Celtis remains from the Lower Pleistocene of Gran Dolina, Atapuerca (Burgos, Spain)

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Abstract

In this paper we present the archaeobotanical record from level TD6 of the Gran Dolina site (Burgos, Spain). The results show the presence of mineralized Celtis (hackberry) seed remains — concentrated primarily in the area where most of the archaeological material was found. Spatial distribution data indicate that the seeds are associated with archaeological remains resulting from human occupation of the cave. Celtis remains were preserved due to biomineralization of seed endocarps. The results presented here contribute to analysis of archaeobotanical Celtis remains as part of the Pleistocene human plant food consumption.

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1. Introduction

The occurrence of plant macro-remains in Palaeolithic sites is uncommon. However, their presence, associated with other archaeological artefacts and remains, is usually accepted as being part of human waste (Matsutani, 1987; Zohary and Hopf, 2003; Weiss et al., 2004; Martinolli and Jacomet, 2005; Hardy et al., 2009; Pryor et al., 2013; Wadley et al., 2011). Evidence of plant remains increases progressively in the archaeological record in the Middle and Upper Palaeolithic and Mesolithic (Matsutani, 1987; Zohary and Hopf, 2003; Weiss et al., 2004; Martinolli and Jacomet, 2004; Lev et al., 2005; Buxó and Piqué, 2008; Hardy et al., 2009), whereas finds in earlier periods are rare. The occurrence of Celtis in archaeological contexts from different periods is relatively common due to the process of biomineralization which aids their preservation (Chaney, 1935; Green, 1979; Matsutani, 1987; Cowan et al., 1997; Jahren et al., 1998; Messager et al., 2008, 2010; Shillito and Almond, 2010; Simchoni and Kislev, 2011).

Today, Celtis, a genus of the Ulmaceae family, is used mainly for ornamental purposes. It is also exploited for its medical properties, and even when bearing little flesh it has been used as a source of food (Yanovsky et al., 1932; Blanco et al., 1998; Demir et al., 2002; Tardío et al., 2006; Simchoni and Kislev, 2011). About 60 different Celtis species are distributed throughout South America, Africa, Asia and Europe (Demir et al., 2002; Simchoni and Kislev, 2011). Celtis australis, Celtis caucasica, Celtis tournefortii and Celtis glabrata are found in the European Mediterranean region (Tutin et al., 1964; Davis, 1982; Simchoni and Kislev, 2011) but at present, C. australis is the only species growing in the Iberian Peninsula (Blanco et al., 1998).

In this paper we present the results of a study of the Celtis assemblage from level TD6 of the Gran Dolina site at Atapuerca (Burgos, Spain). The aim of the paper is to assess the relationship of these remains with the rest of the archaeological assemblage and to consider possible origins of the deposition of the Celtis remains. In
this context, the presence of Celtis adds to our understanding of plant uses among early human groups from the early Palaeolithic period.

2. Site description

The Sierra de Atapuerca is located 14 km east of Burgos in north central Spain at an altitude of 1000 m above sea level (Fig. 1). The archaeopalaeontological sites at Atapuerca are part of a karst cavity formation with different deposits ranging from the Early Pleistocene to the Mid Holocene (Fig. 1). The site of Gran Dolina (TD), located in the Trinchera del Ferrocaril, has yielded an 18-m sediment deposit divided into 11 stratigraphic units numbered TD1 to TD11 from bottom to top (Gil and Hoyos, 1987, and reviewed by Parés and Pérez-González, 1999). The palaeomagnetic, Thermo Luminescence and Uranium series dating of samples taken 100 cm above TD6 provided an age of 936 Ka BP (MIS25) (Parés and Pérez-González, 1995). Level TD6, which was reached during a survey excavation started in 1994, revealed human fossil remains, lithic artefacts and faunal remains (Carbonell et al., 1995). The TD6 hominids have been reported as a new species, Homo antecessor (Bermúdez de Castro et al., 1997; Carbonell et al., 2005). Currently, TD6 is divided into three subunits, TD6-2 and TD6-1 (from bottom to top). Recent work undertaken in TD6-2 (commonly known as Aurora Stratum) reveals a highly complex stratigraphy with a minimum of five sub-layers (Bermúdez de Castro et al., 2008). All sub-layers have yielded more that 4000 faunal and 800 lithic remains, as well as 165 human remains belonging to 11 individuals ascribed to H. antecessor (Bermúdez de Castro et al., 1997; Carbonell et al., 1999; Rodríguez et al., 2011; Saladié et al., 2011). The faunal remains are a result of human consumption, and human remains show clear evidence of cannibalism (Fernández-Jalvo et al., 1999; Carbonell et al., 2010; Saladié et al., 2011, 2012). Evidence for cannibalism correlates with a nutritional practice included in the palaeoeconomic and cultural strategies related to territorial and resource control by human groups (Saladié et al., 2012). Palaeoecological records based on palaeobotanical, macrofauna and microvertebrates studies from TD6 show Mediterranean conditions throughout this level, with Celtis appearing in the palynological record (Rodríguez et al., 2011).

3. Materials and method

The 91 seed remains under study were recovered through sieving or were collected by hand during the excavation. All sediments from TD6 were water sieved. Seeds were identified using a stereo microscope at up to 100 magnifications. An environmental scanning electron microscope (ESEM, FEI QUANTA 600) was used for closer analysis of some seeds to observe surface alterations related to taphonomic processes. When possible, measurements of whole and half specimens were taken using a stereomicroscope (Olympus SZ110) and image processing software (DpxView Pro).

TD6 yielded 91 Celtis endocarp remains, including 57 whole endocarps, 13 halves and 21 fragments which were distributed throughout the level (Fig. 2). Celtis is an elliptical drupe with a bone nutlet; it has 4 ridges and a reticulate-rugulate surface (various authors, 1948; Davis, 1982; Simchoni and Kislev, 2011). The morphology of C. glabrata and C. australis is very similar, although the latter shows a more wrinkled surface. According to the reference collection at the Institute of Archaeology (UCL) and Simchoni and Kislev (2011), C. tournefortii is smaller, has a smooth surface pattern and a denser net pattern.

The presence of archaeobotanical remains in archaeological contexts related to food consumption is limited, due mainly to the difficulty of preserving organic material. Fruits and seeds can be recovered in different forms, carbonization being the most common. Mineralization or biomineralization are not usual, but can happen in some environments and depend on the character of the seed or the type of deposit (Shillito and Almond, 2010). Some seed coats and fruit shells such as Celtis can be naturally mineralized through biomineralization (Shillito and Almond, 2010) because the large quantities of calcium carbonate and silica in Celtis permit this process (Yanovsky et al., 1932; Green, 1979; Cowan et al., 1997; Wang et al., 1997; Jahren et al., 1998; McCobb et al., 2001; Zohary and Hopf, 2003; Messager et al., 2008, 2010; Shillito and Almond, 2010).

As these remains come primarily from sediment sieving where only the excavation square number and Z (depth) are given, a method was used to assign each seed a three-dimensional position providing “random dispersed coordinates” (x,y,z). We did not use “random central coordinates” which generate an accumulation of spots or a hyper-accumulation which could distort the stratigraphic image and distribution density maps by indicating fake accumulation points. Instead, when using non-coordinate materials a
method of “random dispersed coordinates” was chosen which for the purposes of stratigraphic and density analyses give better graphic resolution.

The assignation of “random dispersed coordinates” is achieved using calculation limits or ranks, size of the excavation square and depth data recorded during excavation. The method of archaeostratigraphy, developed by Canals et al. (2003), was used to analyse the position of remains and their association with other material. This enabled identification of the stratigraphic location of seeds, and their placement in density plans. The entire TD6 excavation level from which the data was taken was divided into two areas: the West (between squares J2 and D8), and Central and East (squares J9 to D18) (Fig. 3). However, as there were no seeds in the West area the data used in this study came from the TD6 sub-units TD6-1, TD6-2, TD6-3 in the Central and East area and from longitudinal and oblique projections (Fig. 3). Spatial and density analyses of archaeological data (Celtis and other remains) of TD6 was undertaken using gvSIG software (gvSIG 10.12.0 final (Buld 1417)) for the former, and Sextante gvSIG plug-in for the latter. ArchePlotter iv1.35.4-beta was used to plot profile data.

In order to calculate and illustrate density areas, the point-plotted data of general and Celtis remains are converted into kernel density maps which use a cell to calculate density of objects. In our case, we use a value of 56.00 for search radius and 5.0 for cell size.

4. Results

Measurements of 60 samples studied indicate a maximum length of 7732.29 μm, a minimum of 5353.49 μm with an average of 5990.11 μm. The maximum width is 6239.65 μm, minimum 4365.65 μm, with an average of 4988.10 μm (see Supplementary electronic material). All samples display a considerably wrinkled surface (Fig. 2). These characteristics, and the geographic location of the sample in the Iberian Peninsula, suggest that the remains probably correspond to C. australis.

Some differences in alteration of seeds are visible under the ESEM (Fig. 2); those that are broken in half are more altered than whole ones. Cracks are also visible, probably due to desiccation, and therefore relating to the fossilization process. Although some seeds appear rounded, their preservation is such that those retaining their morphology can be clearly identified. Finally, there are no physical modifications or bite marks produced by biological agents such as rodents. Holes are present in two specimens, but they do not show the characteristic microstriations associated with rodents (Collinson and Hooker, 2000).

Archaeostratigraphic analyses of the remains in level TD6 show that the distribution patterns of remains are the same as those indicated by a former study of the pit (East area) (Canals et al., 2003) (Fig. 4), which suggests a continuity in the layer between the pit (East area) and the Central area (Fig. 4). All projections, including bone, lithic and seed remains, point to an archaeological accumulation in the TD6-2 sub-unit (Aurora Stratum Figs. 4 and 5), in which most Celtis remains are located, thus confirming that Celtis remains are archaeostratigraphically associated with the other archaeological material and therefore H. antecessor remains (Figs. 4 and 5). Horizontal distribution according to density of materials indicates the accumulation of Celtis to be cone-shaped and located in the middle area (Fig. 6). Most Celtis remains are well integrated in the TD6-2 layer and are clearly indicated by longitudinal and oblique profiles. Vertical distribution of remains in Longitudinal section A and oblique section B show stratigraphic association of Celtis and Homo with a clear integration of remains (Figs. 4 and 5).
5. Discussion

The occurrence of *Celtis* during the Plio-Pleistocene is recorded in several Eurasian sites (Table 1). Early and Middle Pleistocene sites such as Zhoukoudian, China; Dmanisi and Akhalkalaki, Georgia; Terra Amata, Lazaret and Aragó, France; and Kärlich, Germany have yielded biomineralized *Celtis* seeds (Chaney, 1935; de Lumley, 1976; de Lumley in Laville and Rénault-Miskovsky, 1977; Bittmann, 1992; Ljubin and Bosski, 1996; Messager et al., 2008). These authors consider that *Celtis* could have contributed to hominin diet. Since Chaney's (1935) discussion of endocarps, debate on whether this is evidence of human food has been ongoing and analysed from different viewpoints. At Zhoukoudian (China), finds of *Celtis cf. barbouri* prompted a wide-ranging discussion on human diet (Aigner, 1969; Binford and Ho, 1985). Aigner (1969:166) points out that studies of fruit-eating in animals suggested to Chaney (Chaney, 1935) that humans, rather than by any other mammal, probably spat out the fruits. Experiments, in which monkeys were offered hackberry fruits, showed they did not spit out the seeds but crushed them. While Chaney's experiments implied that rodents produced no observable gnaw marks, other studies indicate that rodents can indeed produce gnaw marks (Collinson and Hooker, 2000). According to Chaney, there was no evidence of *Celtis* in *Hyaena* coprolites found at Zhoukoudian, whereas another study of 1500 coprolite specimens from the same site, mostly from *Hyaena* but also from *Ursus*, showed them to contain casts of whole *Celtis* seeds (Aigner, 1969). Nevertheless, this does not refute the possibility that the Zhoukoudian seeds were left by humans. In contrast, Binford and Ho (1985) suggest that evidence from Zhoukoudian is not related to human diet, as it is not associated with the human occupation layers. However, de Lumley (de Lumley p. 143 in Laville and Rénault-Miskovsky, 1977) argues for the interpretation of seeds as resulting from human action on the basis of their location inside caves.

The TD6 level of Gran Dolina yielded *Celtis* remains, with the highest concentration being in subunit TD6-2. Deposition of the *Celtis* assemblage in TD6-2 might be due to several agents, including deposition by birds, carnivores, rodents or humans. As observation under a binocular lens showed only slight modification on several seeds, there is no direct evidence of the process that led to their deposition. The most conclusive evidence is that the archaeological position of most seeds, associated with archaeological materials, corresponds to human occupation. Their position indicates a larger accumulation of seeds associated with TD6-2 (see Figs. 4 and 5), directly associated to *H. antecessor* remains. There is evidence of different materials above TD6-2, including bones and lithis, but this could be related to taphosediamentary processes or different occupational uses of the cave (Canals et al., 2003). No *Celtis* seeds have been found below TD6-2. If the association of *Celtis* remains with *H. antecessor* is of human origin, consumption or manipulation must have occurred at this time.

When assessing a proposal for human intervention with *Celtis* remains, it is necessary to consider why these seeds were not introduced by any other agent. The bird assemblage from TD6 (Sánchez Marco, 1999) includes various species which could have deposited the seeds: among them are several fruit-eating birds that might be consumers of hackberries, such as *Prunella collaris*, *Turdus merula*, *Turdus iliacus*, *Turdus philomelos*, *Emberiza citrinella*, *Sturnus*, etc. But birds do not inhabit caves; most nest in trees or on the ground, with the exception of *Prunella* which can nest in rock fissures. The presence of avifauna in the record is related primarily to predators. Rodents also seem unlikely to have deposited the seeds.
as, according to Bennàsar (2010) the rodent assemblage from TD6 was introduced by predators (*Falco tinnunculus*). Furthermore, no rodent tooth marks have been observed.

Given that the same species of birds, rodents and their predators are present in other levels, if they had been responsible for the introduction of seeds, we would expect to find seeds at other points in this Pleistocene sequence. As yet, these seeds have only appeared as an accumulation in sub-unit TD6-2 of Gran Dolina.

Coprolites represent the waste generated by dietary intake and provide information regarding diet, ecological adaptation, behaviour and other issues related to the agents that produce them (Carrion et al., 2001, 2004). Had the *Celtis* fruits been part of a herbivore diet, the remains of their seeds could well appear in predator dung, a result of accidental ingestion with other intestinal contents. The contents of eight *Hyena* coprolites recovered from level TD6-1 and sixteen from TD6-2 were analysed to detect presence or absence of seeds. Results ruled out the presence of seeds. Absence of seeds in the hyena coprolites suggests seeds were not deposited by these carnivores that had eaten the stomach contents of herbivores. In TD6-2 carnivore activity is very low, affecting only faunal remains, whereas human remains show no carnivore marks (Saladié et al., 2014).

Once activity by these other biological or physical agents has been discarded, the presence of seeds within the archaeological context allows us to interpret them as the result of human consumption. Therefore, the presence of whole seeds in TD6-2 suggests that had humans consumed them they probably spat them out again after consumption. According to Lambert (1999), chimpanzees (*Pan troglodytes*) can swallow *Celtis* seeds, whereas reddetailed monkeys usually spit them out although they can also swallow them.

Human consumption of *Celtis* seeds is not exceptional, and probably the presence of such seeds in other archaeological sites is related to human consumption. *Celtis* contains oils, proteins, fibre and minerals and has nutritional and medicinal properties (Demir et al., 2002). Furthermore, ethnographic evidence shows that due to the low proportion of flesh in this fruit (*Celtis occidentalis*) both pulp and stones were eaten by North American Indians, as well as by other human groups (Yanovsky et al., 1932; Simchoni and Kislev, 2011). The archaeological evidence at Atapuerca indicates exploitation of large, medium and small game including other humans, suggesting that early hominins displayed complex social and economic behaviour associated with foraging activities, and were opportunistic hunters (Carbonell et al., 2010; Saladié et al., 2011;
GRAN DOLINA site (Sierra de Atapuerca, Burgos, Spain)
TD6 level - Oblique section "B"

Fig. 5. Oblique section B distribution plan including all archaeological materials (top) and distribution of *Homo antecessor* and *Celtis* (bottom).

GRAN DOLINA site (Sierra de Atapuerca, Burgos, Spain)
TD6 level - Plan of Central & East area
Density of *Celtis* & *Homo antecessor* remains

Fig. 6. Distribution plan by density of the *Homo antecessor* and *Celtis*. 
Table 1
Presence of Celtis in other sites from Eurasia.

<table>
<thead>
<tr>
<th>Period</th>
<th>Site</th>
<th>Taxa</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Pleistocene</td>
<td>Dmanisi (Georgia)</td>
<td>Celtis type tournefortii</td>
<td>Messager et al. 2010</td>
</tr>
<tr>
<td></td>
<td>Zhoukoudian (China)</td>
<td>Celtis cf. barbouri</td>
<td>Chaney 1935</td>
</tr>
<tr>
<td>Middle Pleistocene</td>
<td>Vallonet (France)</td>
<td>Celtis de Lumley 1976</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Achailakalaki (Georgia)</td>
<td>Celtis</td>
<td>Ljubin and Bosski 1996</td>
</tr>
<tr>
<td></td>
<td>Karlich (Germany)</td>
<td>Celtis/Zelkova</td>
<td>Bittmann, 1992</td>
</tr>
<tr>
<td></td>
<td>Caune de l'Acago (France)</td>
<td>Celtis</td>
<td>de Lumley in Laville and Rénault-Miskovský 1977</td>
</tr>
<tr>
<td></td>
<td>Lazaret (France)</td>
<td>Celtis</td>
<td>de Lumley in Laville and Rénault-Miskovský 1977</td>
</tr>
<tr>
<td></td>
<td>Terra Amata (France)</td>
<td>Celtis australis</td>
<td>de Lumley in Laville and Rénault-Miskovský 1977</td>
</tr>
<tr>
<td>Upper Pleistocene</td>
<td>Douara cave (Syria)</td>
<td>Celtis cf. australis-cf. tournefortii</td>
<td>Matsutani 1987</td>
</tr>
</tbody>
</table>

Blasco et al., 2011). In TD6-2 humans were the main agents of bone accumulation, so it seems plausible that the presence of other remains such as Celtis might also be associated with human consumption. Human remains in TD6-2 were abandoned after consumption and were found mixed with other animal remains also deposited and consumed by humans. Hence, the origin of TD6-2 fossil accumulations is clearly anthropic. Both animals and humans were introduced to the cave where they were processed and entirely consumed. TD6-2 was a long-term occupation settlement in which carnivores played a limited and secondary role in assemblage formation processes. In relation to this last point, Saladie et al. (2014) conclude that hominins were well established in the territory, situated at the top of the trophic system and therefore had no need to compete for food with other predators.

The location of these seeds in TD6-2 and their association with other archaeological material indicate their connection with human activity and suggest their probable immediate use. The evidence presented in this paper contributes to our perception that an omnivorous diet could have been common for all human species from the earliest period of human origins, despite the fact that traces of a meat diet leave more evidence.

6. Conclusions

The presence of biomineralized Celtis remains in the archaeological record of Pleistocene sites provides recurring evidence of hominin plant gathering. Arguments relating this evidence to human consumption continue, yet in the context of *H. antecessor*, the association of Celtis with other material in TD6-2, and the abundance of seed remains in particular, suggest they were indeed human waste.

Early hominins probably based their subsistence on opportunistic hunting, as recorded through faunal assemblages, and also on opportunistic plant gathering. However, direct evidence of plant consumption among these hunter-gatherers still remains unclear. It seems obvious that an omnivorous diet was widespread among different hominid species, but plant remains are limited and their interpretation as human waste is always challenging.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jas.2014.11.016.

References


