Palaeoenvironmental and palaeoclimatic approach of the middle bronze age (level MIR 4) from El Mirador Cave (Sierra de Atapuerca, Burgos, Spain)

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PALAEOENVIRONMENTAL AND PALAEOCLIMATIC APPROACH OF THE MIDDLE BRONZE AGE (LEVEL MIR 4) FROM EL MIRADOR CAVE (SIERRA DE ATAPUERCA, BURGOS, SPAIN)

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ABSTRACT

This article undertakes a palaeoenvironmental and palaeoclimatic reconstruction of the Middle Bronze Age on the basis of a study of the small mammals from level MIR 4 of El Mirador Cave. The chronology of the level under study is 3,720-3,140 cal. yr BP. The palaeoenvironmental analysis indicates that it represents the period of transition between the Subboreal and the Subatlantic, during which prevailed a very humid habitat, dominated by woodland and wet meadows. Otherwise, the palaeoclimatic analysis, carried out using the Mutual Climatic Range method (MCR), reveals that level MIR 4 falls within an interval in which the temperatures were very similar to present-day ones, while mean annual precipitation was notably higher than at present, i.e. 485 mm above the present level for Burgos.

Keywords: small mammals, palaeoenvironment, palaeoclimate, Subboreal-Subatlantic, Middle Bronze, El Mirador Cave, Spain

RÉSUMÉ

APPROCHE PALÉOENVIRONNEMENTALE ET PALÉOCLIMATIQUE DE L’ÂGE DU BRONZE MOYEN (NIVEAU MIR 4) DE LA GROTTE EL MIRADOR (SIERRA DE ATAPUERCA, BURGOS, ESPAGNE)

Cet article propose une reconstitution paléoenvironnementale et paléoclimatique de l’Âge du Bronze moyen à partir de l’étude des petits mammifères du niveau MIR 4 de la grotte El Mirador. La chronologie du niveau étudié est comprise entre 3 720-3 140 ans cal. BP. L’analyse paléoenvironnementale indique qu’il s’agit d’une période de transition entre le Subboreal et le Subatlantique, où prédomine un habitat très humide, dominé par la forêt et les prairies humides. Par ailleurs, l’analyse paléoclimatique, basée sur la méthode du Domaine Climatique Commun (MCR) révèle que le niveau MIR 4 appartient à un intervalle dans lequel les températures sont similaires aux températures actuelles, alors que les précipitations moyennes annuelles étaient notablement supérieures, i.e. 485 mm au dessus des moyennes actuelles pour Burgos.

Mots-clés : petits mammifères, paléoenvironnement, paléoclimat, Subboreal-Subatlantique, Bronze moyen, El Mirador, Espagne

1 INTRODUCTION

The climatic periodization of the Bronze Age is highly complex because, as in the rest of the Holocene, it comprises a succession of climate pulsations of varying magnitude. As a consequence, many examples of palaeoenvironmental and palaeoclimatic analysis (Salas, 1992; Mariscal, 1993; González et al., 1995; Terral & Mengíbal, 1999; Jalut et al., 2000; Crucifix et al., 2002; Carrión, 2002; Davis et al., 2003; Mayewsky et al., 2004; López Sáez et al., 2005; Cabanes et al., 2009; Carrión et al., 2010) have focused on an attempt to characterize this period. This is the case with a number of small mammal studies (Laplana Conesa & Cuenca-Bescós, 1995; Oms et al., 2009; Bañuls-Cardona & López-García, 2009; López-García et al., 2010, 2011b; Cuenca-Bescós & García-Pimienta, 2012), including the present one.

The aim of this study, based on palaeoenvironmental and palaeoclimatic analyses of the small mammal remains recovered from level MIR 4 of El Mirador Cave (Sierra de Atapuerca, Burgos, Spain), is to shed light on both palaeoenvironmental and palaeoclimatic conditions
that prevailed during a particular interval (3,720-3,140 cal. yr BP) of the Bronze Age in the Iberian Peninsula.

2 - THE LOCALITY

The Cave of El Mirador is situated in Ibeas de Juarros, to the south of the Sierra de Atapuerca (Burgos, Spain). The site is located at an altitude of 1,033 m above sea level, and its geographical coordinates are 42° 20' 58" N and 03° 30' 33" E (fig. 1). The entrance of the cave is 23 m wide and 4 m high, and the cave is about 15 m deep. The thickness of its sedimentary infilling is estimated to be about 20-m-thick. The first known archaeological intervention in El Mirador Cave was undertaken in the early 1970s by the Edelweiss Speleological Group (Grupo Espeleológico Edelweiss, GEE). This work was not taken up again until 1999, when it formed part of the project “Autoecología Humana y Tecnología de los Pobladores Prehistóricos de la Sierra de Atapuerca” (Human Autoecology and Technology of the Prehistoric Settlers of the Sierra de Atapuerca). It was in 1999 that work started on with the excavation of an area of 6 m² in the central part of the cave, on the basis of which the stratigraphic sequence was established. This is composed of 26 levels that display high lateral and vertical variability due to the sedimentary characteristics of the cave and to post-depositional processes, such as the collapse of blocks and anthropic spatial organization, as well as bioturbation. For this reason, it was decided that the naming and excavation should be in assemblages that distinguish the characteristic facies of anthropized units (Vergès et al., 2002), these latter ranging from the Bronze Age to the Neolithic and deeper to the Upper Palaeolithic (Vergès et al., 2002; Angelucci et al., 2009) (fig. 1).

The studied level, MIR 4, corresponds to the Bronze Age. It is composed of animal dung accumulations, called facies (in archaeological contexts, it is an organic sediment of anthropic origin) that have been distinguished in this level (4a, 4b, 4f, 4c, 4d, 4g, 4m, 4o, 4r, 4v and 4r), i.e. rhythmic sequences, discontinuous and with abrupt limits (Vergès et al., 2002, 2008). Radiometric datings have been performed on two samples of charcoal from this level (Vergès et al., 2002) (fig. 1). As regards the studied material from this level, there are various palaeobotanical studies of pollen, charcoal fragments, phytoliths and seeds, as well as archaeofaunal studies and studies of the lithic and osseous industries and ceramic elements. Most noteworthy among the material, however, are the human remains. Evidence has been documented of a collective inhumation. The human remains belong to the Early Bronze Age, but were buried at that place.

<table>
<thead>
<tr>
<th>Level</th>
<th>Location</th>
<th>Dates Cal. BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIR4</td>
<td>top level</td>
<td>3350-3140</td>
</tr>
<tr>
<td>MIR4</td>
<td>base level</td>
<td>3720-3560</td>
</tr>
<tr>
<td>MIR4</td>
<td>inhumation</td>
<td>4100-3880</td>
</tr>
</tbody>
</table>

Fig. 1: Geographical location (A), stratigraphy (B) (Angelucci et al., 2009) and radiometric datings from MIR 4 level (C) of El Mirador cave.

Fig. 1 : Localisation géographique (A), stratigraphie (B) (Angelucci et al., 2009) et datations radiométriques pour le niveau MIR 4 (C) de la grotte de El Mirador.
during the Middle or Late Bronze Age. These remains display cut-marks and human tooth marks, as well as evidence of manipulation, i.e. boiling and breakage, which suggests a clear case of gastronomic cannibalism (Cáceres et al., 2007).

3 - MATERIAL AND METHODS

3.1 - PALAEOONTOLOGICAL STUDY

The material analysed in this study comes from the excavation of level MIR 4 of El Mirador Cave. To extract the small vertebrates, a system of water-screening was used, with meshes of decreasing size (1 cm, 0.5 cm and 0.05 cm). Then, once the microfossils had been separated from the dry concentrate, each species was duly identified. The process of identification was based on cranial and post-cranial diagnostic elements from the small mammal skeletons. For the Soricidae, we used mandibles and isolated teeth (Furió, 2007; Cuenca-Bescós et al. 2008; López-García, 2008), for the Arvicolineae, the first lower molars (Cuenca-Bescós et al. 2008; López-García, 2008), while for Apodemus sylvaticus and Eliomys quercinus identification relied on isolated teeth (Cuenca-Bescós et al., 2008; López-García, 2008).

3.2 - PALAEOENVIRONMENTAL RECONSTRUCTION

To undertake the palaeoenvironmental reconstruction, the method of habitat weighting was used (Evans et al., 1981; Andrews, 2006 modified by Blain et al., 2008, López-García et al., 2011b). This method consists in distributing each small vertebrate taxon in the habitat(s) where it is possible to find them at present in the Iberian Peninsula. We used five categories of habitats, defined according to a series of well defined environmental features: dry meadow, wet meadow, woodland, rocky areas and areas around water. “Dry meadow” refers to meadowland subject to seasonal changes in climate; “wet meadow” refers to evergreen meadowland with pastures and dense topsoil; “woodland” ranges from leafy forests to woodland margins with moderate vegetation cover; “rocky” denotes rocky habitats without vegetation cover; and “water” includes streams, lakes and ponds.

3.3 - PALAEOCLIMATIC RECONSTRUCTION

In order to produce the palaeoclimatic reconstruction, the Mutual Climate Range method (MCR) was used (Blain, 2005, 2009; Blain et al., 2007, 2009, 2010; Agustí et al., 2009; López-García et al., 2010). On the basis of the distribution of the Iberian fauna we identified the range by simply overlaying the geographical regions where all the species present in a stratigraphical level presently live. We used an atlas based on a 10×10 km UTM network (Palomo & Gisbert, 2005), that provided us the climatic characteristics of our association resulting from the geographical intersection. We calculated the MAT (mean annual temperature), the MTC (mean temperature of the coldest month) and the MTW (mean temperature of the warmest month), as well as the MAP (mean annual precipitation). These climatic characteristics were obtained using current maps of temperatures and precipitation (Font Tullot, 2000). The resulting quantitative data were compared with the present-day climate of the region, which enabled us to ascertain the changes in temperatures and precipitation during this period of the Holocene.

4 - RESULTS

4.1 - SMALL-VERTEBRATE ASSEMBLAGE

The sample under study is made up of 360 remains (NR), among which a minimum number of individuals (MNI) of 212 has been counted from the most abundant bone or tooth from either the left or right side of the animal. Nine small mammal taxa have been identified (tab. 1): Sorex coronatus, Crocidura russula, Microtus arvalis, Microtus agrestis, Microtus arvalis-agrestis, Microtus (Terricola) duodecimcostatus, Microtus (Terricola) pyrenaicus, Apodemus sylvaticus and Eliomys quercinus (fig. 2). The accumulation of microvertebrates is a consequence of the activity of other animals, mainly birds of prey and small carnivores. In our case, the analysis of the microvertebrate assemblage revealed an important taxonomic diversity that may result from the activity of an opportunistic hunter. The nine taxa identified in this association represent 60 % of the fifteen small mammal taxa presently living in the vicinity of the Sierra de Atapuerca.

<table>
<thead>
<tr>
<th>TAXA</th>
<th>MNI</th>
<th>MNI%</th>
<th>D.O</th>
<th>D.H</th>
<th>W</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorex coronatus</td>
<td>7</td>
<td>6.2</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Crocidura russula</td>
<td>20</td>
<td>17.7</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Microtus arvalis</td>
<td>22</td>
<td>19.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Microtus agrestis</td>
<td>31</td>
<td>27.4</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Terricola duodecimcostatus</td>
<td>10</td>
<td>8.6</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Apodemus sylvaticus</td>
<td>22</td>
<td>19.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Eliomys quercinus</td>
<td>1</td>
<td>0.9</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>133</td>
<td>100</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Tab. 1: MNI (minimum number of individuals), percentage of MNI and distribution of the taxa by habitat.

Tab. 1 : NMI (nombre minimum d’individus), pourcentage du NMI et distribution des taxons par habitat.

4.2 - PALAEOENVIRONMENTAL RECONSTRUCTION

On a palaeoenvironmental level, analysis of the small mammal assemblage from level MIR 4 showed it to consist of 54.2 % woodland and 22 % wet meadow species; i.e. there is a predominance of spaces with major humidity requirements. In other words, woodland areas and woodland margins with open spaces are prevalent, as shown by the presence of species such as Sorex coronatus, Microtus (Terricola) duodecimcostatus and Microtus agrestis, which makes up 23.5 %, the highest percentage of the assemblage under study. Meanwhile, drier spaces (15.9 %) and rocky spaces (0.4 %) are largely insignificant, represented by Crocidura russula and Microtus arvalis (fig. 3).
As regards the palaeoclimatic analyses, these show that calculated temperatures are very similar to those measured over the last 30 years in the area at Burgos meteorological station (located at an altitude of 894 m) (Font Tullot, 2000). During the Bronze Age, both mean annual temperature (MAT) and mean temperature of the warmest month (MTW) were slightly lower (0.9 and 0.1°C respectively) than at present, whereas he mean temperature of the coldest month was slightly higher by 0.4°C. In the case of mean annual precipitation, reconstructed value of 1057 mm for the Bronze Age is about twice lower than the present one of 572 mm (tab. 2).

### Tab. 2: Relation of the temperatures and precipitation levels estimated by the MCR (Mutual Climate Range) analysis of small mammal assemblages for each of the studied sites.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean ± SD</th>
<th>Min</th>
<th>Max</th>
<th>∆</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT</td>
<td>10</td>
<td>9 ± 2.7°C</td>
<td>5°C</td>
<td>12°C</td>
<td>-0.9°C</td>
</tr>
<tr>
<td>MTC</td>
<td>10</td>
<td>3 ± 1.6°C</td>
<td>1°C</td>
<td>5°C</td>
<td>0.4°C</td>
</tr>
<tr>
<td>MAP</td>
<td>10</td>
<td>18.4 ± 2.5°C</td>
<td>15°C</td>
<td>21°C</td>
<td>-0.1°C</td>
</tr>
</tbody>
</table>

Abbreviations: MAT: mean annual temperature, MTC: mean temperature of the warmest months, MAP: mean annual precipitation, Mean ± SD: mean and standard deviation of the values obtained, Max: maximum of the values obtained, Min: minimum of the values obtained, ∆: difference between the values obtained by analysing the small mammals from MIR 4 and the present mean of Burgos meteorological station over the last 30 years.
5 - DISCUSSION

During the late Holocene major changes have been recorded in the environment. This period has been characterized by a retreat of arboreal vegetation as well as an increase in temperatures and a decrease in mean annual precipitation (Mariscal, 1993), with an incipient process of desertification occasionally interrupted by periods of torrential rain in the Iberian Peninsula (Font Tullot, 1988). Nevertheless, periods of climatic improvement are also to be observed and characterized by an increase in humidity. This is rather more accentuated towards the middle of the period, which represents a climatic optimum (Mariscal, 1993), during which MIR 4 would have formed.

On the basis of the study of the small mammals from MIR 4, the palaeoenvironmental results confirm the theory of a climatic improvement based on pollen studies undertaken within the Iberian Peninsula, which reveal a transition at the end of the Subboreal from a relatively dry continental climate to a humid oceanic climate (Salas, 1992). By studying the habitat occupied by our faunal association, we have seen that in MIR 4 that there existed a predominance of humidity in the environment, with 22 % and 54.2 % of wet meadow and woodland species respectively. Moreover, other small mammal studies provide similar results for other places in the Iberian Peninsula during the same interval. Such is the case with the Cave of Valdavara 1 in the province of Lugo, in which occurred a clear predominance of woodland in relation to other types of habitat (López-García et al., 2011). The same goes for El Mirón Cave in Cantabria, where a major increase in wet meadowland has been detected for the same period (Cuenca-Bescós & García-Pimienta, 2012) (fig. 4).

![Fig. 4: Probabilities of habitat occurrences deduced from the micromammal fauna for MIR 4 level of El Mirador Cave, level 3 of Valdavara 1 Cave (López-García et al., 2011a) and levels 8 and 9 of El Mirón Cave (Cuenca-Bescós & García Pimienta, 2012).](image)

Though palaeoclimatic studies claimed that the period between 4,300-3,400 cal. yr BP was an arid cold phase (Jalut et al., 2000; Carrió, 2002; Mayewsky et al., 2004), other authors (López Sáez et al., 2005) speak of a slight cooling and increased dryness, though this is by comparison with the previous period, the Atlantic, and not in absolute agreement. Moreover, we have noted that other studies reconstructed a climatic improvement at the end of the Subboreal period, to which the MIR 4 level would belong. For this later period, reconstructed temperatures show no significant differences with present ones, while mean annual precipitation has been documented as 485 mm higher. These results obtained with the MCR method for MIR 4 coincide with those obtained from palaeobotanical studies in the same level (Vergès et al., 2002; Cabanes et al., 2009) and from other pollen studies within the Iberian Peninsula (Salas, 1992; López Sáez et al., 2005), which indicate a mixed environment and an expansion of pine forests. Moreover, comparing our MCR reconstructions with the data obtained by López-García et al. (2011a) from a similar analysis of Valdavara 1 Cave, temperatures are likewise significantly different from present ones. Indeed, these authors ascertain a slightly (0.3ºC) lower mean annual temperature (MAT), as well as a slightly (0.1ºC) lower mean temperature of the warmest month (MTW), whereas the mean temperature of the coldest month (MTC) is seen to be slightly (0.4ºC) higher.

As regards mean annual precipitation, the data show a major decrease of 557 mm, as associated with MIR 4. All these data thus indicate that this part of the Bronze Age is characterized by temperatures that are similar to or slightly below present-day ones, and mean annual precipitation that are twice higher than present-day ones. This suggests that the climatic conditions typical of the Mediterranean climate started to establish during the Subboreal-Subatlantic transition (Terral & Mengual, 1999).

Finally, from a taxonomic point of view, several typically Mediterranean species are present in our association, such as Crocidura russula and Microtus (Terricola) duodecimcostatus, and on the other hand, we have a limited number (30 %) of Euro-Siberian species like Microtus arvalis, Microtus agrestis and Microtus (Terricola) pyrenaicus. As all the taxa populating our Bronze Age assemblage are presently found in the vicinity of the site (Velasco et al., 2005), both climatic and environmental conditions can be assumed to have been similar to modern ones. Moreover, these same species are represented in both caves of Valdavara 1 (López-García et al., 2011a) and El Mirón (Cuenca-Bescós & García Pimienta, 2012), but with some differences. In absence of thermo-Mediterranean species, El Mirón is characterised by a colder climate, whereas the absence of Microtus (Terricola) pyrenaicus in Valdavara 1 is a clear indicator of a milder climate.

6 - CONCLUSION

Our analysis of the small mammals from level MIR 4 of El Mirador Cave revealed, for the Burgos area, a highly diversified association composed of nine taxa: Sorex coronatus, Crocidura russula, Microtus arvalis, Microtus agrestis, Microtus arvalis-agrestis, Microtus (Terricola) duodecimcostatus, Microtus (Terricola) pyrenaicus, Apodemus sylvaticus and Eliomys quercinus.
This assemblage is characteristic of a local environment dominated by woodland and wet meadowland during the Subboreal climatic period, and more specifically during its final phase and the transition to the Subatlantic period. Moreover, temperatures were very similar to present-day ones and twice higher levels of precipitation have been reconstructed. These characteristics are already typical features of a Mediterranean climate, such it exists at present.

The environmental conditions described would have thus been optimal for Human populations to take advantage of the surrounding area. A retreat of the woodland and a concomitant increase in the wet meadowland used for the cultivation of cereals would have favoured pulses toward self-sufficiency.

ACKNOWLEDGMENTS

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