O curve in Figure 6 shows a relatively stable warm/temperate scenario for Levels IV to III, and then a cooling towards Level II. This cold episode is especially meaningful as it roughly coincides with the relatively cold humid meadow expansion during the Chalcolithic/Bronze Age transition (Level II) at Peña Larga. This short "Ice Age" is well documented by Bond et al. (1997, 2001), as the Holocene Cold Event 3 (HCE 3) by means of the record of lithic fragments (fresh volcanic glass from Iceland and hematite stained grains, both contained in drift ice) of European origin found at diverse sedimentary cores from the North Atlantic.

## Conclusions

The Peña Larga rock shelter (Cripán, Álava) has a long archeological sequence of seven stratigraphic units, six of them cultural, comprising the early and middle Neolithic, the early and late Chalcolithic, and the early and middle Bronze Age (Atlantic to Subboreal chronozones). Nearly twenty-eight thousand microvertebrate elements were recovered from the site. From them, 2553 items were identified either to the genus or species level.

The small vertebrate assemblage is composed of mammals, birds, reptiles, and amphibians, and it was naturally accumulated, mainly by owls and, to a much lesser extent, by small burrowing carnivores.

In Peña Larga, only small mammals meet the requirements to be used for paleoenvironmental reconstructions. They are very sensitive to climatic conditions and their distributions throughout the stratigraphic sequence, measured in terms of species relative abundance, serve as rough proxies of habitat and climatic change. Most of the small vertebrate elements identified (77%) come from Level III, which is likely due to a longer lack of human occupation (relative to other levels), and the resulting increase in birds of prey activity, during this period.

Close relationships between environment and the dynamics of human settlement become particularly evident also in Level III, where the cave was used as a collective burial instead of a household, people likely living in open-air dwellings, encouraged by both warm conditions and the proliferation of grasslands during this period.

The paleoenvironmental reconstruction of Peña Larga based on small mammals mostly coincides with other habitat and climatic proxies, such as pollen and the amphibian/reptile record on the local scale, and an ice core from central Greenland on the global scale. Level II's mild conditions roughly correspond to the short "Ice Age" recorded during the Chalcolithic/Bronze Age transition. All these factors turn the paleoenvironmental record from Peña Larga into a very useful tool for comparative purposes both in the regional and continental scales.

## Acknowledgements

Thoughtful comments and discussions with Gloria Cuenca-Bescós were particularly helpful in writing this paper. The English editing of Christine Laurin is also recognized. Juan Rofes has a "Juan de la Cierva" postdoctoral contract (JCI-2010-06148) from the Ministerio de Economía y Competitividad de España. We received economic support from the following projects: UNESCO 09/01 and EHU 10/32 (Universidad del País Vasco UPV/EHU), HAR2008-03976/HIST of the MICIN, and the Research Group: IT-288-07 of the Basque Government. Three anonymous reviewers and the QR editor notably contributed to improve the paper.

## References

Andrews, P., 1990. Owls, Caves and Fossils. The Natural History Museum Publications, London.

Armendáriz, M., Etxebarría, F., 1983. Las Cuevas sepulcrales del Bronce en Guipúzcoa. Munibe 35, 247–354.

Arnold, N., Ovenden, D., 2002. A Field Guide to the Reptiles and Amphibians of Britain and Europe. Harper Collins Publisher, London.

Barrios, I., 2004. El yacimiento de Cueva Lóbrega (Torrecilla en Cameros, La Rioja). Una visión acerca del Neolítico y la Edad del Bronce en el área occidental del Sistema Ibérico. Historia-Arqueología 15, 1–242.

Bea, A., Rodríguez, J.A., Jover, L., 1986. Relations between meteorological variables and the initiation of the spawning period in populations of *Rana temporaria* L. in the Atlantic region of the Basque Country. Amphibia-Reptilia 7, 23–31.

Bertolini, M., Fedozzi, S., Martini, F., Sala, B., 1996. Late glacial and Holocene climatic oscillations inferred from the variations in the micromammal associations at Grotta Della Serratura (Marina di Camerota, Salerno, S. Italy). Il Quaternario. Italian Journal of Quaternary Sciences 9, 561–566.

Bond, G., Showers, W., Cheseby, M., Lotti, R., Almasi, P., deMenocal, P., Priore, P., Cullen, H., Hajdas, I., Bonani, G., 1997. A pervasive millennial-scale cycle in North Atlantic Holocene and Glacial climates. Science 278, 1257–1266.

Bond, G., Kromer, B., Beer, J., Muscheler, R., Evans, M.N., Showers, W., Hoffmann, S., Lotti-Bond, R., Hajdas, I., Bonani, G., 2001. Persistent solar influence on North Atlantic climate during the Holocene. Science 294, 2130–2136.

Bronk Ramsey, C., 2009. Bayesian analysis of radiocarbon dates. Radiocarbon 51 (1), 337–360.

Burjachs, F., López Sáez, J.A., 2003. Análisis paleopalinológico del yacimiento arqueológico de Fuente Lirio (Muñopepe, Ávila). Numantia, Arqueología en Castilla y León 8, 51–54.

Carnicero, S., 2006. Estudio antropológico del yacimiento arqueológico "Cueva de Las Penas" (Mortera, Piélagos, Cantabria). Sautuola 12, 295–300.

Carretero, J.M., Ortega, A.I., Juez, L., Pérez-González, A., Arsuaga, J.L., Pérez-Martínez, R., Ortega, M.C., 2008. A Late Pleistocene–Early Holocene archaeological sequence of Portalón de Cueva Mayor (Sierra de Atapuerca, Spain). Munibe 59, 67–80.

Castaños, P., 1997. Estudio arqueozoológico de la fauna de Peña Larga (Cripán, Álava). In: Fernández-Eraso, J. (Ed.), Peña larga: Memoria de las excavaciones arqueológicas 1985–1989. Memoria de yacimientos alaveses 4. Diputación Foral de Álava, Vitoria-Gasteiz, pp. 127–134.

Castaños, P., 2004. Estudio arqueozoológico de los macromamíferos del Neolítico de la cueva de Chaves (Huesca). Saldvie 4, 125–171.

Cuenca-Bescós, G., Rofes, J., García-Pimienta, J.C., 2005. Early Europeans and environmental change across the Early–Middle Pleistocene transition: small mammalian evidence from Trinchera Dolina cave, Atapuerca, Spain. In: Head, M.J., Gibbard, P.L. (Eds.), Early-Middle Pleistocene transitions: the land-ocean evidence: Geological Society of London, Special Publications, 247, pp. 277–286.

Cuenca-Bescós, G., Straus, L.G., González-Morales, M.R., García-Pimienta, J.C., 2009. The reconstruction of past environments through small mammals: from the Mousterian to the Bronze Age in El Mirón Cave (Cantabria, Spain). Journal of Archaeological Science 36, 947–955.

Cuenca-Bescós, G., Melero-Rubio, M., Rofes, J., Martínez, J.L., Arsuaga, J.L., Blain, H.-A., López-García, J.M., Carbonell, E., Bermúdez de Castro, J.M., 2011. The Early–Middle Pleistocene environmental and climatic change and the human expansion in Western Europe: a case study with small vertebrates (Gran Dolina, Atapuerca, Spain). Journal of Human Evolution 60, 481–491.

Etxebarría, F., Herrasti, L., 2007. Restos humanos de la necrópolis de la iglesia parroquial de San Roque (Acebedo, Álava). Estudios de Arqueología Alavesa 23, 195–208.

Fabián, J.F., Blanco-González, A., López-Sáez, J.A., 2006. La transición Calcolítico-Bronce Antiguo desde una perspectiva arqueológica y ambiental: el Valle Amblés (Ávila) como referencia. Arqueología Espacial 26, 37–56.

Fernández-Eraso, J., 1997. Excavaciones en el abrigo de Peña Larga (Cripán-Álava). In: Fernández-Eraso, J. (Ed.), Peña larga: Memoria de las excavaciones arqueológicas 1985–1989. Memoria de yacimientos alaveses 4. Diputación Foral de Álava, Vitoria-Gasteiz, pp. 27–50.

Fernández-Eraso, J., 2007–2008. La secuencia del Neolítico en La Rioja Alavesa desde su origen hasta las primeras edades del metal. Veleia 24–25, 669–688.

Fernández-Eraso, J., Mujika, J.A., Peñalver, X., 2010. Hábitat y mundo funerario en la prehistoria reciente del País Vasco: nuevas evidencias. Congreso Internacional sobre el Megalitismo y otras manifestaciones funerarias contemporáneas en su contexto social, económico y cultural. Munibe sup 20, 250–270.

Galán, P., 2002. Anguis fragilis. In: Pleguezuelos, R., Márquez, R., Lizana, M. (Eds.), Atlas y libro rojo de los anfibios y reptiles de España. Dirección General de Conservación de la Naturaleza-A.H.E., Madrid, pp. 157–159.

Grayson, D., 1984. Quantitative Zooarchaeology. Academic Press, London.

Grootes, P.M., Stuvier, M., White, J.W.C., Johnsen, S., Jouzel, J., 1993. Comparison of oxygen isotope records from the GISP2 and GRIP Greenland ice cores. Nature 366, 552–554.

Iriarte, M.J., 1997. El entorno arqueobotánico del abrigo de Peña Larga. Análisis palinológico. In: Fernández-Eraso, J. (Ed.), Peña larga: Memoria de las excavaciones arqueológicas 1985–1989. Memoria de yacimientos alaveses 4. Diputación Foral de Álava, Vitoria-Gasteiz, pp. 137–145.

Janeau, G., Aulagnier, S., 1997. Snow vole — *Chionomys nivalis* (Martins 1842). Journal of Mountain Ecology 4, 1–11.

López-García, J.M., Blain, H.-A., Cuenca-Bescós, G., Ruiz-Zapata, M.B., Dorado-Valiño, M., Gil-García, M.J., Valdeolmillos, A., Ortega, A.I., Carretero, J.M., Arsuaga, J.L., Bermúdez de Castro, J.M., Carbonell, E., 2010. Palaeoenvironmental and palaeoclimatic reconstruction of the Latest Pleistocene of El Portalón site, Sierra de Atapuerca, northwestern Spain. Palaeogeography, Palaeoclimatology, Palaeoecology 292, 453–464.

López-García, J.M., Blain, H.-A., Sanz, M., Daura, J., 2012. A coastal reservoir of terrestrial resources for Neanderthal populations in north-eastern Iberia: palaeoenvironmental data inferred from the small-vertebrate assemblage of Cova del Gegant, Sitges, Barcelona. Journal of Quaternary Science 27, 105–113.

López-Sáez, J.A., López-García, P., 2003. Análisis palinológico del poblado calcolítico de Los Itueros (Santa María del Arroyo, Valle Amblés, Ávila, España). Trabalhos de Antropologia e Etnologia 43 (1–2), 171–180.

Marín-Arroyo, A.B., 2010. Arqueozoología en el Cantábrico Oriental durante la transición Pleistoceno/Holoceno. La cueva del Mirón. Ediciones Universidad de Cantabria, Santander.

Marshall, F., Pilgram, T., 1993. NISP vs. MNI in quantification of body-part representation. American Antiquity 58, 261–269.

Martí, B., Pascual, V., Gallart, M.D., López, P., Pérez, M., Acuña, J.D., Robles, F., 1980. Cova de l'Or (Beniarres, Alicante), vol. 2. Servicio de Investigación Prehistórica, Valencia.

Matthews, T., 2006. Taphonomic characteristics of micromammals predated by small mammalian carnivores in South Africa: application to fossil accumulations. Journal of aphonomy 4 (3), 143–159.

Murelaga, X., Fernández-Eraso, J., Bailon, S., Saez de Lafuente, X., 2009. La fauna de microvertebrados del yacimiento Holoceno de Peña Larga (Cripán, Álava). Revista de la Sociedad Geológica de España 22, 155–162.

Palomo, J.L., Gisbert, J., 2005. Atlas de los mamíferos terrestres de España. Dirección General para la Biodiversidad, Madrid.

Pleguezuelos, J.M., Márquez, M., Lizana, M., 2004. Atlas y libro rojo de los Anfibios y Reptiles de España, Dirección General de Conservación de la Naturaleza-Asociación Herpetológica Española, Madrid, third ed.

Pokines, J.T., 1998. The paleoecology of Lower Magdalenian Cantabrian Spain. BAR International Series 713. John and Erica Hedges and Archaeopress, London.

Reimer, P.J., Baillie, M.G.L., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Ramsey, C.B., Buck, C.E., Burr, G.S., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., McCormac, F.G., Manning, S.W., Reimer, R.W., Richards, D.A., Southon, J.R., Talamo, S., Turney, C.S.M., van der Plicht, J., Weyhenmeye, C.E., 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. Radiocarbon 51 (4), 1111–1150.

Repenning, C.A., 2001. Beringian climate during intercontinental dispersal: a mouse eye view. Quaternary Science Reviews 20, 25–40.

Rofes, J., Cuenca-Bescós, G., 2011. Evolutionary history and biogeography of the genus *Crocidura* (Mammalia, Soricidae) in Europe, with emphasis on *Crocidura kornfeldi*. Mammalian Biology 76, 64–78.

Rojo, M.A., Kunst, M., Garrido-Pena, R., García-Martínez, I., 2006. La neolitización de la Meseta Norte a la luz del C-14: análisis de 47 dataciones absolutas inéditas de dos yacimientos domésticos del valle de Ambrona, Soria, España. Archivo de Prehistoria Levantina 39–100.

Ruíz-Cobo, J., Eagan, P., Bandres, A., Etxebarría, F., Herrasti, L., 2008. Los restos humanos de la Cueva del Toro (Fresnedo, Solórzano) en el contexto de las cuevas sepulcrales del valle de Asón (Cantabria). Munibe 59, 157–170.

Sesé, C., 2005. Aportación de los micromamíferos al conocimiento paleoambiental del Pleistoceno Superior en la región Cantábrica: nuevos datos y síntesis. Museo y Centro de Investigación de Altamira, Monografías, 20, pp. 167–200.

Speybroeck, J., Crochet, P.-A., 2007. Species list of the European herpetofauna — a tentative update. Podarcis 8, 8–34.

Utrilla, P., Cava, A., Alday, A., Baldellou, V., Barandiarán, I., Mazo, C., Montes, L., 1998. Le pasaje du Mésolithique au Néolithique ancien Dans le basin de l'Ebre (Espagne) d'après les datations C14. Préhistoire Européenne 12, 171–194.

Vergès, J.M., Allué, E., Angelucci, D., Burjachs, F., Carrancho, A., Cebriá, A., Expósito, I., Fontanals, M., Moral, S., Rodríguez, A., Vaquero, M., 2008. Los niveles neolíticos de la cueva de El Mirador (Sierra de Atapuerca, Burgos): nuevos datos sobre la implantación y el desarrollo de la economía agropecuaria en la submeseta norte. In: Hernández, M.S., López, J.A. (Eds.), IV Congreso del Neolítico Peninsular, MARQ. Diputación Provincial de Alicante, Alicante, pp. 418–427.

Wilson, D.E., Reeder, D.-A.M., 2005. Mammal species of the world. A Taxonomic and Geographic Reference. The Johns Hopkins University Press, Baltimore.

Zilhao, J., 2001. Radiocarbon evidences for maritime Pioneer colonization at the origins of farming in west Mediterranean Europe. PNAS 98, 14180–14185.