La utilización de los recursos vegetales durante el Mesolítico y Neolítico en la costa atlántica de la península ibérica

The Use of Plants during the Mesolithic and the Neolithic in the Atlantic coast of the Iberian Peninsula

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“When you have eliminated the impossible, whatever remains,
no matter how improbable, must be the truth.”

Sherlock Holmes, by Arthur Conan Doyle. The Sign of the four, 1890.

“It is a capital mistake to theorize before one has data.
Insensibly one begins to twist facts to suit theories, instead of theories to suit facts.”

Sherlock Holmes, by Arthur Conan Doyle. A scandal in Bohemia, 1892.

“The little things are infinitely the most important.”

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ABSTRACT AND THESIS STRUCTURE

In this thesis, plant exploitation activities in Atlantic Iberia during the Early and Middle Holocene have been approached through the study of non-woody plant macroremain assemblages at Mesolithic and Neolithic archaeological sites in the Cantabrian region and Portugal. Little direct information was previously available; this thesis therefore contributes to the enrichment of current knowledge about the Cantabrian region and offers completely unprecedented data for Portugal, critical for the understanding of past human culture and essential for the comprehension of the different Neolithisation processes. The new archaeobotanical data shed light on the dynamics of the exploitation of plant resources, particularly regarding the phenomenon of the transition from wild resource gathering to domestic agriculture. A wide spectrum of wild resources and the earliest crops in Portugal, with an extensive range of cereals and possibly legumes, have been attested.

This thesis is divided into five parts; in addition to the general index, each part has its own detailed index.

Part I is dedicated to the framework in which this work has been developed. A general framework section approaches theoretical, environmental, social and historical issues regarding multiple aspects of Neolithisation. First, the key concepts in the topic are discussed. A general characterisation of Mesolithic and Neolithic societies, particularly as regards the exploitation of plant resources, follows the environmental outline of the studied regions. A detailed state of the art by region and archaeobotanical proxy is then presented. Next, the objectives of the work are described and, finally, a detailed description of the studied archaeological contexts follows.

Part II contains a review of the potential known methods (from direct ones to indirect) for approaching past plant exploitation and ethnobotanical considerations, with particular attention to carpological or non-woody plant macroremain analysis. The particular potentials and limitations of each method are discussed, and results from them have been used to construct the state of the art when available.

The results of this research are described in Part III. First, an extensive review is made of the identified taxa (Part III A) and the ecological, ethnobotanical and taphonomical information associated with them. The non-woody plant macroremain assemblages per context are then described in full (Part III B). An overview for each site taking into account taxonomical, taphonomical and ecological issues follows.

Part IV is dedicated to the discussion of the results. First, some thoughts about archaeobotanical taphonomy are articulated. Next, the new state of the art regarding Mesolithic and Neolithic plant-resource exploitation in the Atlantic coast of the Iberian Peninsula is discussed. Finally, the conclusions of this work are presented.

Finally, in Appendices and references, the sources employed during the development of this research are listed, including the sources of plant material donated by different institutions for the creation of a new seed reference collection at the Cantabrian International Institute for Prehistoric Research (IIIPC).
RESUMEN Y ESTRUCTURA DE LA TESIS

En este trabajo se ha estudiado la explotación de los recursos vegetales en la costa atlántica ibérica durante el Holoceno Inicial y Medio, a partir del estudio de restos carpológicos de yacimientos arqueológicos mesolíticos y neolíticos de la región Cantábrica y Portugal. La información previa disponible era muy limitada; esta tesis contribuye al enriquecimiento del conocimiento sobre la región Cantábrica y ofrece datos hasta ahora únicos para Portugal, para la comprensión de las culturas del pasado y de los diferentes procesos de neolitización. Los nuevos datos arqueobotánicos arrojan luz sobre las dinámicas de explotación de los recursos vegetales por las sociedades del pasado, y en particular en el marco de la transición de la recolección de recursos silvestres a la agricultura de domésticos. Se ha documentado un amplio espectro de recursos silvestres, y los primeros cultivos de Portugal, formados por diversos cereales y posiblemente leguminosas.

Esta tesis se divide en cinco partes; además del índice general, cada parte tiene su propio índice.

En la primera parte (Part I: Framework) se revisa el marco general de este trabajo, considerando las cuestiones teóricas, medioambientales, sociales e históricas. En primer lugar, se revisan los conceptos clave y las explicaciones sobre los procesos de domesticación y neolitización. A continuación, se describe el marco físico en que se enmarca el problema histórico estudiado, así como sus características socioeconómicas, particularmente al respecto de la explotación de recursos vegetales. Después, presenta el estado de la cuestión por región y método. A continuación, se plantean los objetivos a las que se enfrenta el autor en este trabajo y finalmente, se presentan los contextos estudiados ordenados por región y cronología.

Los restos materiales estudiados en este trabajo son un tipo de restos de plantas conocidos como carporrestos (frutos y semillas), con un potencial y unas limitaciones que se debaten de forma extensa en el capítulo metodológico sobre arqueobotánica (Part II: Methods), junto con otros métodos utilizados para la elaboración del estado de la cuestión.

Los resultados del estudio material se presentan en la tercera parte: la primera sección (Part III A: Results: the identified taxa) presenta la descripción de las características de los taxones identificados en todos los sitios estudiados; la segunda parte (Part III B: Results: the studied contexts) incluye la presentación detallada de los conjuntos carpológicos contexto por contexto.

En la cuarta parte (Part IV: Discussion and conclusions), se ponen en relación los datos obtenidos aquí con los datos disponibles hasta el momento de realización de este trabajo y se discute su contribución a completar el estado del conocimiento para los periodos y regiones estudiadas. Finalmente, se presentan las conclusiones.

Finalmente (Appendixes and references), se cita la lista de referencias utilizadas durante el desarrollo de este trabajo, junto con los programas informáticos utilizados y las fuentes de material vegetal donado por distintas instituciones, que han sido cruciales en la creación de la nueva colección carpalógica de referencia en el Instituto Internacional de Investigaciones Prehistóricas de Cantabria (IIIPC).
RESUMEN EXTENDIDO

Introducción

El momento del pasado estudiado en este trabajo tiene como punto de inflexión la aparición de las especies domésticas foráneas en la costa atlántica ibérica. Tras este fenómeno subyace un repertorio confuso y multidimensional de términos y conceptos que no siempre tienen una interpretación unívoca. En primer lugar, existen dos ámbitos de discusión con aspectos diferenciados y entremezclados: uno histórico, centrado en el cómo; y otro teórico, centrado en el por qué. Suponer que existe un porqué es ya una cuestión subjetiva que para algunas corrientes teóricas deja de tener sentido aunque en la tradición investigadora ha tenido mucha relevancia. Cierta confusión terminológico-conceptual existe resultado de la evolución de la ciencia y el conocimiento y trata aquí de salvarse mediante la explicitación de los conceptos que se suponen tras cada término convencional, siempre teniendo en mente que la mera etiquetación no es capaz de reflejar la diversidad y variedad de las sociedades humanas.

El estudio de la evolución de las relaciones sociedad-medio y los inicios de la domesticación de los recursos posee unos sesgos característicos del enfoque cultural eurocéntrico, una visión de la historia como evolución lineal hacia el progreso, definido por la trayectoria del mundo occidental, que es visto como el fin de la historia. Aunque este enfoque es típico de la mentalidad occidental desde la época de Aristóteles y su materialización en la investigación arqueológica tiene origen en las conceptualizaciones evolucionistas del siglo XIX, pervive de alguna manera en la asociación injustificada de:

• recurso silvestre – natural – sociedad cazadora recolectora – Paleolítico y Mesolítico
• y recurso doméstico – artificial – sociedad agricultora – Neolítico, paquete neolítico

Es necesario aclarar que los términos de “agricultura”, “cultivo” y “domesticación” hacen referencia a conceptos que no son intercambiables ni equivalentes ni tienen la misma visibilidad arqueológica. La cuestión tiene dos dimensiones que no siempre se diferencian netamente: una etológica y una genética. Se denomina “agricultura” al conjunto de las prácticas relacionadas con el uso de los recursos vegetales, silvestres o domésticos, que suponen una intervención más profunda que la mera recolección y que se emplean con el objetivo de controlar su producto de alguna forma (quema, replantación, irrigación, cultivo, etc.). Las prácticas agrícolas son asincrónicas. El “cultivo” o producción es una práctica agricultora que dependiendo de cómo se practique puede provocar la domesticación. Las sociedades humanas que no producen alimentos domésticos pueden llevar a cabo diversas formas de explotación de los recursos silvestres que pueden implicar la puesta en práctica de diferentes actividades agrícolas. La “domesticación” es una forma de mutualismo biológico, resultado accidental o intencionado de la puesta en práctica de varias formas de agricultura: bien la selección de uno o varios rasgos genéticos en el cultivo, bien el aislamiento genético relacionado con actividades como el transplante. Existen formas de domesticación que no acarrean cambios morfológicos, al menos detectables arqueológicamente. Por lo tanto, arqueológicamente se pone el énfasis en las especies que sufren cambios apreciables y la domesticación de otras plantas se infiere sólo a partir de evidencias más subjetivas, como la explotación intensiva.
La evidencia etnográfica manifiesta que los grupos humanos pueden utilizar las plantas para una multiplicidad de usos, tanto materiales como abstractos. Existe una relativamente amplia serie de técnicas de procesado vegetal y usos de plantas. Las plantas pueden ser de forma muy general clasificadas como silvestres y domésticas. Existen sociedades que utilizan exclusivamente recursos silvestres cuando no disponen de domésticos o cuando los conocen pero por la razón que sea han preferido no adoptarlos. Sin embargo, las sociedades que hacen uso de productos domésticos nunca abandonan los silvestres, y esto se puede deber a numerosas razones: culturales, funcionales, económicas, sociales. Los términos “Mesolítico” y “Neolítico” se utilizarán aquí para hacer referencia al periodo del Holoceno en que los grupos humanos explotaban especies silvestres en el primer caso y con silvestres y domésticas en el segundo.

La investigación sobre las causas de la aparición de especies domésticas se integra en el marco de la evolución sociocultural en general y por tanto participa del debate sobre la relación entre individuo y estructura. La dispersión de las diversas especies de plantas domésticas por Europa y la Península Ibérica se explica de acuerdo con múltiples modelos. En la fachada atlántica europea el panorama es heterogéneo, dándose varios tipos de procesos que pueden ser caracterizados entre los extremos: la colonización por inmigrantes que portaban los cultivos domésticos y la rápida adopción de esta agricultura avanzada por la población mesolítica existente; o un proceso lento y gradual de adopción de la agricultura. Lo que los datos parecen mostrar actualmente es que la universalidad no es aplicable a ninguno de los dos y es necesario particularizar los distintos procesos que ocurren a nivel local.

A partir del 7000 cal BCE, comienzan a dispersarse por Europa plantas domésticas originarias del llamado Creciente Fértil de Oriente Próximo, en donde se habían domesticado entre el X y el VII milenio: cereales (la escaña menor o esprilla, *Triticum monococcum*; el trigo farro, escanda o escaña mayor, *Triticum dicoccum*; *Triticum turgidum*; la cebada, *Hordeum vulgare*; el trigo candeal o común, *Triticum aestivum*; el trigo duro, *Triticum durum* y la espelta, *Triticum spelta*), legumbres (el guisante, *Pisum sativum*; la lenteja, *Lens culinaris*; el garbanzo, *Cicer arietinum*; la arveja o chícharo, *Vicia ervilia*; la almorta o guijo, *Lathyrus sativus*; el haba, *Vicia faba*) y una planta oleaginosa (el lino, *Linum usitatissimum*). Poco después, a partir del 5000 cal BCE, comienzan a aparecer signos de domesticación de otras especies, esta vez domesticadas posiblemente fuera de los centros originales de domesticación: la adormidera (*Papaver somniferum*), los denominados “cultivos secundarios” (el centeno, *Secale cereale*; la avena, *Avena sativa*; la colza, *Camelina sativa*), legumbres (los altramuces, *Lupinus spp.*; la alforba, *Trigonella foenum-graecum* y el arvejón, *Lathyrus clymenum*), dos “cereales menores” (el mijo italiano o panizo, *Setaria italica* y el mijo común, *Panicum miliaceum*). Posteriormente, la horticultura y arboricultura (olivo, higuera, vid), aunque no se puede descartar la existencia de “bosques manipulados” desde momentos muy anteriores. La evidencia de plantas en la costa atlántica ibérica, particularmente de plantas domésticas, entre el 8000 y el 3000 cal BCE es muy limitada: mientras que los datos sobre plantas silvestres son más abundantes pero están probablemente sesgados hacia tipos de plantas particulares, principalmente frutos (avellanas, bellotas, pomos, espinos, moras, etc.), los datos sobre los primeros domésticos se limitan a algunos yacimientos cantábricos con varios tipos de trigo y cebada y un yacimiento portugués de cronología incierta con algunos cereales y leguminosas.
Objetivos

Esta tesis tiene como objetivo abordar dos cuestiones: una arqueobotánica y otra histórico-arqueológica.

Por un lado, desde la perspectiva arqueobotánica, se desea conocer los usos de las plantas (¿qué plantas se usaban? y ¿cómo y para qué se usaban?) por las sociedades del pasado, con el objetivo último de conocer dichas sociedades.

Por otro lado, se pretende obtener nuevos datos para la comprensión del proceso de neolitización en la costa atlántica de la península ibérica, con la perspectiva de un marco temporal entre el 8000 y el 3000 cal BCE.

Esto enmarca el trabajo en la arqueobotánica o paleoetnobotánica (aquí considerados sinónimos). Diez yacimientos con contextos de cronologías entre el 8000 y el 3000 cal BCE han sido elegidos para realizar una aproximación a la explotación de los recursos vegetales en la costa atlántica ibérica.

Métodos

La arqueobotánica, o paleoetnobotánica, puede ser definida como el estudio de los restos de plantas que han sobrevivido en el registro arqueológico y sus usos culturales por los grupos humanos del pasado. Existen múltiples definiciones para la disciplina, de acuerdo con diferentes tradiciones investigadoras y posiciones teóricas. Mientras que muchos autores utilizan ambos términos como sinónimos, otros proponen una separación disciplinar, en la que el término paleoetnobotánica otorga una mayor importancia al aspecto etnobotánico y cultural del tema, mientras que arqueobotánica resalta la vinculación con la arqueología. Aunque este es un trabajo de arqueobotánica de metodología carpológica, el estudio de macrorrestos botánicos (semillas y frutos) no es el único método para el conocimiento de las prácticas paleobotánicas desarrolladas por las sociedades prehistóricas. Idealmente, los estudios multiproxy son los más apropiados para la comprensión del rol de las plantas en las sociedades del pasado, ya que cada método tiene unos potenciales y limitaciones determinados por el tipo de preservación de cada clase de resto que estudia, por la forma en que se desarrolla el método y las dificultades con que se encuentra. Algunas especies o tipos de usos sólo son visibles a partir de un sólo método. De esta forma, si se combinan varios, se pueden obtener datos complementarios sobre distintos taxones y usos. Las evidencias para el uso de plantas son muy variadas: desde otras fuentes directas hasta indirectas, restos relacionados de alguna forma con el uso de plantas. En esta tesis se han obtenido datos carpológicos a partir del estudio de los conjuntos arqueobotánicos carbonizados obtenidos en yacimientos arqueológicos de la península ibérica. Estos datos se han contextualizado con otras evidencias arqueobotánicas obtenidas a partir de otros métodos.

Resultados

Más de 12000 restos de plantas, procedentes de unos 75 taxones diferentes, han sido estudiados en esta tesis. En primer lugar, la descripción de los taxones documentadas ha sido organizada teniendo en cuenta la descripción general a partir de la observación de los carporrestos haciendo, cuando lo permiten las circunstancias, referencia a metodologías de identificación específicas. A continuación se nombran los yacimientos en que aparecen y su presencia arqueológica general. Después, se describen brevemente los requisitos ambientales de la especie, sus características (morfología, forma de reproducción, época de floración, propiedades, etc.) y otros aspectos que puedan resultar interesantes.
para su interpretación. A continuación, se citan los usos conocidos, principalmente conocidos a través de fuentes etnográficas, para cada una de las partes de la planta aprovechables. Finalmente, se mencionan los estudios experimentales, de otros autores o realizados expresamente en el marco de esta tesis doctoral, que son relevantes para la comprensión de los procesos tafonómicos potencialmente responsables de la aparición del taxón en el registro arqueológico. Al final del capítulo una tabla resume los datos (vid. Table 76). Esto ha permitido la constatación, confirmando lo que ya es sabido para los casos de preservación por carbonización (e.g. Zapata Peña 2000), de que la mayor parte de los taxones y partes de plantas recuperados son los que por sus formas de preparación implican la utilización de fuego. Además de la variedad taxonómica, los taxones identificados se dan en una variedad de ambientes y tienen diversas técnicas de dispersión. Por otro lado, los potenciales usos alimenticios y medicinales son los más frecuentes, aunque los tecnológicos son también amplios.


Discusión

Esta tesis ha tratado de aportar nuevos datos para la comprensión de las actividades de explotación de los recursos vegetales desarrolladas por las poblaciones humanas durante el Mesolítico y Neolítico en la costa atlántica ibérica. Los datos obtenidos y su integración en el estado de la cuestión están condicionados por la forma en la que han sido obtenidos: las estrategias de muestreo y técnicas de recuperación han influido notablemente en los resultados disponibles: independientemente del tipo de yacimiento y su antigüedad, los yacimientos muestreados sistemáticamente y con unas técnicas apropiadas han sido los que mejores resultados han aportado, tanto a nivel de abundancia como calidad de la información. Algunas especies de potencial importancia para las sociedades del pasado no han sido identificadas en el registro arqueológico, pero en el actual estado de la cuestión es difícil establecer si esta ausencia se debe a problemas de conservación, recuperación e identificación, o a una verdadera ausencia de explotación. Por otro lado, se han reconocido varios indicadores potenciales de usos de plantas difícilmente registrables carpológicamente que necesitan ser explorados en profundidad: los foraminíferos, los excrementos de artrópodos carbonizados y los esclerocios de hongos de tipo micorriza.
Gran diversidad de recursos silvestres (frutos y herbáceas) han sido explotados durante el Mesolítico y Neolítico, siendo los usos alimenticio, medicinal y tecnológico (fibras, etc.) los más firmemente sugeridos por las evidencias disponibles.

En Portugal destaca la explotación del pino piñonero (*Pinus pinea*) en los yacimientos mesolíticos y de camariña (*Corema album*) en los neolíticos. Se han obtenido las primeras evidencias de cultivos domésticos en el Neolítico Inicial de Portugal, principalmente conformadas por un amplio espectro de cereales (trigos y cebadas: *Triticum “nudum”, Triticum durum, Triticum dicoccum, Triticum monococcum, Hordeum vulgare var. nudum y Hordeum vulgare var. vulgare*), y complementadas con posibles cultivos de leguminosas (*Pisum sativum, Lens culinaris, Vicia faba, Lathyrus sativus/Vicia ervilia, Vicia sativa, Vicia cracca*). Esta evidencia apuntan a la posible existencia de conexiones culturales con la costa sur de la Península Ibérica y el norte de África.

Para el Cantábrico, se han complementado los datos obtenidos en trabajos previos (*Corylus avellana, Quercus sp., Sorbus sp.*) y se ha documentado la explotación de nuevas especies de frutos silvestres (*e.g. Arbutus unedo, cf. Ficus carica*). Con respecto a los domésticos, se ha documentado por primera vez la presencia de cebada desnuda (*Hordeum vulgare var. nudum*) a finales del IV milenio. La evidencia disponible para evaluar la neolitización en el Cantábrico está exclusivamente formada por cereales (trigos y cebadas), y es aún muy limitada.

**Conclusiones**

Este trabajo ha cumplido el objetivo de proporcionar nuevos datos para la comprensión de la neolitización y la utilización de recursos vegetales por las sociedades humanas de la Iberia atlántica entre el 8000 y el 3000 cal BCE. Esta tesis también ha contribuido a mostrar que los carporrestos pueden ofrecer información muy relevante sobre las prácticas humanas del pasado cuando se ponen en práctica estrategias apropiadas de muestreo y recuperación en todo tipo de yacimientos arqueológicos.
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1 General framework

The chronohistorical framework of this work is the Mesolithic and Neolithic periods (vid. p. 28), spanning several millennia (from the 8th to the 4th in the Iberian Peninsula) and corresponding to the climatical Early and Middle Holocene periods, in which domesticated species appear for the first time in a recognisable form through most of the European continent. As human culture is constructed by its environment, both abiotic, biotic and social (Halstead & O'Shea 1989), all these background aspects, together with a clarification of terms and concepts, will be considered as briefly as possible to address the object of this work.

1.1 Theoretical and conceptual issues

The process of appearance of domesticate species has several dimensions running not necessarily in parallel directions and a series of terms and concepts which are often intermingled, confused and discussed (e.g. Sherratt 2007). This is a result of the natural evolution of science and knowledge, but it complicates the approach to the matter. The multidimensional aspects spoken of are the historical one, interested in the practical evolution of things (what and how), and the theoretical one, interested in why things happen (Vicent-García 1988). This multidimensionality, not always properly recognised in historiography, has produced a series of terms which often have different associated concepts, evolving through time and according to the theoretical point of view about the issue. Both the abandonment of old-fashioned terms and the creation of new ones and the usage of traditional terms with explicit connotations, have been at times considered the best alternatives. This last option has been the one taken in this work, because all terms, new ones and old ones, have necessarily a subjective conceptual background important to think about and make explicit.

1.1.1 Agriculture, farming, cultivation, production and domestication

Agriculture, cultivation and domestication are terms which have traditionally been associated and still are in some theoretical standpoints. However, they most likely refer to different realities (e.g. Rindos 1990; vid. Figure 1), and thus they are not equivalent nor exchangeable, neither do they have the same archaeological visibility. Whilst domestication is a biological, probably accidental phenomenon, cultivation and all the others are cultural, thus intentional, phenomena (Price & Gebauer 1996). Because they have been erroneously considered, the panorama has resulted blurred, so that “looking for the beginnings of agriculture is a research pursuit doomed from the start” (Terrell & Hart 2008). The complexity of this issue partly relies on the fact that two dimensions exist, and which sometimes, but not always, run parallel: an ethological and a genetical one.
1.1.1.1 **Agriculture or farming**

Agriculture and farming are terms that reunite several techniques of food production of vegetable and animal origin, of unequal relevance and with very diverse consequences (vid., Castro-Martínez 2005). All practices related to the management of plant resources, irrespectively on either wild or domestics, involving more than the mere gathering, with the objective of controlling the product somehow (burning, transplantation, irrigation, cultivation, forest nurturing, etc.) are considered agricultural (e.g. Bender 1975; Hastorf 1998a; Messer 1979). The problem is that “there is no single turning point before which people-plant relations were “simple” and after which they were “complex” (Jones & Colledge 2001). Thus, agricultural practices are asynchronical (Denham & Iriarte 2007) and could, in a certain way, be considered a form of domestication (Terrell & Hart 2008). “When looked at closely, foraging is not as different from farming as popularly believed” (Terrell & Hart 2008); “the ethnographic evidence indicates that people who do not farm do about everything that farmers do, but they do not work as hard” (Harlan *apud* Fernández-Armesto 2001). Foragers are always experimenting with new plants, not only for food (Hastorf 1998a). What is transmitted with the Neolithic are plant domesticates, but not agriculture (Barrett 2011). From very early times, humans have practised woodland management: forests are nurtured by pollarding, coppicing and shredding (Balée 1989; Denevan 1992; Out, Vermeer & Hänninen 2013; Shipek 1989). Groups relying on seeds and nuts (annual or biannual) tend to set wildfires regularly to encourage them at the expense of perennial fruits and nuts (Keeley 1996).

“Definitions of agriculture focused on domestication are conceptually inadequate to characterise the emergence of early agriculture because they assume that the selective pressures exerted through deliberate management of species cause morphogenetical changes in animals and plants. Such perspectives underestimate the potential influence of genetical isolation on the emergence of distinctive
genotypes and phenotypes. Genetical isolation isolation could have occurred due to various activities, including those not ordinarily understood to be agricultural. Furthermore, such definitions are substantively insufficient because they fetishise one epiphenomenon of plant exploitation over all others, including environmental transformation and cultivation practices; thereby, they fail to represent the diversity and multifaceted nature of early agricultural practices in different parts of the world” (Denham & Iriarte 2007).

1.1.1.2 Domestication

Plant domestication is a form of biological mutualism, resulting accidentally or intentionally from several agricultural practices: either the selection of one or several genetical traits on cultivation (Allaby, Fuller & Brown 2008), or the genetical isolation whilst transplanting (Jones & Brown 2007).

One of the traditional problems of understanding domestication is the search for a valid explanation for both plants and animals, or even landscapes (Jorge 2000; Terrell & Hart 2008), whilst it is now clear that explanatory models must be sought separately, not only for the different orders, but even for species. The characteristics of the domestication process vary according to each trait and species, depending on ecological preferences and reproductive mechanisms, and the human context of use, including the forms of gathering, transplantation, and purposes (Allaby, Fuller & Brown 2008). Careful comparison shows that each of the crops has a unique evolutionary history in its own right despite apparent similarities between selection under domestication of crop groups (vid. Abbo et al. 2009; Ladizinsky 1989).

Theoretically, fully domesticated plants cannot survive without human intervention: most cereals are in an intermediate state in which weedy races evolve and recover the wild system of seed dispersal and reproduction (cf. Zohary, Hopf & Weiss 2012). In the case of legumes, domestication involves morphological changes which do not necessarily mean genetical barriers (Smartt 1980). Other less widely spread lines of thought consider that domestication is just knowing how to use a resource (Terrell & Hart 2008).

It is generally accepted that the domestication of plants follows an evolutionary trajectory with deep cultural roots based on a long-term process of exploiting wild life in general and of a long trial and error process with plant species (Abbo, Gopher & Lev-Yadun 2005). “Plant domestication [is] an outgrowth of typical gatherer-forager practices” (Pearsall 2009). Despite that, for some authors, plant domestication is a revolution, a Big Bang (e.g. Abbo et al. 2006) and they consider it necessary to distinguish between domestication episodes and the later crop evolutionary processes under domestication, crop improvements, which are still ongoing (Abbo, Lev-Yadun & Gopher 2012). Such a distinction is however disregarded by those that consider domestication a multidimensional and multirelational long-term phenomenon spanning from centuries to millennia (e.g. Fuller, Asouti & Purugganan 2012; Willcox 2005). The main issue seems to lie on the consideration of intentionality and casualty: “while we see the domestication episode as a culmination of a long process of deep perceptual change in culture-nature (man-world) relations, the proponents of the protracted domestication model see domesticated crops as an end product of a long unconscious process, which began with no intention to domesticate” (Abbo, Lev-Yadun & Gopher 2012).
In addition to the differences in approach, problems involved in the understanding of domestication processes are diverse, because generalisation is impossible. Concentrating on a search for a clear practical and functional explanation for plant domestication may be somewhat misleading, especially when making cross continental comparisons and depicting possible global scenarios (Abbo, Lev-Yadun & Gopher 2010).

Two main sources of knowledge about past plant domestication are exploited: archaeobotanical remains and genetics (Zohary, Hopf & Weiss 2012). However, research into how domestication occurred requires the accumulation of other multidisciplinary data, such as geography, ecology, agronomy, etc. (Abbo, Lev-Yadun & Gopher 2012) which are sometimes difficult to conciliate. Domestication involves genetical and, usually but not always (e.g. Bender 1975; Terrell & Hart 2008), and especially not always in an archaeobotanically detectable way, morphological changes in the plants. This is often the case for drupaceous fruit-plants, where selection is directed towards changes in the quality of the flesh and not in the archaeologically preservable endocarps (Zohary & Hopf 1993); thus, the study of plant domestication in these types of plants has always been understudied, and subjective appreciations, such as the intensiveness of exploitation, have been used as proxies. Genetical evidence might be misleading too, as naturally induced genetical mutations in wild species (about 10 %) might induce to suppose the existence of selection practices (Zohary, Hopf & Weiss 2012).

The study of the mechanisms of domestication is partially founded over the nuclear zone hypothesis, because it is necessary to determine the distribution of the wild progenitors, rather than determining the most genetically diverse current populations, as was initially thought (Vavilov 1926). This relies on the assumption that the current distribution of potentially wild progenitors is similar to that in the time when domestication occurred (the propinquity or hilly flanks hypothesis, e.g. Braidwood 1960) and this seems to fit some cases (e.g. the oldest archaeobotanical remains with the first signs of proto-domestication of some species appear in the same regions where their wild progenitors are currently distributed; Zohary, Hopf & Weiss 2012). However, the wild progenitor distribution is sometimes difficult to establish (e.g. the case of apples and pears; Zohary, Hopf & Weiss 2012), too wide (Zohary, Hopf & Weiss 2012) or even mismatches the old one. Therefore, it is often necessary to check the geographical limits of the original regions by devising abstract models taking into account several ecological factors (e.g. Barker 1985; Harris 2007; Willecox 1999).

1.1.1.3 Cultivation or “production”

Cultivation, sometimes labelled as “production”, is an agricultural practice that, depending on how it is carried out, can lead to domestication. “Cultivation is the act of planting a seed or other propagule in a new situation” (Peña-Chocarro & Zapata 2010). Predomestication cultivation (e.g. Allaby, Fuller & Brown 2008; Asouti & Fuller 2012; Helbaek 1959; Hillman 2000; Zohary, Hopf & Weiss 2012) also known as protoagriculture (Keelley 1996) was possibly (though not for the defenders of the Big-Bang model of domestication; Abbo, Lev-Yadun & Gopher 2012; Peña-Chocarro & Zapata 2010) a stable and long-lasting practice, not just a transitional practice existing whilst the domestication process was developing (Jones & Brown 2007) but that passes unperceived because of the bias towards morphological identification of domestication (Hastorf 1998a). Domesticating cultivation involves
gathering by uprooting or cutting with sickles, whilst non-domesticating cultivation involves techniques such as beating (Hillman 2000).

1.1.2 Folk biological taxonomy and nomenclature

Human groups with traditional ways of life often have an extensive botanical knowledge that points to the importance of plants in their material culture. A great number of species of plants are identified by traditional societies, i.e., they are individually named and assigned to specific functions (Brown et al. 1985; Brown et al. 1986; Powell 1976; Sillitoe 1988). Plants play an important role even in areas where plant life is not abundant (Lee & DeVore 1968). The living world is identified, classified and categorised by all societies in different ways (Ford 1978a), according to their forms of understanding the world, in a process that is continuously evolving (Brown et al. 1986): taste, conceptions of good and bad, habitat, perceived masculine or feminine gender, etc. Different plants might be put together under a single name (Brown et al. 1986), whilst others might have several names each (Ford 1978a). The process of classification depends on the characteristics that are chosen to be distinguished (natural or cultural) and serves as a method for reducing the complexity of the environment (Wetterstrom 1978).

The existence of similarities between modes of subsistence and modes of taxonomical organisation have been thoroughly discussed, and it is sometimes argued that farming brings structural changes in folk taxonomies, but it is not clear whether correlation exists between the development of farming and the tendency to subcategorisation and binomialisation in folk taxonomies (Brown et al. 1985; Brown et al. 1986). Current categorisations of the living world might not be extensible to other societies, especially those of the past, including the Neolithic (Cummings & Harris 2011) and this contributes to the complexity of the Neolithisation process. It is not known how the Neolithisation affected the existing taxonomies nor if the frequent phenomenon of the replacement of species under a specific vernacular term after exogenous introductions could have taken place in Neolithic Europe: e.g. common millet was an important crop in Portugal, known as milho in Portuguese, which was replaced by maize under the same term after the European contact with America.

Plants are often broadly categorised, from our European perspective, as wild and domesticated (Valamoti 2015), although the frontiers between them are sometimes blurry, both in theoretical and practical issues. In addition, major categories of plant use or crop types follow: grain crops (cereals and pseudo-cereals), pulses (beans and bean-like crops), root foods or tubers, oilseeds, tree fruits, nuts, other herbaceous seed or fruit crops, leafy vegetables, spices or condiments and fibre crops (Fuller 2006). Starting with the theoretical issues, the distinction between different realities represented by the two terms (wild-domesticated) is dubious (Valamoti 2015). Whilst the term wild refers to those plants that generally grow without cultivation, difficulties involved in the definition of what is plant domestication exist (vid. p. 11). Moreover, a pre-domestication cultivation exists and a large number of other managed species (Mason 2000) are perceived as wild or naturalized domesticates (Łuczaj et al. 2012). The use of wild and domesticated resources is always inseparable for many reasons (e.g. Ertug 1998; Mason & Hather 2002), the cultivation of crops might even encourage the intensive exploitation of wild plants (Colledge & Conolly 2014):
cultural: some gathered wild plants are reported to taste better than when cultivated (e.g. Ertug 1998) and many of the uses of wild food plants are related to the diversification of a monotonous diet in non-famine times (Łuczaj et al. 2012);

functional: different types of plants serve different purposes (e.g. some groups depend on wild foods but have domesticated psychotropic plants (e.g. Rudgley 1999); wild plants tend to serve as children’s snacks (Łuczaj et al. 2012);

economical: gathering wild plants is important for the subsistence of poor families and in times of famine (e.g. Łuczaj et al. 2012), but also gathering and exchanging wild plants, particularly those of medicinal properties, with others who do not have the knowledge can be a specialised activity (e.g. Messer 1979);

social: wild plant gathering is a social activity (e.g. Ertug 2003).

The distinction of wild and domesticated is also difficult in archaeobotanical practice: often, plant remains of both types are indistinguishable, not to speak of the problem posed by intermediate specimens with a mixture of characters of both types. Assumptions of their status have often been made according to abundance proxies: when remains are scarce, they are often interpreted as wild, when abundant, as domesticated (e.g. Kislev 1989). This is obviously a circular argument which relies on prejudices about what should be, when and how, according to current theoretical and subjective hypotheses.

1.1.2.1 Wild plants

Wild resources are generally abundant, predictable, easily gathered and storable (Harlan 1992), “relatively inexhaustible types of rapidly reproducing, resilient resources” such as grass seeds and nuts (Hayden 2009). Because seeds and fruits have very good storable qualities, they cannot be proxies of seasonality in archaeological sites. An environmental management of wild plants by non-agrarian early Holocene peoples in Europe is believed to have been developed (Mason 2000; Kroll 2013).

Wild plants can be categorised, always imperfectly, according to their ecological groups, habitats or growth habits.

1.1.2.1.1 Herbs / weeds

Many herbaceous plants are interesting resources for human exploitation, either for their seeds, flowers, leaves, straws, fibres or roots, for many different uses, as foodstuffs, medicines, etc. It is a frequent bias to characterise as weeds many of the herbs that are currently obnoxious. Any herbaceous plant growing where it is not wanted is a weed (Harlan & Wet 1965); however, weeds are not and have not always been weeds. i.e., a plant that within a crop field might be considered a weed, whilst in its natural habitat might be desired and intentionally exploited for different purposes. So categorising a wild plant from an archaeological context as a weed is a very delicate matter. But herbs which act as weeds and research into “weed life histories” (Jones 2002a) if very useful for reconstructing past plant
management. Some weeds, known as *obligatory weeds*, have lost their primary habitats (Zohary 1950). Some might even be managed as *economic weeds* (Kroll 2013).

Herbs might be classified according to their habitat, although some of them are multi-habitat:

- **Adventitious**: spontaneous or accidental plants growing outside their natural habitat.
- **Comensal**: plants that share nutrients with other plants.
- **Ruderal** plants, from herbaceous annuals to woody perennials, that grow in disturbed areas. These are mostly areas with human impact, such as roadsides, domestic waste deposits, thatching, fallow fields, animal sheds, forest clearings, etc. In natural environments, disturbed areas are rarer, such as river banks, lake shores, flooded areas, land slips, steep cliffs, forests after fires, overgrazed grasslands, trails affected by intense animal trampling, burrows, regions where glaciers have retreated, etc. (Harlan & Wet 1965).

- **Segetal or agrastal** plants are directly linked to agricultural practices, as they appear in crop fields and home-gardens. Depending on their seasonality (fruiting time) they can be useful for inferring when a crop of several possible seasons of cultivation was indeed cultivated and how the fields were kept (determining the extent of weeding, manuring, irrigating, etc.) and the harvesting technique (Bakels 2009; Bogaard 2004).

### 1.1.2.1.2 Fruit trees and shrubs

Fruit trees and shrubs are perennial and start to bear fruits 3-8 years after planting and reach full productivity seven years later. Their reproduction under cultivation is usually by vegetative reproduction (grafting), allowing the fixation of the desired types of fruits. The physical (anatomical or morphological) distinction of domestication in fruit trees is difficult to detect in the archaeological record, because the key factor is the selection towards bigger fruit sizes, and whole fruits are rarely preserved. Methods for detecting woodland management, “the long-term influence of people on trees and shrubs to improve and optimize the quantity and quality of the wood”, are now being developed (Out, Vermeeren & Hänninen 2013). The geographical factor can show the introduction of a species outside its natural range, but cultivation within the natural range before the discovery of the scion cutting technique is impossible in the present state of the art. Most of the fruits recorded in this work were supposedly taken into cultivation by grafting in classical times, although they were heavily exploited over several millennia before and cultivation with reproduction by seeds cannot be ruled out. Thus, it is considered that all are likely to be wild species in the absence of a method for proving the contrary (Zohary, Hopf & Weiss 2012).

### 1.1.2.1.3 Underground plants

Plant with large underground vegetative organs, such as tubers and rhyzomes, have played an important role in many human societies, particularly in the tropics. It is often considered that the role of these plants in temperate Europe must have been limited, as they are relatively scarce (*e.g.* Asphodelus, Lilium, Scorzonera), and many of them are seen as uninteresting because of their small size (*e.g.*
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*Allium, Muscari* or toxic in a raw state (*e.g.* *Veratrum, Colchicum, Convallaria*). However, this view has been appropriately recognised as probably skewed as a result of the underdevelopment of parenchyma analyses in archaeobotanical studies (Mason & Hather 2000). Furthermore, it is now sufficiently demonstrated that resource size is not necessarily a limiting factor in their exploitation (*e.g.* Harlan 1992), nor is the toxicity (*e.g.* Fairbairn 2007), always surmountable with certain processing and a useful property in itself.

**1.1.2.2 Domesticated plants**

Different types of domesticated plants exist, that have in common certain traits (mainly, their reproduction system and usefulness) that have changed through selection (*e.g.* cereals, from shattering to non-shattering, from hulled to naked, etc.; legumes, from dehiscent to indehiscent, from thick impermeable seed coats to thin permeable, etc.; fruits, from small fruit-meat to big; fibre-plants, from short and weak to long and strong fibres, etc.).

**Arable crops**

Cereals and legumes have been the main arable crops in history since the first agriculture. By practising rotation or mixed cultivation of cereals and legumes, high levels of soil fertility are maintained. This ancient and highly successful combination of cereals and legumes is usually referred to as a natural choice due to the complementary nutrient contents of the two crop types (Zohary & Hopf 2000).

Cereal and pulse cultivation involves a wide group of year-round activities: soil preparation for planting, sowing, manuring, irrigation, pest treatment, weeding, harvest and processing (a series of diverse activities from preparing the threshing floor and threshing, winnowing, dehusking, screening, etc. to final use). These activities vary depending on the type of crop, the destination and the ambient (dry or humid) in which it is processed. Many of them are developed in the field and for a short time during the year, and for that reason, fields are a very interesting object of study for the reconstruction of productive processes (Hastorf 1998b), and they might be recognised with the appearance of artefacts present in the compost (Wilkinson 1982). Whilst some activities, such as preparing the soil or harvesting are labour intensive, it is sometimes argued that less demanding tasks, such as weeding, might have been developed by children and old people unfit for heavier work (Halstead 1989). The latter stages of processing are carried out in domestic areas and are therefore more likely to be carried out on a daily basis and thus represented in the charred archaeobotanical record (Fuller, Stevens & McClatchie 2014).

The are several types of land use, listed from less to more intensive (Boserup 1965): itinerant agriculture (long fallow); slash-and-burn agriculture or wood fallow (from 1 to 2 years of intensive cultivation and wood recovery in the next 20 to 25 years); shrub fallow (cultivation between 1 and 8 years and recovery between 6 and 10 years); short fallow (between 1 and 2 years); annual harvest (some months of recovery between harvest and next sowing); crop-rotation; multiple cultivation (2 or more successive harvests in the same cropfield), maslin cultivation and multi-story cropping (Butler 1999).
Considerable debate exists regarding the type of agricultural system after the introduction of domesticated crops in Europe, between a small-scale intensive agriculture (garden cultivation) or a slash-and-burn nomadic agricultural system; the former seeming to be the most likely in Central Europe (Bogaard 2004).

The difference between winter, spring or facultative sowing varieties of the same genus is genetical (they are lines, cultivars or land-races) and does not show in cereal grain morphology. Considerable debate also exists on the seasonality of crop cultivation: winter cultivation might not have been practised in fields with low agricultural pressure (Holzner & Numata 1982) until some time later after the beginnings of agriculture (Hillman 1981). However, winter crops would have been preferred because of their higher yield and because sowing cereals in autumn allows the labour efforts to be distributed more evenly throughout the year, as pulses and oil plants need to be necessarily planted in summer (Bogaard 2004). It is often difficult to tell the seasonality of crops, but both have been potentially identified, sometimes co-occurring, already at Late Neolithic contexts (Behre & Jacomet 1991).

The characteristic of soils might influence or condition the chosen crops to be cultivated and the amount of work required for cultivation: heavy soils (e.g., clayey) require more labour, risk and a shorter period of work; whilst light soils (e.g., calcareous) are easy to work, warm quickly, more vulnerable to drought and lower in plant nutrients.

Animal farming is an activity strictly related to both agriculture (e.g., Charles, Halstead & Jones 1998) and wild resource exploitation (Foxhall 1998). The way in which animal farming complements plant use varies according to social, political, economical and environmental factors. In a very simplified manner, crop productivity depends on animal manuring whilst the capacity of sustaining animals depends on crop sizes (Forbes 1998). Alternate farming is more productive than permanent pasture (Bradley 1978). Some foddering strategies do not require much extra human work (e.g., the use of by-products as fodder or forest browsing) whilst others do require some input (e.g., the creation of grasslands for grazing) (Bouby & Ruas 2005). Animal dung might be used as manure for crops or fuel for domestic activities. Chaff (light components of the cereal spikes) and crop by-products or even the crops themselves can serve to feed the animals indistinctly (Foxhall 1998) or selectively (Palmer 1998). But in addition to animal fodder, cereal straw, particularly from wheat and rye, can be used for domestic technologies, and can even be the objects of trade (van der Veen 1999; Mingote-Calderón 1987): building, particularly for thatching and livestock enclosures, but also for walls, within mud-bricks or plastered bunches; for domestic equipment, such as basketry, cordage, brooms, straw mattresses; for enclosures or scarecrows in crop fields; for fuel to light or maintain the fire; for cattle bedding and beehives; for pottery manufacturing, to provide shape and consistency; for flattening threshing floors, mixed with wet soil and trampled or pressed with a roller; as food-stuff preservative, thermal isolator; for protection for transported manufactures (e.g., pottery vessels), etc. When the straw is going to be used, techniques such as low sickle-cutting or uprooting are employed for the harvest and the straw is separated from the spikelets by percussion (animal trampling or with a threshing sledge), or double cutting at different heights is done.
Garden crops

Crops grown in vegetable gardens usually need more manure and more care, such as watering, than arable crops.
1.2 Environmental framework: landscape

The Atlantic façade of the Iberian Peninsula has been a common research area for the Mesolithic, because of a long shell-midden research tradition and a possible littoral concentration of populations (Straus 2008). It is also an interesting scenario for researching the phenomenon of Neolithisation, because of experiencing a certain delay in the appearance of plant domesticates, not merely explainable by the simple fact of its location in the extreme opposite of the core region where domesticates first appear. Although the exploitation of natural resources is conceived here as a cultural activity and not a mere ecological adaptation, the potential repertoire of resources available needs to be considered in order to try to understand how humans make their choices. The Iberian Peninsula constitutes a territory where climatic, geological, biogeographical and historical conditions have converged to produce environmental heterogeneity and diversity (González Sampériz & the Paleodiversitas Team 2010). It comprises two of the 3 regional traditions in the exploitation of plants during the Mesolithic in Europe: the Mediterranean basin and temperate Europe (Zvelebil 1994). This matches the current (Quaternary) distribution of the Iberian flora in two macro biogeographical/climatical regions: the Eurosiberian, with some particularities due to its proximity to the Atlantic Ocean, and the Mediterranean, which displays more complex patterns and singularities, now and in the past (González Sampériz & the Paleodiversitas Team 2010). Moreover, these two regions, probably because of their different sociological evolution in recent times, have quite different historiographical traditions, which have produced different states of the art, sometimes hardly comparable between one another.

The reconstruction of physical or geographical conditions is relatively easy for such a recent period as the Holocene, due to the fact that changes are relatively subtle: whilst orography is practically unchanged, the most important modifications have occurred in sea levels and their consequent effects in water flows (estuaries, river courses, etc.) due to climatical variations, and as a result of the combination of eustatic sea-level changes and vertical land movements. However, substantial spatial and temporal variability in sea-level changes and coastal evolution is known to have occurred during the Early Holocene, even when localities lie close to each other (Leorri et al. 2013), and different proxies can lead to contradictory reconstructions (vid. infra). Climate and landscapes are more difficult to reconstruct, as different proxies, with consequently different potentials and constraints, might be employed at a general scale and can only in some particular cases be particularised at a small scale. "Any attempt to generalise
from existing data, differing both in time and space, raises issues of over-interpretation” (Berger & Guilaine 2009). In addition, a single ecological proxy can match several possible landscapes. Moreover, in addition to the traditional landscape determining factors, such as climate and geography, human impact and the anthropisation of landscapes is increasingly recognised as a key element complicating the reconstruction of landscapes (López Sáez, López García & López Merino 2006).

According to climatical periodizations, the Early-Middle Holocene (8000-5000 – 5000-2000 cal BCE) is the climatical framework of this work, a relatively stable warm period characterised by the interruption of the typically Pleistocene glacial and interglacial successions, which produced a large sea level rise (Smith et al. 2011). However, several climatical shifts occurred and most prominently an abrupt climate event between 6450 and 6050 cal BCE (known as the “8200 BP event” or “8.2 ky event”), which brought general cold, dusty and dry conditions to the northern-hemisphere, mostly in wintertime, producing an abrupt change in the atmospherical and oceanic circulation patterns and even a temporary interruption, possibly caused by the combination of an extensive meltwater input at local level and solar output fluctuations at general level (Alley et al. 1997; Rohling & Pälike 2005). In South-West Europe, the episode implied highly erosive effects, with streaming processes and torrential events in the wet season and widespread and frequent fires in the dry season, which might be correlated with a generalised process of vegetation opening; this would be archaeologically relevant in as much as it could also imply the erosion of Mesolithic depositional layers, over which Early Neolithic ones would sit in palimpsest-like archaeological sites, or population decreases, or a combination of the two (Berger & Guilaine 2009). According to the evolutionist theory, the forest is the stable paraclimatic state of vegetation in most temperate European regions in the Holocene, and the natural ecological dynamical tends to progressively close all vegetation clearances, caused by natural and anthropic factors, until reaching the “climax”. Natural prairies only existed in valley floodplains. Therefore, landscapes are supposedly evolving continuously towards the end point of evolution, and a large and diverse assemblage of intermediate landscapes exists, with their particular plant associations, according to different natural factors and the intensity of human pressure (Bouby & Ruas 2005).

1.2.1 Cantabrian region

The term Cantabrian region is usually employed to refer to a natural region, formed by the mass of land between the Bay of Biscay and the mountain range known as the Cantabrian Cordillera. This longitudinal strip is oriented in an East-West axis at between 42º and 43º latitude North. Thus, it has nothing to do with political regional administrative boundaries nor it is limited to the territory of the Spanish Autonomous province of Cantabria, but includes several administrative entities. It is a natural region with ecological particularities given by its geographical position and orography.

Orography in the Cantabrian region is abrupt, as most relief features are the result of recent alpine formation processes. The western part of the region is mainly formed by folded Palaeozoic rocks; whilst the eastern part is mostly Mesozoic limestone and marl. The Bay of Biscay coastal area is a typical inundation coastline, in which erosive processes are dominant along the Cantabrian coast, as constant wave attack causes active cliff destruction (Leorri & Cearreta 2004). The region has suffered intense karstification processes. Mires are abundant, but endangered due to intensive exploitation, in the mountain range. A high level of precipitation and an overall climate which promotes the existence of
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forests is ensured by humid north winds detained by the southern mountain range (López Sáez, López García & López Merino 2006). In addition to this and because of the proximity of the mountains to the sea, river courses are short and torrential. The Gulf Stream ensures a mild oceanic climate despite the relatively high latitude, the climate is Atlantic, with mild temperatures and moderate variations and heavy annual precipitation, although some microclimatical Mediterranean locales exist.

Relative sea-level (RSL) fluctuations on the Early Holocene changed the seashore from a few metres up to a few dozens of metres depending on the microlocation. “The northeastern coast of Spain is characterized by Mesozoic–Cenozoic sedimentary rocks forming high cliffs interrupted by short, narrow estuaries that are separated from the open sea by sandbars, beaches and dune deposits. The morphology and extent of the different estuarine sedimentary environments are constantly altered by erosion and deposition of sediments, and they are sensitive to even small changes in sea level” (Leorri & Cearreta 2004). The Early Holocene is characterised by probable episodical long-term incursions of the warm and salty Iberian Poleward Current into the Bay of Biscay (Mojtahid et al. 2013) with the initial development of estuarine environments from 6500 cal BCE (Leorri & Cearreta 2009); and a marine transgression occurring at a quick rate up to 5500 cal BCE and much slower since 5000 (Leorri & Cearreta 2004 contra Mojtahid et al. 2013), with a period with unreliable markers between 5500 and 5000 cal BCE (Leorri, Cearreta & Milne 2012), being quite stable until industrial times. In the central part of the Cantabrian coast, Holocene sea-level rise was stepped and two neat sequences have been recognised, although precise dating has not been achieved (Cearreta & Murray 1996).

High precipitation (Mojtahid et al. 2013) and relatively cold temperatures (warmer than in the Pleistocene but colder than in the climatical optimum) were recorded before 5850 cal BCE and notably between 9600 and 8600 cal BCE (López-Merino, Martínez Cortizas & López-Sáez 2010). The warmest temperatures were recorded for the period 5850-3500 cal BCE, with a brief interruption of a cooler spell and aridity crisis by 5000 cal BCE (López Sáez, López García & López Merino 2006), which was followed by erosion events (López-Merino, Martínez Cortizas & López-Sáez 2010). This coincides with the hypsithermal period or climatical optimum and the 8.2 ky event (López-Merino, Martínez Cortizas & López-Sáez 2010). After 4000 cal BCE there was surface ocean water cooling and a steep decline in Northern Hemisphere summer insolation (Mojtahid et al. 2013).

A recent palynological report (Peña-Chocarro 2012) puts in regional context the results for a site with Early and Middle Holocene contexts with the evidence from both archaeological sites and mires (e.g. López Sáez, López García & López Merino 2006): At the beginning of the sequences, clear evidence for woodland expansion is recorded, particularly hazel (Corylus avellana), oak (Quercus robur tp.) and Scots pine (Pinus sylvestris), and other arboreal taxa with more reduced but continuous presence, such as beech (Fagus sylvatica), birch (Betula spp.), alder (Alnus spp.) and willows (Salix spp.). Throughout the Early Holocene, a discontinuous presence of mesophytes or mesothermophiles is seen, such as evergreen oak (Q. ilex tp.), chestnut (Castanea spp.), lime trees (Tilia spp.), walnut tree (Juglans regia), hornbeams (Carpinus spp.), elms (Ulmus spp.), ash (Fraxinus spp.), holly (Ilex aquifolium) and poplar (Populus spp.), and sclerophyllous trees, olive (Olea) and Philligrea. The herbaceous and shrub taxa are typically plants from the group of lettuces and dandelions (Liguliflorae/Cichorioideae), grasses (Gramineae), thistles (Centaurea spp.), legumes (Leguminosae) and heaths and blueberries (Ericaceae) and several ferns (Monolete tp., Trilette tp. and Polypodium). Two principal types of forest are thought to have existed: a mixed deciduous forest with oaks (Quercus
spp.); and a riparian or gallery forest, with alder (Alnus spp.) and willows (Salix spp.), on the banks of rivers and other waterlogged areas. A marked herbaceous increase is recorded from the 6th millennium BCE, particularly grasses (Gramineae), lettuces and dandelions (Liguliflorae/Cichoroideae) and heaths (Ericaceae), probably due to the anthropisation of the landscape. It matches a progressive decrease in the presence of hazel (Corylus avellana spp.) and oak (Quercus robur tp.), but a highly arboreal profile always remained, due to the increase of opportunist arboreal taxa such as Scots pine (Pinus sylvestris tp.) and birch (Betula spp.).

Pollen analyses in a coastal mire in the central part of the Cantabrian region (López-Merino, Martínez Cortizas & López-Sáez 2010) complements this evidence, slightly biased due to the location of the mires in the mountain chain and the limited general validity of pollen profiles from archaeological sites: during the Early Holocene, birch (Betula spp.), followed by alder (Alnus spp.) and oaks (Quercus spp.) have the highest percentages; whilst pines (Pinus sylvestris) are scarce and are considered a vestige of the arboreal Pleistocene vegetation. At the Holocene climatical optimum, a general increase in the arboreal pollen occurs, reaching values up to 90 %, dominated by oaks (Quercus spp.) and alder (Alnus spp.), with sporadical presence of maritime pine (Pinus pinaster) that could occupy coastal sandy substrates. The arboreal pollen is, for a short phase, reduced to about 50 %; whilst heath shrubs (Erica type) and herbaceous pollen taxa, related to early human activities (vid. Figure 3), increase: lettuces and dandelions (Liguliflorae/Cichoroideae), plantains (Plantago lanceolata tp.), knotweeds (Polygonum persicaria tp.) and stinging nettle, (Urtica dioica tp.). Subsequently, arboreal pollen recovers and the first evidence of cereal agriculture are seen, with occupation of cleared areas by ferns (Polypodium spp. and Filicales). Greater forest cover seems to have occurred between ca. 5800-5400 cal BCE and by ca. 5000 cal BCE; whilst forest declines and expansion of shrub and herbaceous communities are suggested by ca. 5400 cal BCE and ca. 3550 cal BCE (López-Merino, Martínez Cortizas & López-Sáez 2010).

1.2.2 Portugal

Portugal is located in the Atlantic western coast of the Iberian Peninsula, and three natural regions might be differentiated: the South, a flat mass of land with Mediterranean climate; the Atlantic North, with a typical rainy climate and the transmountain North, over 400 m a.s.l. and with marked continentality. Each of these natural regions has several landscape units, according to differences in geology, orography, hydrology, vegetation and climatical particularisms resulting in a high diversity. In the Mediterranean region of Southern Portugal, where the sites studied are located, 3 main biotopes can

Figure 3: Synthesis of the Holocene environmental history in the NW of the Iberian Peninsula. From Martínez-Cortizas, Costa-Casais & Lopez-Sáez 2009.
be distinguished: Estremadura (Mediterranean with Atlantic influence), Alentejo and Algarve. This last one, in the extreme South, remains understudied (Cortés Sánchez et al. 2012) and has no published archaeobotanical data yet. This work deals with the central-south regions Estremadura and Alentejo, in which the Tagus and Sado valleys play an important role.

Data about the Portuguese relative sea-level (RSL) is contradictory according to different proxies (vid. van der Schriek et al. 2008): RSL might have risen rapidly from the last glacial maximum until ± 7000 cal BCE, to about ± 20 m below present levels, then followed a slowdown in the rising rate until ± 2600 cal BCE, when sea level stabilised; a low rate of RSL rise might have taken place in the Sado estuary after ± 2600 cal BCE up to the present; RSL were stable on the Atlantic Iberian coast around ± 4300 cal BCE.

The 8200 cal BP climatical event meant that mean temperatures on the Atlantic coast of the northern hemisphere descended between 1.5 and 3 °C, reducing evaporation and increasing rains and ultimately altering oceanic circulation, particularly the Gulf Stream, and possibly the upwelling regime: on the Portuguese coast, a low level of upwelling, and consequently an impoverishment of the nutritive elements in coastal waters, has been theoretically connected to this event (Carvalho 2010a). Different vegetation sequences in southern Iberia suggest a regional drying trend between 5500 and 4000 cal BCE, which might be related to the fall in lake levels and increased aeolian activity recorded after 3000 cal BCE in southern Iberia (van der Schriek et al. 2008).

In general, the Holocene sees the expansion of thermophile species, such as olive (Olea europaea), mastic tree (Pistacia lentiscus), buckthorns (Rhamnus-Phillyrea), evergreen oaks (Quercus spp.) and strawberry tree (Arbutus unedo) and the disappearance of cryophiles such as Scots pine (Pinus tp. sylvestris). From the Middle Holocene onwards a clear distinction between landscapes North and South of the Tagus River appears (Carrión Marco, García & Figueiral 2012).

The Early Holocene is a period of relative humidity, in which the first paludification phase of some current lagoons takes place, and when the forest maximum occurs, with deciduous, marcescent and conifer forests, and a limited shrub vegetation. In littoral areas, a wide spread of maritime pine (Pinus pinaster) is proposed, occupying poor-soil zones; and marcescent forests in the richer valley soils, Quercus pyrenaica in mountainous areas (Mateus & Queiroz 1993).

The Middle Holocene had in general a sub-humid climate, in which shrubby vegetation spreads, with increasing importance of cork oak (Quercus suber), and other thermo-Mediterranean taxa, including silver or white birch (Betula pendula) around the lagoons. Conifer forests of maritime and Scots pine (P. pinaster and P. sylvestris) are in clear decline in coastal and mountainous areas, whilst high maquis-shrub vegetation, sometimes sub-arboreal, expands: heaths (Erica scoparia) in valleys as the Sado, associated with Kermes oak (Quercus coccifera); tree heath (Erica arborea) in mountainous regions (Mateus & Queiroz 1993).

1.2.2.1 Estremadura

Mediterranean taxa dominated the Atlantic hills from the Early Holocene period, and average temperatures and precipitation were comparable to the present day throughout the Holocene: from ± 9500 to 4200 cal BCE, a Mediterranean forest with pine (Pinus spp.); xerothermic forest dominated by
oak (*Quercus* spp.) developed between ± 9500-7600 cal BCE and changed to mesothermic forest, indicating slightly cooler conditions after ± 7600 cal BCE. Pine (*Pinus* spp.) forests suffer a major decline at ± 4200 cal BCE and are replaced by evergreen oaks (*Quercus* *ilix*), whilst deciduous oak (*Quercus* spp.) pollen percentages decrease, suggesting a regional drying trend around 5500–4000 cal BCE (review *apud* van der Schriek et al. 2008).

From ± 6200 cal BCE, there was a relatively dry climate in the central Portuguese lower Tagus basin, located in the rain shadow of the Atlantic Estremadura hills. Initially, there was an open woodland environment dominated by pine on the interfluves, whilst semi-deciduous oak (*Q. faginea*) probably occupied the valleys. The open pine woodland environment declined progressively and an open landscape was predominant around 5000 cal BCE on the interfluves in the lower Tagus area. Between ± 6200-4800 cal BCE, the following evolution is recorded: first, low values for pine (*Pinus* spp.) and juniper (*Juniperus* spp.) and relatively high values for crucifers, composite flowers and grasses (*e.g.* Cruciferae, Compositae and Gramineae), which probably indicate an open or semi-open landscape. Subsequently, oak (*Quercus* spp.) and pine (*Pinus* spp.) pollen values increase, although the presence of heaths (*Erica arborea, Calluna* spp.), legumes (*Genista* spp., Leguminosae), plants in the mint family (*Labiatae*) and labdanum (*Cistus ladanifer*) point towards an open woodland environment. Pines (*Pinus* spp.) probably occupied the free-draining sandy soils adjacent to the valley floor, whilst semideciduous oak (*Q. faginea*) would have occupied the fringes of the freshwater valley floor with more moisture-rich soils. Freshwater indicators such as alder (*Alnus* spp.), willows (*Salix* spp.), sedges (*Cyperaceae*), Chenopods (*Chenopodiaceae*), lettuce and dandelions (*Liguliflorae/Cichorioideae*), buttercups (*Ranunculus* spp.) and horsetails (*Equisetum* spp.) originated from upstream parts beyond the limit of the saltwater intrusion and marshland was abundant. Pine woodland suffers progressive losses that are interspersed with regeneration episodes; declines in pine pollen are associated with increases in herbs such as lettuces and dandelions (*Liguliflorae/Cichorioideae*) and especially crucifers (*Cruciferae*) pollen. In the latter period, traces of open freshwater taxa, such as cattails (*Typha* spp.), watermilfoil (*Myriophyllum alterniflorum*) and lilies (*Nymphaea* spp.), which are indicative of standing or low-energy waters, increase (van der Schriek et al. 2008).

### 1.2.2.2 Alentejo

The lower course of the Sado River, where the shell-midden sites studied in this work are located, comprises a broad delta and a deep sandy and clayey valley. Extensive infilling of the southern Iberian estuaries started ± 5900 cal BCE in the lower Tagus and Sado floodplains, seemingly overlapping the date for the beginning of Mesolithic occupation of the area. Although estuarine environments contracted slowly from ± 5500 cal BCE, estuarine conditions near the mouth of the valleys and in the adjacent lower floodplains existed up to 3800 cal BCE, at least 1000 years after site abandonment. “Accepted archaeological hypotheses linking Mesolithic settlement abandonment to disappearing estuarine environments and resources need to be revised in the light of these new data” (van der Schriek et al. 2008). The high level of the oceans in the Late Atlantic period resulted in a long narrow estuary reaching deep inland (30 kilometres) and creating a rich muddy valley floor which was exposed at ebb-tide.
Between 4500–4000 cal BCE, the first evidence of anthropisation appear in the NW Alentejo, more clearly accentuated from 3400–3000 cal BCE (Mateus & Queiroz 1993), a regional decline in pine woodland is recorded around ± 5500 and ± 4200 cal BCE (Mateus & Queiroz 2000). Important vegetation associations in the NW Alentejo are shrubs of Phoenician Juniper (*Juniperus phoenicea*) and Portuguese crowberry (*Corema album*) on the internal side of littoral sand dunes; hydrophyllous forests of willows (*Salix* spp.), alder (*Alnus* spp.), poplar (*Populus alba*) and glossy buckthorn (*Frangula alnus*) with fluctuations according to the tidal variations, and appearance of vine (*Vitis vinifera*), ivy (*Hedera helix*) and honeysuckle (*Lonicera* spp.) as epiphyte vegetation in gallery forests in river valleys; humid shrubs with heaths (*Erica ergena*) in coastal lagoons (Mateus & Queiroz 1993).
1.3 Social: human societies in the Early and Middle Holocene

The characterisation of Early and Middle Holocene societies and Neolithisation, the transition from Mesolithic to Neolithic societies, are the objects of arduous discussions. One of the underlying reasons might be that it generally involves two groups of scholars with different interests (Mesolithic: subsistence and adaptation; Neolithic: ideology and belief); and thus, the problem is rather methodological as often a common basis from which to work is lacking (Bradley 2008).

1.3.1 Labels of human behaviour

The first thing to have in mind when approaching the matter of social characterisation is that labelling and classifying human activities and ways of life is always a simplification of very complex objects of study. Additionally, the labels themselves might be controverted (e.g. Sherratt 2007). As a consequence of this, in this work, the terms Mesolithic and Neolithic are preferred as referring to periods of the Holocene in which human societies were mostly differentiated by the availability of domesticated plants. The terms hunter-gatherers and farmers are avoided as much as possible, it is preferred to refer to societies that exploit wild resources and societies that exploit wild and domestic resources (although this might be, in turn, a biased categorisation, vid. p. 15). It must be always born in mind that this might not always be so in other references used in this work.

There has traditionally been a dichotomisation of human behaviour, typical of the European cultural approach issuing from a simplistic evolutionist view of human societies, as conceived by a wide span of authors [from Aristotle to the 19th century archaeologists1 (Morgan 1877 with his savage and barbaric societies or Childe 1936 (1925) with his predatory and productive societies), in which a lineal evolution towards progress has the only end defined by the trajectory of the Western world (Shohat & Stam 2002; Sober 1994 apud Terrell & Hart 2008). In this dichotomous view of human behaviour the poles are the associations of various elements: on the one hand, simple hunter-gatherer societies gathering wild food resources; on the other hand, complex agricultural societies producing storable domesticated food resources (vid. Figure 4). “Human societies do not belong to a simple category without historic evolution, no society is fossil even though it can be stable at long term” (Price & Brown 1985). “Where archaeology tends to focus on large-scale cultural uniformity to prehistoric hunter-gatherers, ethnographic and ethnoarchaeological observations point to the existence of a significant and highly dynamic small-scale variation” (Gron, Klokkernes & Turov 2009). The use of simplistic labels and the labels themselves have been for long widely criticised in the literature (e.g. Sherratt 2007).

Many authors in the last fifty years have made subcategorisations of ways of subsistence in order to overcome the heterogeneity of human behaviour and socioeconomic organisation and to improve the connection between labels and the realities they refer to: manipulation and transformation (Harris 1969); foraging and gathering (Binford 1968); casual gathering, systematical gathering, limited cultivation, advanced cultivation and intensive cultivation (Jarman, Bailey & Jarman 1982); domiculture (Hynes & Chase 1982); incipient agriculture, horticulture and field agriculture (Ford 1985);

1 With its equivalent in other humanities disciplines, Adam Smith, Turgot, Comte, Marx, Max Weber, Spencer, Durkheim.
opportunism or casual gathering, systematic and intensive gathering, agriculture, wild plant cultivation and domesticated plant cultivation (Zvelebil 1994); hunter-horticulturalism (Gudden 1992); low scale food production (Smith 2001); agriculture and horticulture (Bellwood 2005). However, the aforementioned evolutionist view and its conceptual association (the logical continuum, Terrell & Hart 2008), which actually refer to very different realities, still lies behind all these simplifying categorisations. The development of agricultural practices does not necessarily mean the use of domesticated resources and in every society with domesticated resources, certain degree of overlapping with the use of wild ones always exists (e.g. Mason & Hather 2002). The act of gathering continues until recent times; gathering is not exclusively a subsistence strategy but rather a (set of) practice(s) (Cummings & Harris 2011).

1.3.1.1 Neolithisation

By Neolithisation it is usually understood the process of historical change that leads to the development of social systems which adopt the elements of the Neolithic package (vid. p. 30). From the classic theory of the Neolithic revolution by Childe Childe 1936 (1925) several aspects have been associated with changes brought about by the Neolithisation of societies. Childe proposed, inspired by Engels (1891), that domestication is in the origin of institutions such as the family and the state, and that the urban revolution is a long-term consequence of the Neolithic revolution in a straight line of progress. These hypotheses have been much criticised as many of the aspects seem to be not among the consequences of Neolithisation but among the causes or, contradictorily, both. Therefore, the idea of unitarian, homogeneous and lineal change is seriously questioned, although it is still relatively widely spread.
1.3.1.2 Mesolithic / Hunter-gatherers

Clear-cut definitions for the term *Mesolithic* (vid. Zvelebil 1986), which can be considered as a synonym of *Epipalaeolithic*, are lacking, as the terms were originally devised to refer to a transitional period between the Palaeolithic and the Neolithic. Although some slight theoretical connotations in these terms, Mesolithic and Epipalaeolithic, might move researchers to choose one or the other, they usually refer to a period characterised by no other innovation in human societies than the existence of very diversified economical systems. This is known as *broad spectrum economy* (Flannery 1969), based on the intensive and selective exploitation of wild resources (Buxó & Piqué 2008), through hunting, gathering and fishing. This strategy allegedly allowed the sustainment of a higher demographical density and consequently reduced group mobility, possibly originating geographical territoriality (e.g. Arias Cabal 1997). Whilst traditionally it has been believed that this supposedly new economical strategy coincided in time with the Early and Middle Holocene; new evidence is pushing the intensive exploitation of small game, aquatic resources and plants further back in time (vid. Erlandson 2001; Stiner, Munro & Surovell 2000; Weiss *et al.* 2004a): “biotic resource specialisation is a long term trend in human subsistence through the Holocene” (Harris 2007).

1.3.1.3 Neolithic / Farmers

Definitions on the term *Neolithic* vary according to the theoretical framework in which they are formulated (vid. García Martínez de Lagrán *et al.* 2012 for a recent compilation). In general terms, it has often been used to refer to a time period in which the archaeological contexts present one or more of the elements of the *Neolithic package*, mainly pottery, polished stone, megalithic monuments and domesticated animals and plants (for social changes, *vid.* p. 29). Traditionally, it was considered an indissociable package and the appearance of one of the elements in an archaeological context was a sign of the adoption of the whole package by the past population (Zvelebil & Rowley-Conwy 1986), but this idea is rarely maintained today since serious criticisms were put forward (Thomas 1999). The common practical procedure by archaeologists in charge of categorising contexts, usually follows this premise: “whether actual economic practices themselves or whether only material symbols originally associated with agricultural economies were initially adopted, archaeologically these people would become Neolithic” (Armit & Finlayson 1992).

1.3.2 Early and Middle Holocene societies in Atlantic Iberia

It is usually agreed, independently from the theoretical conception of human societies, that population density plays a very important role in social complexity and dynamics. During the Early and Middle Holocene, an increase in population density is thought to have produced important social changes; however, it is unclear the role played by domesticates within these changes. This increase in population density might be seen as a consequence of climatical optimum conditions, purely demographical dynamics or sociocognitive changes. However, the purpose of approaching this matter here is not as ambitious as to discuss why or how societies changed, but to broadly characterise Early and Middle
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Holocene societies in order to better understand plant exploitation strategies. These would hopefully be able in the future to take a more important part in theorisations about human behaviour.

These life-style changes of the Early and Middle Holocene are wide-ranging: improvements or worsenings in living standards (e.g. Boserup 1965; Lee & DeVore 1968; Sahlins 1974); appearance of food-risk minimisation strategies (vid. Dimbleby 1967(1978)); widespread of illnesses (Cohen 2009; Lambert 2009); food diversification or impoverishment; sedentarisation and population growth (Bender 1975); changes in population density and size (e.g. Cordy 1981), natality and mortality; increase in social complexity and sense of community (e.g. Renfrew 1976); establishment of authorities and social instability (e.g. Bradley 2008; Cherry 1978) or patriarchy (cf. Castro-Martínez 2005); food-surplus (Ames, Smith & Bourdeau 2008; Castro-Martínez 2005); social inequality, exchange and specialisation (e.g. Clark & Parry 1990); institutionalisation of the sense of property (Hayden 1996); food-production intensification and feasting (e.g. Friedman & Rowlands 1978; Hayden 2009; Mauss 1967); appearance of new elements in the material culture, such as monuments (Thomas 1999); long-term and permanent storage; food-production activities and facilities or symbolical behaviour; etc.

The existence of egalitarian societies prior to the existence of food production (understood as the management of domesticated species) have been long discussed and the development of inequality and hierarchisation has been traditionally seen a consequence of agriculture (Childe 1936 (1925)). The traditional dichotomised view on hunting-gathering vs. farming links egalitarian social systems with the first economical system, whilst farming systems are thought to be intrinsically inegalitarian (hierarchical, competitive, authoritarian). However, human societies are inherently unequal in any of multiple dimensions (social, political, economic, ideological): before the economical inequalities which appear in Late Prehistory, other inequalities had existed (based on age, sex, religion, etc.) (Curet & Pestle 2010). In any population of more than 50 individuals necessarily some try to benefit in detriment of the whole group: the hierarchisation of societies is not due to the appearance of inequalities but to the removal of the constraints that ensure the strict equality (Hayden 1995). Different theoretical views link this process of institutionalisation of inequality to the abundance and reliability of resources, demographical stress, cultural rules, cognitive changes, etc. Mesolithic societies show certain characteristics which make them suspect of certain changes in equality and are thus labelled as “complex hunter-gatherers” or transegalitarian (vid. Hayden 1995) societies (in transition from economically egalitarian to inegalitarian).

It is likely that the existence of natural barriers, such as the Cantabrian Cordillera, favoured the territorial behaviour characteristic of Holocene groups (Arias 2007).

Cognitive changes are as well considered important elements of Early and Middle Holocene societies, both from the point of view of seeing them as causes and as consequences of the adoption of domesticates. The ritualisation of domestic life (Bradley 2008), a connection between mortality and the agricultural cycle (Thomas 1999) and the notion of property and time beyond annual cycles might be key elements characterising new world views in societies who have adopted domesticates (Renfrew 1976). The status of women is also though to have changed in the Holocene (e.g. Hayden 1995), usually due to their frequent association with plant processing activities in many societies studied ethnographically (Dalhberg 1981; Hugh-Jones 1979; Kahn 1986; cf. Lee 1979 apud Berihuete Azorín & Piqué i Huerta 2006; Castro-Martínez 2005; Ertug 2006; Hastorf 1998a; Owen 2002; Stone 2009). Such is the relationship between women and plants that some authors (Hastorf 1998a) refuse the term
of “plant husbandry” introduced in the 70s (Higgs 1972) because of its implicit connotations and propose others such as plant-mothering, nurturing or midwifery (Miksicek). Women were, according to various authors from very different theoretical backgrounds (Hastorf 1998a; Bar-Yosef 2008; Watson & Kennedy 1991), the instigators of the domestication process, because they were the main agents of plant gathering or were at least channelling plant-food consumption to their families. Pressure for taking care of two sets of offspring (children and plants) might have led to transplanting near the homebase, thus starting the development of kitchen-gardens (Hastorf 1998a). However, this sexual division of labour and the association of women with plant exploitation is far from proved for prehistorical times and might be just a modern-biased assumption (vid. Piqué i Huerta et al. 2008).

Four major categories of risk buffering mechanism are though to exist in Holocene societies: mobility, diversification, storage and exchange (Halstead & O’Shea 1989); to overcome three types of risk: predictable (seasonal and interannual) and unpredictable (long-term). Storage is the mechanism against predictable risks (O’Shea 1989), and is thought to have been employed from the Mesolithic onwards (Rowley-Conwy & Zvelebil 1989).
1.4 **Historical framework: the appearance of domesticated species in Europe**

Two *metanarratives* are involved in the appearance of domesticated species during the Holocene in Europe: the original domestication of plants and their transmission (Barrett 2011). Because of the association of concepts, these processes are diversely debated in the literature, according to several different theoretical stand-points. The actual fact underlying all theories and models, independently of any bias, is the following: in a particular time in history (chronologically and geographically heterogeneous), domesticated species came to take part of the series of exploited resources by human societies. How this came to be and what this meant are the objects of ongoing discussions and their formulations depend on theoretical *a priori* claims or *self evident truths* (Woodman 2000) of human nature and the relationship between nature and culture in human and environment interaction. Models intend to clarify the investigation of complex structures: early archaeological models are simplifying and generalist, but “complex realities are not best described by simplified abstractions”; thus, most recent models try to include the complex details that impede the verification of the old simplistic models (Barrett 2011).

1.4.1 **The origin of domesticated species**

Diffusionist (either demic or acculturation) explanations on cultural change, originating in theoretical trends in the 19th century, are regarded as outdated in most fields of social sciences. However, this is not the case for the appearance of many of the domesticated plant species in Europe, because of purely biological matters: the limited natural distribution of the wild species from which most domesticates have been developed. However, not all of the Old World domesticated species were in fact domesticated in the Levant, as has traditionally been considered within the framework of the *Levantine Primacy Illusion* (Watkins 2008 *apud* Cruz Berrocal 2012). Domestication areas (*core centres* and *noncentres*, *sensu* Harlan, 1975) from which domesticated species spread, either by cultural diffusion or by demographical expansion, have been proven to exist. It is in these areas where domestication in itself is thought to have been invented, and where several species were domesticated (*centres* or *cores*, *e.g.*, Bellwood 2005; Vavilov 1926); perhaps in geographically independent, although not necessarily culturally independent (Abbo, Lev-Yadun & Gopher 2010), domestication events (*noncentres*, *e.g.* Purugganan & Fuller 2009). A distinction between centres where the first evidence of domesticated plants appear and centres where the first evidence of use appear is necessary (where the wild ancestors exist) (Harris 1996).

Research into the causes of domestication of plants is included in the framework of the study of sociocultural evolution and thus is part of the debate about the relationship between individuals and structure (Denham & White 2007), strongly subjected to the differences in the different theoretical positions. Even considering that a cause exists and can be known is a positivist theoretical position which not all social-science researchers, particularly those of post-processualist views, share. Although the author of this work is more likely to share this latter view and a deep theoretical discussion is not the objective of this work, a brief review of the theoretical models of plant domestication is considered
important, as it helps understanding the current state of the art regarding the introduction of plant domesticates in Western Europe. Theoretical models about domestication, which consider different types of factors (environmental, social and cognitives) as provokers of historical change (Verhoeven 2004), are plentiful. They have in common the ultimate motive, the search for equilibrium (Thorpe 1996). Classifying the different hypotheses for the origins or agriculture is difficult because it is often unclear what phenomena are they are trying to explain (Harris 1989). In addition, “several contributions [...] remain locked into conceptual frameworks and interpretative positions that arose 20 or 30 years ago” (Denham 2009).

The first evolutionist model, bibliographically known as paradigm of consciousnes, is not really explanatory, as it considers the change to a superior way of life automatically when the population was “culturally prepared” or had suffered “a special mental leap” (Hawkes 1983). Many of the hypotheses were conceived a long time ago and new data have been added to the state of the art; this has not invalidated them and their defenders have only modified them so as to adequate them to current data. It will be observed that the distinction between domestication, agriculture and cultivation has not always been clear (still is not) all along the historiography. Whilst some authors and theoretical trends ask themselves why plants were domesticated, others conceive domestication as an unintentional event and ask themselves why plants were cultivated. This has important bearings on the interpretation of human agency. Some other new models propose domestication as multidimensional and multirelational long-term phenomenon in which not a single explanatory cause can be the universal explanatory scenario (e.g. Henry 1989; MacNeish 1992; Redding 1988; Thomas 1999; Verhoeven 2004; Willecox 2005). The monocausal explanations that have long dominated research can be summarised as follows:

1.4.1.1 Accidental domestication

These proposals consider humans as active agents, which have been intentionally developing agricultural and wild resource exploitation practices of different relevance over millennia. In these views, nothing in the minds of ancient peoples suddenly changes towards something new, as domestication is not the result of an express intention of achieving anything (this does not mean that domestication is unconscious), but rather the result of natural ecological evolution:

- result of the long-term interaction or symbiosis between humans and natural resources (Rindos 1980); in the case of certain type of wild resources (plants that share certain characteristics which make them prone to be domesticated), when certain forms of exploitation are developed (certain forms of gathering, cf. Hillman 2000),

- result of the appearance of highly anthropic areas: the dung heap, habitation weeds or attractive volunteers hypotheses (e.g. Anderson 1952; Darlington 1963; Sauer 1952; Zeven 1973): seeds and/or vegetative plant materials that were collected as food stuffs, were brought to camps for processing and consumption and were either discarded or lost in the process, later germinated (or rooted) around human dwellings or near refuse heaps where soil fertility was high, and were later adopted as crops.
1.4.1.2  **Intentional domestication**

The most abundant explanations regarding the complex phenomenon of plant domestication have arisen amidst the confusion of the presence or absence (absence in most cases) of distinction between domestication and cultivation in different theoretical trends. It is clear for the authors in this train of thought that there must be a “plausible, simple, causal, verifiable and global” explanation to understand the reasons why people started to cultivate plants (Price & Gebauer 1996).

1.4.1.2.1  **Humans as adaptative/passive agents**

Humans are seen as responsible agents for a decision to which they have been inexorable led, due to the disequilibrium between population size and resources and the consequent environmental and demographical stress. This type of hypotheses is characteristic of materialist and evolutionist theoretical trends, in which domestication is the solution (consciously or unconsciously) to affront stress and return to stability (Bellwood 2005):

- the *oasis* or *propiquity* hypothesis (Rumpelly 1908; Childe 1936 (1925)): because of great climate dryness, most living forms are obliged to seek refuge in oasis (Childe 1928) or hilly flanks (Braidwood 1960), and the narrow cohabitation with humans and wild things lead to their ultimate domestication; this is more generally known as the *classic theory*, with the Younger Dryas the ultimate cause (*e.g.* Cappers & Bottema 2002),

- the different processualist *marginality* or *edge* hypotheses, in which cultivation and domestication is either undistinguished or considered equally intentional:
  - because of the general cooling, less inhabitable rich land is available and resources are lacking, making the search for alternatives of food procurement compulsory (*e.g.* Bar-Yosef & Belfer-Cohen 1992; Binford 1968; Bray 1976; Flannery 1973; Harris 1969; Harris & Hillman 1989; McCorriston & Hole 1991; Moore & Hillman 1992; Reed 1977; Renfrew 1976);
  - demographical hypotheses are centred on population pressure, which moves people to live in poorer environments, producing a general decline in health, so that food production becomes necessary for subsistence (*e.g.* Abernathy 1979; Bocquet-Appel & Bar-Yosef 2008; Boserup 1965; Cohen 1977 (1981); Cohen 2009; Cohen & Armelagos 1984; Grigg 1976; Sahlins 1974; Smith 1972; Spooner 1972).

1.4.1.2.2  **Humans as active agents**

Humans are entirely active agents who cultivated and domesticated fully consciously, a view characteristic of idealist theoretical trends:

- domestication was precluded by a symbolical and social change towards control of the wilderness (*e.g.* Cauvin 1997; Hodder 1990; Heiser 1990),

- social competition lead to domestication in order to obtain different products and surplus, elements on which prestige was based (*e.g.* Bender 1975; Cogwill 1975; Katz & Voigt 1986; Hayden 1996).
• domestication was a result of the search for psychoactive products (e.g. Sherratt 1997; Wadley & Martin 1993),

• people began to be concerned with the creation of identity and appropriation of identity markers, among which plants in home-gardens played an important role, as they are associated with places, events and lineage-groups (Hastorf 1998a),

• a fully conscious sociocultural move based on the choice of specific food sources (e.g. Abbo, Lev-Yadun & Gopher 2010; Zeder & Smith 2009).

1.4.2 The introduction of domesticated species in South-Western Atlantic Europe

Domesticated species appear in Europe as a result of the dispersal from foreign centres of domestication or of local domestication events. Several theories explore the causes and ways in which domesticated species spread through Europe, taking into account evidence from multiple sources. In the following paragraphs, the main explanations relevant for the framework of this thesis will be examined (vid. p. 36). This theoretical background will then be contrasted with the factual evidence for the appearance of domesticated plants in Europe (vid. p. 44), with particular emphasis in the available evidence of plant remains in Atlantic Iberia.

1.4.2.1 The generals

Because of the association of concepts and historical events typical of Neolithisation research tradition, the debate on the introduction of domesticated species in Europe is intermingled in the literature within a series of contending general theoretical models. Regarding domesticated plant species, which is the interest of this work, Neolithisation models must be necessarily diffusionist to a great extent, as has been seen above. However, insufficient efforts have been undertaken so far to obtain a reliable chronology of the introduction of allochthonous domesticated species, although increasing numbers of theoretical archaeologists are becoming aware that “a solid chronology is a basic requirement before any serious attempt can be made to interpret past events” (Carvalho 2010b). Still, a great part of the work on the process of Neolithisation is based on materials dated which offer low methodological confidence (undetermined wood or bone) and unclear relation with the archaeological contexts – i.e., the historical events – that are intended to be dated. AMS direct dating of diagnostic material (bones from domesticated animals and charred cereal seeds) suggests that the beginning of agriculture in different parts of Europe was sometimes as much as several millennia later than previously thought on the basis of dates on bulk charcoal, pollen diagrams and the assumption that appearance of Neolithic artefacts in the archaeological record could be used as a proxy for the introduction of agropastoral economies (Zilhão 2001). Thus, to begin with, a taphonomic filter or chronometric hygiene is needed to distinguish between the neolithization of societies and the neolithization of sedimentary deposits (Carvalho 2010b).

The basic distinction between models of Neolithisation lies in whether they consider the plants as diffused via exogenous or via endogenous forces (vid. Linden 2011). Therefore, the introduction of domesticated species, sometimes made equivalent to the beginning of the Neolithic, is a topic of lively
debates centred on the problem of rupture vs. continuity in ways of life and the homogeneity or heterogeneity of the record. Depending on how sociological dynamics are understood, different pieces of evidence on early farming practices are given different interpretive emphases, sometimes little founded in reliable data, according to different ideological and theoretical approaches, thus leading to circularity (Cruz Berrocal 2012; Cummings & Harris 2011). The debate is sometimes felt as an attitude problem, in which “controversies are determined by ideology rather than fact”: “taking one’s view of what human History should have been as what human History actually was” (Zilhão 2011). The debate has been strongly polarised at some stages of research, but in the last decade efforts have been made to integrate different positions. It is often recognised that, because of the old insistent polarisation, the debate does not progress in our better understanding of the transition (Cummings & Harris 2011). In fact, the debate is even worsened in quality because of the simplistic caricaturisation of each of the views by their opponents, a dichotomisation of active vs. passive, or good vs. bad (Zilhão 2011), leading to more counter-productive opposition (Linden 2011).

The traditional models are externalist. They are based on the grouping of domesticated species with other elements, such as cultural practices, language or genes. These demic or migrationist models suggest the colonisation of Europe from an original Indo-European core region, in population displacements on a large-scale, with stagnation periods (e.g. Clark 1965), occupying territories previously depopulated or inhabited by hunter-gatherers, annihilating them, obliging them to move elsewhere or integrating them: the so-called Pontic steppe hypothesis (Childe 1936 (1925); Gimbutas 1982; Anthony 1991), further formulated in the wave of advance mathematical model (according to which population pressure is the origin of the dispersion, at a 1 % annual rate, of about 2000 kilometres per generation or 2 km per year (Ammerman & Cavalli-Sforza 1984).

These proposals have been for a long time widely criticised for their lack of universal validity (e.g. Dennell 1983; Price 2000; Renfrew 1987; Renfrew 2003; Thomas 1999; Venel 1986; Zvelebil 1986; Zvelebil 2009), and have resulted in the appearance, in contrast, of aboriginal, indigenist or adoptionist models (Rowley-Conwy 2011), such as the agricultural frontier model (Zvelebil 1986) or the Neolithic demographic transition model (Bocquet-Appel et al. 2012). These models put the emphasis on continuity, heterogeneity, local and small-scale change, and are very important in post-processual considerations (Warren 2007 apud Cummings & Harris 2011). The exogenous character of most domesticates is not denied but the importance of migration is restricted (Linden 2011); local hunter-gatherer populations were active agents who adopted and transformed cultural elements and let themselves be transformed by them; the existence of different relationships and attitudes are shown in the heterogeneous dispersal rates and stagnation periods (Dennell 1983; Zvelebil 1986), allowing for the distinction of different phases: availability (domestics have a presence lower than 5 %), substitution (5-50 % of resources are domestic) and consolidation (more of 50 %). When the availability phase is prolonged in time, it is considered that a situation of resistance occurred (e.g. Dennell 1992) until it was unavoidable, either because of climatical or demographical pressures (Barker 1985), the unequal distribution of resources (Runnels & van Andel 1988) or within social competition frames (Thomas 1999) and internal conflicts (Thorpe 1996).

As a result of these critiques, corrections or reformulations of the migrationist model (e.g. Cavalli-Sforza & Cavalli-Sforza 1995; Cavalli-Sforza 1997; Ammerman & Biagi 2003), with new mathematical variables (e.g. Davison et al. 2006; Baggaley 2012) have been put forward to answer criticisms and
include different rhythms (e.g. Bocquet-Appel et al. 2012), as in the leap-frog model (Runnels & van Andel 1988), the arrhythmic model (Guilaine 2000-2001) or the lurches of advance model (Rowley-Conwy 2011). This has been done without renouncing the universalist global conception of the early farming dispersal phenomenon, as global explanations are perceived as the only way able to ignore local irregularities, which with enough perspective are irrelevant (Bellwood 2009). This is a typical positioning inherent to comparative approaches to social phenomena (Denham & Iriarte 2007); the inductive covering law model of explanation (Watson 1996) in which emphasis is given to grand narratives (Whittle 2011) and general universal or statistical laws (Watson 1996), and in which coherence, homogeneity, global, large-scale and long-term change, and unity of the Neolithisation play important roles.

In opposition to this conception, multiple integrationism hypotheses are suggested (e.g. Rowley-Conwy 2011; Zvelebil & Lillie 2000), mostly evolved from the first indigenist proposals, which have in common the understanding that most domesticates were foreign and the Neolithisation process is not explainable by a single whole colonisation or acculturation model. The arrival of foreign populations does not necessarily imply the disappearance of the local ones (as is suggested by genetics, Rowley-Conwy 2011), but rather the intermingling of them in a process of transformation, where indigenous people and incoming farmers would both have had things to offer each other (Cummings & Harris 2011). Lack of material exchange does not indicate lack of contact: material culture might be used to differentiate identities in times of heightened contact (apud Cummings & Harris 2011). Some researchers argue for a rupture, not demic but in the ways of life, because of the new necessities associated with the domesticates (Price 2000); whilst others propose that they were just incorporated into the subsistence system, firstly with possible importance in ritual, symbolical and ritual practices (Fairbairn 2000; cf. Hastorf 1998a; Hayden 1996; Thomas 1999; Zvelebil 1986; Whittle 2000).

1.4.2.1.1 Neolithisation on Iberia’s Atlantic façade

On the European Atlantic façade, the introduction of domesticated species is an apparently late, heterogeneous and complex matter, and scantily supported by direct archaeobotanical data (Arias 2007): whilst relatively abundant data exist regarding the introduction of domesticated crops in the Mediterranean coast and a much more limited quantity of information for the interior of the Iberian Peninsula, there is absolutely none for the Atlantic coast in the 6th millennium (vid. Figure 5). Thus, theorisations about the Neolithisation of the Atlantic regions arise from other material evidence of the process, particularly ceramics (with all the problems it entails, Cruz Berrocal 2012). According to this evidence, it is agreed that the environments along the Atlantic coast were the location of many long-persisting foraging societies well after the introduction of agricultural technology into neighbouring regions (Arias 1999), partly because they were intensively exploiting rich marine resources.

Several of the two types of polarised models, sometimes reformulated and adapted to the Iberian case, have been proposed for different areas: the colonisation of inhabited areas by Neolithic immigrants bringing domesticated species (e.g. Zilhão 1993; Zilhão 2000; Zilhão 2003; Zilhão 2011) or the adoption of domesticated species by the pre-existent Mesolithic population, either done readily or gradually (e.g. Alday 2005a; Soares & Silva 2003). Several models particularly conceived for the Iberian Peninsula discuss the Neolithisation process in terms of conciliation of the two traditionally
opposed hypotheses (Hadjikoumis 2011): the dual model (Bernabeu 2002; Bernabeu Aubán 2006) and the functional model (Barandiarán & Cava 1992). Genetical evidence seems to argue in favour of an integration of a small group of population in the Neolithic with previously existing populations of a Palaeolithic/Mesolithic origin (Santos et al. 2014).

For the arrival of the allochthonous domesticated species to the Iberian Peninsula, two directions are proposed, from Central Europe across the Pyrenees or by sea from the Mediterranean basin (Buxó i Capdevila et al. 1997), either north or south (Carvalho 2010b), or a combination of the two (Bernabeu Aubán 2006).

- The Cantabrian region

Cantabrian Spain is one of the classical areas for Mesolithic studies in the Iberian Peninsula (Arias 2007) but research has traditionally been centred in caves and rock-shelters, which has produced a rich corpus of data on these very particular types of sites and a lack of information about open-air sites. Mesolithic sites in the Western part of the region are typically shell-middens located at the entrance of coastal caves and rock-shelters, composed of a great majority of shells and of sparse bones and other remains, conforming what has traditionally been called the Asturian culture (Gutiérrez-Zugasti et al. 2011). Most of these shell-middens are solidified, with a few exceptions: Mazaculos II and El Toral III (vid. p. 56), inhibiting the distinction of features and living floors upon excavation. In the Eastern part of the region, on the contrary, Mesolithic sites are characterised as contexts with shells, rather than shell-middens (Gutiérrez-Zugasti et al. 2011). Recent investigations have shown the potential of cave mouth vicinities to provide evidence about Mesolithic dwelling places (Arias et al. 2015). A reduction of mobility and diversification of resources is seen in the whole region from the Upper Palaeolithic onwards, as well as a tendency to bury the dead in those layers with shells or shell-middens (e.g. Gutiérrez-Zugasti et al. 2011), a fact that makes some researchers wonder about the relationship of these contexts with habitation areas and its seasonal or permanent use. The potential information
provided by plant resource exploitation has not traditionally been used, as has been often considered that “because they are not preserved in archaeological contexts, plant data cannot be included in any systematic attempt to evaluate change” (Clark 1987). The little information available for the exploitation of plants in the Mesolithic is often brought forward as a confirmation of the broad spectrum economy, simply by comparison with earlier periods where plant information is almost inexistent.

Comparatively, knowledge about the Early Neolithic in the Cantabrian region is sparse. This absence of Early Neolithic contexts might be a result of the research focus on caves and rock-shelters, where activities might have been only occasionally carried out (Zapata Peña 2005-2006), whilst little is known about open-air sites, with a few exceptions whose Neolithic chronology need to be better defined (Peña-Oviedo / La Calvera, Díez Castillo 1996a; L’Hortá/Las Corvas, Fernández Mier et al. 2014; Fernández Mier & González Álvarez 2014). The camouflage of Early Neolithic contexts as Asturian-like shell-middens with pottery and a few domesticated animals could as well be the cause of this apparent absence of Early Neolithic contexts (Fano & Cubas 2012). In this respect, promising results are being now obtained by the research focus on open-air spaces adjacent to caves and rock-shelters with shell-middens (Arias et al. 2015). Whilst the sea level rise in this particular time lapse and region is almost negligible, it is possible that the climatical disturbances associated to the 8.2 ky event were partially responsible for the erosion of certain contexts (Berger & Guilaine 2009). The absence of Early Neolithic information is particularly remarkable in certain geographical areas, such as the central part of the Cantabrian region, and in certain areas of knowledge, such as the exploitation of plant resources. This lack of data served initially to present proposals about the delay in Neolithisation and the survival of the hunter-gatherer way of life for a very long time (Clark 1987; cf. González Morales 1992) but with the current data, this has been moderated to a shorter “décalage” with respect to the Neolithisation in Mediterranean Iberia (Ramil-Rego, Dopazo Martínez & Fernández Rodríguez 1996).

The first evidence of the exploitation of domesticated species in the area appears in the first half of the 5th millennium cal BCE; this is relatively late in comparison with the neighbouring Ebro valley, allowing the last centuries of the Mesolithic in Cantabrian Spain to be defined as an example of dense hunter-gatherer societies in the availability phase (Arias 2007). The scarce record shows that the Neolithic package does not appear as such in a homogeneous and indivisible way (Arias 1999): domesticated animals and pottery appear in contexts from the first half of the 5th millennium in several sites whilst evidence for plant domesticates (Peña-Chocarro et al. 2005) and megaliths appear only in the second half of the 5th millennium, about 500 years later. This has suggested an importance of pastoralism over agriculture to some authors (Clark 1987). Certain fully Neolithic contexts, where the appearance of domesticates is sudden and proportionally important, coexist with other late Mesolithic contexts (Fano, Cubas & Wood 2015), which not only show a continuity with no sign of domesticated species, but also possible evidence of gathering intensification (Arias 2007). As new and abundant data is unavailable, the current state of the art allows different explanations, a rupturist one in which this duality is merely a question of logistic mobility (specialised hunting and gathering settlements of farmers), and a continuist, with Neolithisation in a mosaic pattern, with farmers and hunter-gatherers coexisting in neighbouring areas.

The most extreme rupturist proposal argues in favour of colonisation events by foreign populations, at least for some regions such as the interior and central part of the region, particularly in the Deva and Nansa valleys (González Morales et al. 2004; Díez Castillo 2008a): the first Neolithic groups appeared
in the eastern part or the region and coexisted with the Mesolithic peoples in the western part for along a millennium, until because of climate change and the colonisation of previously inhabited areas in the interior, the farming way of life, in which seasonal migration and gathering were important particular aspects, became universal.

For other mild rupturists, a relatively late adoption of the elements in the Neolithic package was made suddenly by some local populations after a long period of ignorance or resistance, producing important changes in settlement patterns, social organisation and belief systems. Although caves were still used (Fano, Cubas & Wood 2015), their use was different to that of previous times: now caves were animal dens and funerary deposition areas. Megalithic monuments possibly conceived as territorial markers, to domesticate the landscape (Jorge 2000). Wild resources were relegated to a secondary role (Zapata Peña et al. 2005) with a possible new concentration on the intensive gathering of acorns as a specialised valued resource, instead of the typical hazelnuts from the Early Holocene (Ramil-Rego, Dopazo Martínez & Fernández Rodríguez 1996). The adoption of domesticates must have meant more than the mere integration of new plants in the food chain: cereal cultivation, even at small scale, constitutes a radical qualitative change in labour organisation strategies and requires the species to adapt to specific climatic peculiarities (Zapata & Peña-Chocarro 2005).

Continuists-indigenists stress the abundant continuities (funerary practices and inhabitation areas in caves, hunting and plant and shell gathering, lithic industry) that show a gradual but relatively rapid process of change after the initial resistance, carried out by the local Mesolithic populations, into a mixed economical system in which domesticated species come to form part of the broad-spectrum economy and complement wild resource exploitation, with growing domestic importance with time (Arias Cabal 1997; Arias 2007; Cubas & Fano 2011; Fano & Cubas 2012; Fano, Cubas & Wood 2015; López Quintana 2005; Ontañón-Peredo 2005). Neolithisation (or megaliths as the end point of that process of deep social change) is the spread of “an idea, a concept, and each society interpreted it in its own way, incorporating elements of its own cultural background and its own history”, rather than a population spread (Arias 2007).

- Portugal

Early proposals saw the Neolithic originating in North Africa, and spreading from there to the Iberian Peninsula. In the mid-1940s, the origin shifted into the Levant (apud Cruz Berrocal 2012).

The natural heterogeneity of the western Atlantic coast of the Iberian Peninsula and the heterogeneity of the state of the art about the Neolithisation at regional level has the consequence that current models are built over fragmentary data. Moreover, because of the limitations imposed by the taphonomy of the contexts and the uncertainties concerning the dated samples, part of the available radiocarbon chronology should be regarded with caution: whilst sites are hardly comparable amongst themselves (Dean, Valente & Carvalho 2012), many old radiocarbon dates have been made on mixtures of dispersed charcoal or in bones which might be affected by reservoir effects (Carvalho 2010b). As a consequence, new efforts in radiocarbon-dating materials from the Mesolithic-Neolithic transition are being carried out (e.g. Bicho 2012). In this framework, single explanatory and linear models are being criticised and regional mosaics of distinct processes are being identified (Bicho et al. 2003, Carvalho 2010b; Diniz 2007): diverse factors, such as cultural (the Mesolithic and Neolithic populations
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attitudes) and environmental are brought forward as influential (Carvalho 2003). Plant macroremains, often characterised as *archaeologically opaque* (Carvalho 2003), have been unsearched or/and unfound, so they have not been permitted to play any role in this discussion. Thus Neolithic agriculture, has often been inferred from arguable indirect evidence such as the presence of querns and lithic blades with sickle gloss. Some authors thus refer to “the myth of the development of a ‘productive system’ in the 6th and 5th millennia BC” in the sense that, local hunter-gatherers reacted by a process of selective integration of certain elements of the *Neolithic package*, precisely excluding cereal cultivation (Jorge 2000). It is argued that this package must be considered in a regional framework, and not site by site (Carvalho 2003).

In the North, both Mesolithic and Neolithic settlements (Monteiro-Rodrigues & Angelucci 2004; Sanches 1997) are scarce. According to certain archaeological features and the assemblages collected, scarcely any clear difference exists between the Mesolithic and the Neolithic layers, apart from the introduction of ceramics and allochthonous lithics. Thus, relative continuity in the settlement and subsistence strategies between the Mesolithic and the first Neolithic occupants is proposed (Monteiro-Rodrigues & Angelucci 2004) although with possibly intermittent occupation evidenced in several hiatus between the 10th and the 5th millennia (Monteiro-Rodrigues 2012). The continuity in sedimentation does not necessarily imply a population continuity, though, and a continuity in material culture (i.e. lithics, can be rather a result of raw material availability, Carvalho 2003). It is left to wonder if these hiatuses are really a result of an intermittent occupation or rather due to taphonomical factors (Berger & Guilaine 2009). The first Neolithic communities, from about 5000 cal BCE, have a material culture with a mixture of influences from the Meseta and the South (Carvalho 2010a).

During the Mesolithic, human population in Central and South Portugal seems to move from the littorals and concentrate semi-sedentarily around big river estuaries (namely the Tagus-Muge, Sado and Mira) and the upper southern coast (littoral Alentejo), creating characteristic shell-middens (Carvalho 2010a) which were deposited during a time lapse of about a millennium (Martins, Carvalho & Soares 2008). Most of these shell-midden sites are open-air, whilst a few of them are located in caves, and different features, such as post-holes or hearths, have been recognised in them (Gutiérrez-Zugasti et al. 2011). These estuarine sites are characterised by intense shell-food processing, which meant a progressive increase of the aquatic fraction in human diet (Martins, Carvalho & Soares 2008), accompanied of other domestic and funerary activities. Dogs were the only domesticated animals. The high inter-site variability (resources exploited, size of the middens) and the homogeneity of the material culture and funerary rites is usually interpreted in two divergent ways. On the one hand, as a single settlement system (composed of various middens) per estuary: in the Sado estuary the biggest middens in the region, Cabeço do Pez and Poças de São Bento (archaeobotanically studied in this work), would be the main residential sites, seasonally occupied (CP in the autumn-winter seasons and Poças de São Bento in spring-summer) but regularly, whilst other smaller middens would be temporary associated settlements occupied for specific activities (Arnaud 1985; Arnaud 1990; Gutiérrez-Zugasti et al. 2011). On the other hand, it could prove the existence of different populations inhabiting, either the sites nearer the seashore and the sites further inland (Umbelino et al. 2007). The occurrence of shell deposits in sites further inland shows a high mobility during the Early Mesolithic (Gutiérrez-Zugasti et al. 2011); whilst the estuarine regions have a widely accepted Late Mesolithic occupation contemporary to the earliest littoral Neolithic ones, thus embodying an important debate between rupturists and continuists in Neolithisation.
The earliest contexts with elements from the Neolithic package are documented in the western Algarve and in the centre of Estremadura at ca. 5500 and 5400 cal BCE respectively, spreading subsequently to the interior regions (Carvalho 2010b). This is considered to be the main support for the maritime pioneer colonisation model (Zilhão 1993), in which allochthonous populations arriving by sea created Neolithic enclaves in a territory that was only marginally exploited or depopulated (ultimately due to climatical causes, Zilhão 2003 or Carvalho 2010a). Traditionally, it was thought that the Western Mediterranean was the origin of the Neolithic innovations (Zilhão 2003), whilst more recently, the Maghreb’s influences seem stronger, at least for the Early Neolithic in the Algarve (Cortés Sánchez et al. 2012), with populations making a “partial reformulation of their material cultures” upon arrival (Carvalho 2010a; Carvalho 2010a). Because of the relatively quick arrival of these Neolithic elements from the earliest and nearest contexts with the same evidence in Europe and because of their restriction to coastal sites, the arrival by sea has seemed plausible, with the operation of long distance relocation episodes instead of the demic diffusion model wave-of-advance based on the mechanism of short distance settlement expansion in which population growth was accommodated through gradual and slow incorporation of adjacent land; the rapidity of the spread indicates that long distance colonisation events took place well before saturation levels were attained at the point of origin (Zilhão 2001).

This maritime hypothesis has been maintained (Zilhão 2011; Martins et al. 2015) despite its questioning by the publication of new contexts and dates in the Iberian Peninsula, both Mesolithic and Early Neolithic: whilst in the Algarve recently dated contexts suggest the continuity of economical and sociocultural patterns, and thus genetically, through the transition (Bicho et al. 2003); geographically intermediate Iberian contexts with Neolithic elements, the Interior Neolithic, which allow for the spread over land of the latter or of populations carrying them (e.g. Alday 2005b; Gonçalves comment on Carvalho 2003; Rojo-Guerra et al. 2006), the chronological difference between the dates from coastal and inland sites are starting to fade and the Neolithic sites in the Spanish plateau are not necessarily found immediately by big rivers (Cruz Berrocal 2012). These new pieces of evidence are questioned though a taphonomical revision of the contexts (Zilhão 2011), generating a very heated debate (e.g. Alday 2011), and a revision of the determinations of domesticated species (Martins et al. 2015). The pioneer colonisation model is also criticised theoretically (Cruz Berrocal 2012). The supposed hiatus between the Palaeolithic and Neolithic contexts in the central area has been questioned as a taphonomical bias (Berger & Guilaine 2009). Even if the hiatus was proven to be truly occupational, “a hypothetical depopulated land could be settled by local populations from neighbouring territories, bringing with them Neolithic innovations, and not necessarily by ‘colonisers’ from the Mediterranean” (Jorge 2000).

Regarding Neolithisation, according to the continuists-indigenists, certain clear aspects in elements of the material culture (e.g. Bicho et al. 2003; Soares & Silva 2003), wild resource exploitation and settlement dynamics (Arnaud 1993) and biological populations (Jackes, Lubell & Meiklejohn 1997) are shared between Mesolithic-Neolithic contexts. A politically correct (Diniz 2007) change by the hunter-gatherers themselves is proposed, e.g.: “from the end of the 6th/beginning of the 5th millennia BC three types of people co-existed in these regions: groups of traditional Mesolithic hunter-gatherers, groups of hunter-gatherers who occasionally used ‘Neolithic’ artefacts (as in the shell middens of the Tagus and the Sado), and groups of hunter-gatherer-herders who used ‘Neolithic’ artefacts and became less nomadic in lifestyle” (Jorge 2000). Most researchers accept the existence of the Neolithic littoral enclaves, although not necessarily as migration processes but rather cultural exchange or transmission
processes, involving notions such as osmosis and percolation (Jorge 2000). The Neolithic implied an economical discontinuity and a population reorganisation with a diversification of site types supporting the hypothesis of the creation of enclaves in sparsely populated territories (Carvalho 2010a). Both a resistance phenomenon within the Mesolithic population towards Neolithisation (Carvalho 2003) and a dialogue and integration between the peoples of the Neolithic enclaves with the neighbouring Mesolithic populations are suggested (Carvalho & Cardoso 2003; Marchand 2005; Marchand & Manen 2006 apud Carvalho 2010a), with even a hybridisation in the material cultures within differential fusion phenomena (Diniz 2007). The locals from the estuarine areas experimented some life-style changes (such as fertility or diet, Jackes & Meiklejohn 2004; Lubell et al. 1994) and new elements of the material culture (such as ceramics), started to appear as a result (Arnaud 1987) or the cause (Dean, Valente & Carvalho 2012) of the progressive adoption of Neolithic cultural traits, which at first might have been prestige items (Straus 1991). This delayed adoption was a result of the successful broad spectrum economy developed by the Late Mesolithic groups: the exploitation of a great variety of complementary resources and a dynamical and flexible settlement strategy, with a certain degree of sedentarisation (Arnaud 1993) and demographical pressure, either of their own or exercised by the Neolithic populations in the littoral with which they were interacting long before (Arnaud 2000; Straus 1991).

According to the diffusionists, Neolithisation involved the extinction of the Mesolithic populations and a rapid complete population replacement with the Neolithic Euro-Mediterranean incomers carrying the whole Neolithic package (Chandler, Sykes & Zilhão 2005), with the apparent material continuity as a result of the percolation of archaeological objects between Mesolithic and Neolithic neighbouring layers affected by bioturbation (Zilhão 1993, Zilhão 1998) and the arguable (Lalueza & Gonzalez 1998) biological continuity. Although the temporal and regional coexistence of Mesolithic hunter-gatherers in the estuarine Tajo, Sado and Mira areas and Neolithic farmers is accepted during the 6th millennium, it is argued that interaction did not exist between them, as they had independent resource exploitation systems: the autochthonous Mesolithic communities continue to thrive in their own territories for some 500 years after initial Neolithic settlement, but ended absorbed by the demographical expansion of the Neolithic communities (Zilhão 1993). Biological continuity is equally denied according to changes in skeletal morphology (Lalueza Fox 1996; Zilhão 1998) and mitochondrial DNA (Chandler, Sykes & Zilhão 2005), but this might be a result of the use of results which are not comparable due to their origin from heterogeneous analysis methodologies and samples (Cruz Berrocal 2012; Jackes & Meiklejohn 2004).

1.4.2.2  The particulars

Three phases can be distinguished in the process of the appearance of domesticated species in Europe, some of which are still unknown in the Late Prehistory record of the Iberian Peninsula (unless otherwise stated, data in this subject come from Weiss & Zohary 2011 and Zohary, Hopf & Weiss 2012):

• from 7000 cal BCE, several domesticated species originated in the region traditionally known as The Fertile Crescent, either considered a single centre of short-term domestication (e.g. Abbo et al. 2009; Lev-Yadun, Gopher & Abbo 2000) or a core nucleus of centres of multiple long-term domestication
Part I: Framework

events (e.g. Fuller, Wilcox & Allaby 2012; Ladizinsky 1998; Weiss, Kislev & Hartmann 2006; Wilcox 2005), domesticated between the 10 and 7th millennia:

- long-cycle cereals with an annual crop. The traditional view is that cereals were the first domesticates:
  - einkorn \( Triticum monococcum \) or \( T. monococcum \) ssp. \( monococcum \), from \( T. boeticum \) Boiss. or \( T. monococcum \) ssp. \( aegilopoides \) (Link) Thell.
  - \( T. turgidum \) L. group:
    - emmer (\( Triticum dicoccon \) Schrank. or \( T. turgidum \) ssp. \( dicoccon \) from \( T. dicoccoides \) Körn or \( T. turgidum \) ssp. \( dicoccoides \) Körn. Thell.)
    - rivet wheat (\( Triticum turgidum \) L. or \( T. turgidum \) ssp. \( turgidum \) from \( T. dicoccoides \) Körn or \( T. turgidum \) ssp. \( dicoccoides \) Körn. Thell.)
    - macaroni wheat (\( Triticum durum \) or \( T. turgidum \) ssp. \( durum \) from \( T. dicoccum \) Schrank. or \( T. turgidum \) ssp. \( dicoccum \))
  - \( T. aestivum \) L. group (from \( T. turgidum \) L. group and \( Aegilops tauschii \)):
    - spelt (\( Triticum spelta \) L. or \( T. aestivum \) ssp. \( spelta \))
    - bread or common wheat (\( Triticum aestivum \) L. or \( T. aestivum \) ssp. \( aestivum \) from \( T. spelta \) or \( T. aestivum \) ssp. \( spelta \))
    - club wheat \( T. compactum \) Host. or \( T. aestivum \) ssp. \( compactum \) (Host) MK
  - barley \( H. vulgare \) L., or \( H. vulgare \) ssp. \( vulgare \) from \( H. spontaneum \) C. Koch. or \( H. vulgare \) ssp. \( spontaneum \) (C. Koch.) Thell.
    - \( H. distichum \) L. or \( H. vulgare \) ssp. \( distichum \)
    - \( H. hexastichum \) or \( H. vulgare \) ssp. \( hexastichum \)
  - legumes: because of the absence of clear morphological identification criteria between wild and domesticated forms in archaeological remains, the moment of domestication is unclear. The most progressive hypothesis considers domesticated specimens those of sites such as Abu Hureyra, ca. 11,000 cal BCE (Hillman 2000), according to the proposal of legume domestication before cereals (Bouby & Léa 2006; Kislev & Bar-Yosef 1988). Conservative positions consider cereals the first domesticates and consider legumes as domesticated only when appearing with cereals:
    - pea \( (P. sativum) \), probably from \( P. humile \) Boiss. & Noë
    - lentil \( [L. culinaris] \) Medik. or \( L. culinaris \) Medik. ssp. \( culinaris \), from \( L. orientalis \) (Boiss.) Hand.–Mazz. or \( L. culinaris \) ssp. \( orientalis \) (Boiss.) Shmalh.
    - chick pea \( (C. arietinum) \), from \( C. reticulatum \) Ladiz.
    - bitter vetch \( (V. ervilia) \)
    - faba bean or broad bean \( (V. faba) \) from unknown ancestor

\footnote{Names are given following both the traditional binomial nomenclature and the new genetic nomenclature (Zohary, Hopf & Weiss 2012)}
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- grass pea \((Lathyrus sativus \text{ L.})\), probably from \(L. \text{ cicera L.}\).
- an oil plant: flax \((Linum usitatissimum \text{ L.})\), from \(Linum bienne \text{ Mill.}\).
- shortly after, from 5000 cal BCE signs of domestication in other species, both indigenous and exotic, appear:
  - opium poppy \((Papaver somniferum \text{ L.} \text{ or } P. \text{ somniferum } \text{ ssp. somniferum} \text{ (L.) Corb.}, \text{ from } P. \text{ setigerum DC.} \text{ or } P. \text{ somniferum } \text{ ssp. setigerum} \text{ (DC.) Corb. in SW Europe})\).
  - secondary crops: which first evolved as weeds and ended as domesticated crops
    - cereals:
      - rye \((Secale cereale \text{ L.})\). Alternative views argue for the possible domestication between 10,700-9000 cal BCE en Abu Hureyra (Hillman \text{ et al.} 2001 but Nesbitt 2002).
      - oats \((Avena sativa)\).
    - oil plants:
      - gold of pleasure \((Camelina sativa \text{ L.)})\).
  - another three legumes:
    - Lupin \((\text{several species, among which } Lupinus \text{ albus L., } L. \text{ luteus L. and } L. \text{ angustifolius L.)})\).
    - Fenugreek \((Trigonella foenum graecum)\) in Southern Europe and South-West Asia.
    - Spanish vetchling \((Lathyrus clymenum \text{ L.)})\) in the Mediterranean region.
  - two short-cycle cereals, whose domestication is still unclear:
    - common or broomcorn millet \([\text{Panicum milieaceum L.}, \text{ possibly from } P. \text{ ruderale in Asia, at ca.10,000 BP (Lu \text{ et al.} 2009)}]\).
    - foxtail millet \((Setaria itálica \text{ from } Setaria viridis, \text{ Hunt \text{ et al.} 2008})\).
- the existence of managed forests and fruit gathering from the wild predates the development of horticulture for several millennia (Mason 2000), but the first definite signs of domestication appear later. Domestication in fruit trees consists of the shift from sexual to vegetative reproduction, allowing desired fruit types to be fix by cloning and reducing variation. However, as this type of domestication does not produce morphological changes in seeds, disagreement exists in what constitute definite signs. Traditionally, fruit trees are considered as domesticated when appearing outside their natural distribution regions, usually in the Levant (Zohary, Hopf & Weiss 2012); other regions of domestication, or multiple domestications, are also considered:
  - first-wave \((\text{from 5000 cal BCE})\) fruit trees (simple vegetative reproduction): olive \((Olea europaea \text{ L.}, \text{ with possible multiple domestications Terral \text{ et al.} 2004}), \text{ figs (Ficus carica L., alternative chronological view from Kislev, Hartmann & Bar-Yosef 2006), grapevines (Vitis vinifera L., alternative version in de Mattia \text{ et al.} 2008) and later pomegranates (Punica granatum L.)})\).
In historical times with the connections with other continents and the development of long-distance trade, in the frame of the Classical civilisations, the Silk Road, the American colonisation, etc. other domesticated species, which had been domesticated independently millennia before, start to spread across Europe. Since the start of the 2nd millennium BCE, the first written and graphical sources record the domestication of greens in vegetable gardens (leek, garlic, onion, lettuce, chufa, etc.). In the 3rd millennium, the variety in vegetable gardens increases to include beet, turnip, cabbage, carrot, asparagus, parsnip, celery, etc. Many of these have wild varieties which spread around Europe and which have been recorded from the Neolithic in sites with particular preservation conditions.

**Mesolithic and Neolithic plant exploitation in the Atlantic Iberian façade**

Plant use, and more particularly wild plant use, is an understudied topic in the Atlantic region of the Iberian Peninsula. Archaeobotanical studies in the region have traditionally been focused on pollen and charcoal studies with the purpose of environmental reconstructions (Zapata et al. 2002), so other types of archaeobotanical evidence are scarce. The general scarcity of data on wild plant exploitation is frequently a result of the bias on crops and crop weeds in archaeobotanical studies (Mason & Hather 2002). Research in Western Europe and other areas of the Atlantic European coast has produced considerable evidence for the use of plants, preserved mainly by waterlogging but also charring, both from open-air and cave contexts, which should be encouraging.  

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3 Typical waterlogged sites are Tybrind Vig or Hallskov (Kubiak-Martens 1999; Kubiak-Martens 2002); sites with charred preservation might be open-air, such as Star Carr, Sand or Staosnaig (Carruthers 2000; Mason & Hather 2000) or cave sites such as l’Abeurador (Vaquer & Ruas 2009).
Non-woody plant macroremain evidence is scarce, and more particularly, evidence obtained exhaustively; therefore biasing the information towards specific taxa more likely to be found by non-exhaustive recovery techniques. This is a result both of historiographical traditions and of the specific taphonomical problems of the archaeobotanical record (vid. p. 114). Often, plant use is discussed based on assumptions (e.g. Clark 1987; González Morales et al. 2004; Straus 2008), such as “hazelnuts, acorns and other nuts presumably exploited” (Fano & González Morales 2004). Hypotheses about the broad spectrum economy from the Early Holocene (Flannery 1969), or even earlier (Weiss et al. 2004a), have long been accepted. This economical strategy is characterised, among other things, by the major role played by wild plant food resources: intensive exploitation of nuts and mass seed-gathering, appearance of mass plant processing and storage technologies (Clarke 1976; Clark 1987; Hayden 2009; Zvelebil 1994). This evidence has had to be reconsidered in some cases of arid climates, in which animal dung might be responsible for the presence of seeds in large quantities (Miller 1996). On the other hand, plant resources have sometimes been thought unimportant until the introduction of domesticated species, either explicitly (Ramil-Rego, Dopazo Martínez & Fernández Rodríguez 1996) or implicitly, by simply omitting any reference to plants in research projects and publications. Even when Neolithic contexts are discussed and the topic is the introduction of the Neolithic economy and agriculture, plants are often not considered.

**Cantabrian region**

The old affirmation that “there is little primary evidence for plant foods” (Clark 1987) is nearly valid for the most part of Prehistory almost 30 years after its formulation, though the reason is not that plant evidence is inexisten. Beginning with Pleistocene sites, the Magdalenian layers of El Juyo Cave have provided the oldest and widest macrobotanical evidence for the region, more than 850 plant remains of several species preserved by desiccation and carbonisation (Freeman et al. 1988; Ibañez-Angulo 1991).
El Caballo Cave has allegedly provided the single possibly oldest vine (*Vitis vinifera* ssp. *sylvestris*) remain from the Iberian Peninsula (Rivera Núñez & Walker 1989). During the Holocene, the most usual remains of wild plants are hazelnut (*Corylus avellana*) shell fragments, acorn (*Quercus* sp.) cotyledons, and fruits from the rose family (Rosaceae), such as crab apple (*Malus sylvestris*), or whitebeam, wild service trees or rowans (*Sorbus* sp.), from sites such as Lumentixa and Kobaederra (Zapata Peña 1999a; Zapata Peña 2000), A Fontenla (Ramil Rego & Aira Rodríguez 1998), Abrigo XXIX (Ramil-Rego, Dopazo Martínez & Fernández Rodríguez 1996) and later protohistorical sites (Dopazo Martínez 1996). These have been recovered when no special retrieval techniques are employed (vid. Table 121). Other less conspicuous plant macroremains have been abundantly recovered from floated sites like El Mirón, with plants in the pink and knotweed families (Caryophyllaceae and Polygonaceae), legumes (Leguminosae), bedstraw or cleavers (*Galium* sp.), rushes (*Luzula* sp., Juncaceae), sedges (*Carex* sp., Cyperaceae), grasses (*Lolium* sp., Gramineae) and speedwell (*Veronica* sp.) (Peña-Chocarro 2012); Los Canes, with sloes or cherries (*Prunus* sp.) (Ramil-Rego, Dopazo Martínez & Fernández Rodríguez 1996); Mendigana, with heaths (Ericaceae), storksbills (*Erodium* sp.) and plants in the daisy family (Compositae) and blackberries or raspberries (*Rubus* sp.) (Ruiz-Alonso et al. 2010); Xestido, with grasses (Gramineae) and cinquefoil (*Potentilla* sp.) (Ramil-Rego, Dopazo Martínez & Fernández Rodríguez 1996); and Curro Vello, with bird’s foot trefoil (*Lotus* sp.) (Ramil-Rego, Dopazo Martínez & Fernández Rodríguez 1996). The Early Holocene layers of La Riera (Cushman 1986) has provided an Oleaceae? (*Fraxinus excelsior*) nutshell fragment determination.

The Neolithic crops in the Cantabrian region are four allochthonous cereal species found in several archaeological contexts from the middle of the 5th millennium onwards (Kobaederra, Pico Ramos and Lumentxa, in Vizcaya and El Mirón, in Cantabria): emmer (*Triticum dicoccum*), einkorn (*Triticum monococcum*), common or bread wheat (*Triticum nudum*), and barley (*Hordeum vulgare*) (Peña-Chocarro et al. 2005a). The absence of evidence for pulse exploitation (with the exception of a large legume seed from Kobaederra which might be cultivated, Zapata Peña 1999b) is thought to be linked to sample poverty rather than actual absence from the Neolithic crop package (Zapata Peña 2005-2006).
Table 1: Non-woody plant macroremain evidence available for the Cantabrian region between 8000 and 3000 cal BCE.

This plant macroremain evidence (vid. Table 1) is complemented by data arising from other archaeobotanical sources, both direct and indirect.

On the one hand, direct archaeobotanical evidence of wild resource exploitation is hinted by charcoal analyses in which several taxa, many of which provide fruits and nuts of economical interest in addition to their wood for technological activities and fuel, are often encountered with variable abundance depending on the period and locations: white oaks (*Quercus* subgenus *Quercus*), pome bearing trees (*Pomoideae*), ash (*Fraxinus* sp.) and beech (*Fagus sylvatica*) (e.g. Tapia Sagarna et al. 2008). In addition, phytoliths from spikes from wild grasses have been identified at the Mesolithic layers of El Mirón Cave (Zurro 2012).
On the other hand, several determinations of cereal pollen, which must be considered with precaution due to the impossibility of the absolute discrimination of pollen from wild grasses and cereals (vid. Behre 2007), have been made at various sites from the second half of the 6th millennium onwards (Iriarte, Mujika & Tarriño 2005): O Reiro (La Coruña) (López Sáez, López Merino & Pérez Díaz 2010) and other mires in Galicia and Asturias (López-Merino, Martínez Cortizas & López-Sáez 2010), Los Gitanos (Cantabria) (cf. Ontañón Peredo 2008) and Herriko Barra (Basque Country) (Peña-Chocarro 2012).

The indirect evidence is formed by some plant grinding/pounding stones in Asturian (Mesolithic) contexts and Asturian picks which are thought to have potentially been used for grubbing vegetal foods (Straus 1979 apud Straus 2008), although experimental evidence does not support this hypothesis (Clemente et al. in press). In addition, use-wear analyses on shell tools evidence their probable use for processing of plants (Cuenca, Gutiérrez-Zugasti & Clemente 2014; Cuenca Solana 2012), on the basis of the similarities with experimental tools (Cuenca-Solana, Gutiérrez-Zugasti & Clemente-Conte 2011): most shell tools from limpets (Patella spp.) and mussels (Mytilus galloprovincialis) from the Mesolithic layers of El Toral III have shown to be specialised in plant processing activities such as fibre scrapping and cutting; a fragment from cross-cut carpet shell (Ruditapes decussatus L.) from the Neolithic levels of Santimamiñe was probably used for the processing of non-woody silica-rich plants.

Paleoanthropological evidence arises from two sources. First, stable isotopes analyses on human skeletons from different Mesolithic contexts in the region, which group into two clusters: one with what is considered typical of a terrestrial protein diet (δ¹³C values between -20-19 ‰), continued through the Neolithic, whilst other coastal sites of the same chronology show higher δ¹³C values, between -17-15 ‰, as well as high δ¹⁵N values, between 11-13 ‰, indicating a mixed terrestrial-marine protein diet (Arias & Álvarez-Fernández 2004; Arias 2005). δ¹⁵N values are in all terrestrial cases around 8 ‰, which could be due to a highly carnivorous diet or to certain protein-rich plant foods (Arias 2005). Secondly, pathologies in dental wear point to carbohydrate rich foods (Arias 2005).

Portugal

Non-woody plant macroremain evidence from Portugal is even more limited than that of the Cantabrian region (vid. Table 2). Prazo is one of very few sites in which flotation has been carried out. Carpological remains have been obtained from the various layers (9-5th millennia cal BCE) although frequent intermingles of small charred materials in the palimpsest-like hearths of the site (Monteiro-Rodrigues 2012) impels to consider the chronological attribution of the remains with care, or even to question the Neolithic attribution for the site (vid. Zilhão’s comments on Carvalho 2003). Many of the specimens have been radiocarbon dated; however, this has been done in many cases by the conventional method, unfortunately in mixtures with wood from not particularly short-lived species (Arbutus unedo, Cistaceae, Gymnosperma, Pinus pinaster/pinea, Quercus sp. and Quercus suber). In addition, a few fruits from the strawberry-tree (Arbutus unedo) proved to be historic intrusions on radiocarbon dating (Monteiro-Rodrigues & Angelucci 2004). The Mesolithic layers provided fragments of pine cone of Pinus sp. (probably corresponding to the Pinus pinaster/pinea present in the anthracological samples) and an undetermined seed fragment; the Early Neolithic layers, a fruit fragment of possible common hawthorn (Crataegus monogyna?), fragments of pine cone of Pinus sp. (probably Pinus pinaster/pinea) and an undetermined bulb.
Table 2: Available non-woody plant macroremain evidence for Mesolithic and Neolithic (8000-3000 cal BCE) Portugal.

<table>
<thead>
<tr>
<th>Plant Family</th>
<th>Vale Pincel I (5700-5200 cal BCE)</th>
<th>Buraco da Pala (5000-3000 cal BCE)</th>
<th>Ameal IV (3500-3000 cal BCE)</th>
<th>Bolada (ca. 3100 cal BCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gramineae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrhenatherum elatius subsp. bulbosum</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hordeum vulgare var. vulgare</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triticum sp.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Triticum “nudum”</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Pisum sativum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicia faba</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicia faba var. minor</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Allium sphaerocephalon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quercus robur</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quercus sp.</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olea europaea subsp. sylvestris</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Pinus pinea</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubus sp.</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Sorbus sp.</td>
<td>✓</td>
<td></td>
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</tr>
</tbody>
</table>

The only available direct data for domesticated plants attributed to the Neolithic is an assemblage composed of remains of naked wheat (Triticum “nudum”), barley (H. vulgare var. vulgare and H. vulgare var. nudum), pea (Pisum sativum) and broadbean (Vicia faba y Vicia faba var. minor), from contexts dated between the late 6th and early 5th millennia in the rock-shelter Buraco da Pala (Sanches 1997). However, radiocarbon dating was done by conventional methods and thus large amounts of organic material were required, which resulted in the mixture of seeds with undetermined charcoal, thus compromising the quality of the dates.

At Cabeço de Amoreira, a flotation strategy (10l. per layer) has been followed since 2003 but results by M. Wollstonecroft have not yet been published. A case of modern intrusions with recent plant material (Olea sp.) in Neolithic layers has been reported at Vale Boi (Bicho, pers. comm.). According to the published information, no other Early Holocene site has been floated in Portugal and the remainder of the evidence arises from other non-exhaustive retrieval techniques (often unspecified). The site of Vale Pincel I has provided Pinus pinea cone bract scale fragments and nutshell (Carrión Marco, García & Figueiral 2012). Ameal IV, a Late Neolithic site in northern Portugal, has had identified several roasting pits with acorns (Quercus sp. and Quercus cf. robur) (Senna-Martínez 1995). At the site of Bolada (Sampaio & Carvalho 2002), tubers from round-headed leek (Allium sphaerocephalon), tuber oat-grass (Arrhenatherum elatius subsp. bulbosum) and olive (Olea europaea subsp. sylvestris) have been recovered. Other wild olive fruits and acorns are reported from several Middle and Late Holocene sites (Queiroz & Mateus 2006); umbrella pine (Pinus pinea) cone scales and seeds have been recovered.
from sites of the Neolithic onwards (Queiroz et al. 2006), a few seeds from a Rubus berry, fruits from the strawberry-tree (Arbutus unedo) and acorns (Quercus sp.) have also been recovered (Queiroz 2003).

Several anthracological analyses in archaeological early and middle Holocene contexts show that in general, the wood from particular genera of nut bearing trees, such as pine (Pinus pinea) and oaks (Quercus sp.), predominate over other taxa which had been exploited with less frequency, such as olive (Olea europaea), strawberry-tree (Arbutus unedo), pome trees (Maloideae), hawthorn (cf. Crataegus monogyna), mastic trees (Pistacia sp.) (Carvalho 2003; Lubell & Jackes 1985; Monteiro 2013; Monteiro, Bicho & Zapata 2015; Queiroz & van Leeuwaarden 2004).

The three most abundant taxa in pollen analyses from the Muge region have been considered relevant proxies for the reconstruction of human plant exploitation strategies (Jackes & Meiklejohn 2008), which could have been employed for raw material procurement beside food. Palynological analyses do not evidence the presence of cultivated plants until later times (López Sáez, Monteiro-Rodrigues & López Merino 2006-2007; Straus et al. 1992) but deforestation and bush expansion episodes during the 6th millennium are thought to be the consequence of clearing for crop cultivation (apud Carvalho 2010a).

Isotopic evidence from Muge shows certain variation within δ^{13}C and δ^{15}N values in skeletal remains but always within a closed range of relatively high values (δ^{13}C range from -19 to -15 ‰; δ^{15}N from 10 to 14 ‰; Jackes & Meiklejohn 2004), forming relatively homogeneous dietary groups by site, with some notable exceptions which might reflect a dietary specialisation in disabled people (Jackes & Meiklejohn 2004). These values have been considered a typical marine diet (Lubell et al. 1994), the result of “the consumption of C₃ terrestrial foods and a single marine source, or the consumption of a mixture of marine foods in well-defined proportions” (Carvalho & Petchey 2013). No evidence points to the consumption of C₄ plants. It seems that the Late Mesolithic economy was more diversified than the Neolithic one, leading to a wide range of isotopic composition (Lubell et al. 1994). Sado skeletal remains (much fewer) show a lesser degree of marine food in the diet (from non-marine diets to marine components up to 30 %) and a probably higher vegetable component (Umbelino et al. 2007): δ^{15}N values range from 8.3 to 13.6 ‰ and δ^{13}C from -20.5 to -16.9 ‰ (Diniz & Arias 2012). In general, Neolithic human remains analysed show a reduction in both δ^{13}C and δ^{15}N in comparison with the Mesolithic samples in the same regions (δ^{13}C from 19-21 ‰ and δ^{15}N 7-10 ‰), which has been sometimes linked to the abandonment of a marine based diet typical of the Mesolithic style diet (Jackes & Meiklejohn 2004) and probably means the diet was based mainly on herbivores fed on C₃ plants, rather than directly on C₃ plants (Lubell et al. 1994). The range of variation in Neolithic diets seems more limited than those of Mesolithic (Lubell et al. 1994). However, a clearly outlying individual (from Lagares Cave, Melides) shows high values in both δ^{13}C and δ^{15}N. This case has been considered either a reflection of “the most extreme marine shift” and the maintenance of a Mesolithic style diet in the Neolithic (Jackes & Meiklejohn 2004), or a questioning of its Mesolithic or Neolithic ascription (Zilhão 1998).

Other palaeoanthropological forms of evidence are certain fluorescing rings in Mesolithic human bones, interpreted as the ultimate result of consumption of plant foods such as fruits (pine nuts, pistachios or acorns) and grains which could have been stored and fermented (Palmer 1987 apud Lubell et al. 1994). Dental pathologies within human samples from the late Mesolithic at Muge show co-occurrence of strong molar attrition and occlusal caries (Jackes & Meiklejohn 2008), evidence of a diet with a high consumption of sugar and carbohydrate rich food, like wild vegetables, dried fruits and nuts.
but also honey (occlusal caries) and cereals or fibrous or hard wild fruits, like acorns (attrition). Human
caries might be used as proxies for abrupt dietary changes in populations, such as that which occurred in
the Mesolithic-Neolithic transition (Jackes 2009) but “dental pathology is not universally a good marker
of the shift to agriculture” (Lubell et al. 1994). In central Portugal, no simple increase in dental
pathology occurs in the Early Neolithic: markedly lower attrition levels and a rise in occlusal caries rates
do not occur until after 5500 cal BP (Jackes & Meiklejohn 2008). In Neolithic samples, cupped wear
has much greater incidence than before, which might be related to the introduction of fine-grinding grain
techniques (Lubell et al. 1994).

Technological indirect evidence is restricted to the so-called Mirian macroliths, which dominate the
lithic industry in Late Mesolithic contexts and are interpreted as shellfish and plant exploitation tools
(Straus 2008); presumed cereal grinding stones quite frequent in the contexts ascribed as Neolithic, like
Salema (Straus 1991), São Pedro de Canaferrim (e.g. Simões 2003) and Bolada (Sampaio & Carvalho
2002), Ameal IV (Senna-Martínez 1995); and lithic tools from the coastal area of Corticóis which
display a well developed micro-polish that extends along most of the tools’ edges and some blank
modification, permitting their diagnosis as marks produced during the harvesting of cereals or other
non-ligneous plants whilst hafted in sickles (Carvalho, Gibaja & Cardoso 2013).

Finally, there is indirect zooarchaeological evidence. Among the molluscs recovered at Medo Tojeiro
“there was a significant component of very small non-edible species including numerous small
gastropods (Gibbula) that live on seaweed (either Laminaria of Zostera). Whilst their presence could be
fortuitous, it does suggest collection of seaweed [,] perhaps for food, or as fuel for steaming molluscs, or
for other domestic purposes such as bedding” (Lubell et al. 2006). In addition, the house mouse (Mus
musculus) is absent in the Iberian Peninsula during the Pleistocene but appears during the Neolithic: it
has been associated with the development of human settlements in deforested areas, indirectly pointing
to the existence of agricultural plots in the immediate vicinities (Póvoas 1998 apud Carvalho, Gibaja &
Cardoso 2013).
2 Objectives

This thesis aims to obtain archaeobotanical data to address two main issues: an archaeobotanical one and a historical-archaeological one.

On the one hand, the archaeobotanical aim of this thesis is the research into specific aspects of past societies related to the exploitation and management of plant resources. Additionally, this thesis aims to obtain a more thorough knowledge of plant remain taphonomy, as understanding the influence of both natural and anthropic processes in the archaeological (and archaeobotanical) record is essential for research into past human activities.

On the other hand, the historical or archaeological issue concerns the process of Neolithisation: the purpose of this thesis in this respect is to obtain new data crucial for the understanding of the dynamics of transformation of Holocene societies from hunter-gatherers of wild resources to farmers and managers of domesticated resources, within the framework of the Atlantic Iberian Peninsula between 8000 and 3000 years cal BCE.

This work has been carried out bearing in mind that knowledge and how knowledge is obtained is influenced by how authors understand the world in their own personal subjective way and what their interests are.

Thus, the discipline framework for this work is archaeobotany or palaeoethnobotany (here considered as synonyms). The combination of its chronological framework (when the appearance of domesticated species occurs) and its physical framework (where the complexity of the Neolithisation process is still confusing) makes it a critical framework of historical change.
3 Studied contexts

In this chapter, the archaeological contexts that yielded the charred plant macroremain assemblages studied here are thoroughly described. The 10 studied sites are distributed between the two regions of Atlantic Iberia central for this thesis: the Cantabrian region and Portugal (\textit{vid.} Figure 7). Whilst for the Cantabrian region more Mesolithic \((n = 5)\) than Neolithic \((n = 2)\) contexts have been available for study; for Portugal, less sites have been studied \((n = 4)\), but they have been sampled in a more homogeneous way so to provide data for the Mesolithic and the Early Neolithic more easily comparable.

The studied assemblages possess the essential characteristics of a minimum representativeness, even when the assemblages are either quantitatively or qualitatively poor, ensured by the recovery techniques and a chronological support for the stratigraphy. Assemblages from several other sites have also been examined preliminarily but, for several reasons, have not been chosen for further study:

- La Garma A (Cantabria, Spain): this cave with a long Pleistocene and Holocene stratigraphical sequence has been excavated since the 1990s by a team directed by Pablo Arias and Roberto
Ontañón. Intensive sampling and flotation of at least 30% of the excavated area has been carried out. The Mesolithic shell-midden layer (SU 2) detected upon excavation was covered by a carbonate concretion, which had been broken in an imprecise late prehistorical time to dig a burial. Despite the isolation of this burial pit upon excavation, intrusive materials have been found during the excavation of the shell-midden layer and the analysis of the flotation samples (n=60) produced large numbers of charred plant materials that clearly did not match the Mesolithic cultural and chronological ascription. Due to the impossibility of clearly distinguishing the intrusive from the in situ plant remains, this context has not been studied further. In addition, a sample of these charred plant remain intrusions was submitted for 14C AMS dating but proved to have insufficient carbon.

- Meu Jardim (Nazaré, Estremadura, Portugal): this possible Neolithic shell-midden has been extensively excavated in the last decade by ERA-Arqueologia, Conservação e Gestão de Património, S.A., but the sampling strategy has been extremely limited: whilst most of the sediment from the excavation has been dry-sieved, less than 1 l soil samples and only from a few stratigraphical units have been floated. The analysis of the (really few) samples did not produce the recovery of any non-woody plant remains, but only a few pieces of wood charcoal.

- Veguillas 4 (Jarandilla de la Vera, Cáceres, Spain): a possible Neolithic hut was excavated in a short survey in 2010, under the direction of Pablo Arias and Enrique Cerrillo Cuenca. All sediment from the excavation has been floated and it provided abundant charred and uncharred plant material which has been analysed preliminary. However, radiocarbon dating of several samples (although none of them were plant remains) evidenced a modern historical chronology for the habitation structure.

Two of the carpological assemblages from two Cantabrian contexts presented in this work have been previously studied by the author in the framework of a Master’s thesis (Arangas and Los Gitanos); however, as the study of the remains has been furthered and substantial improvements have been achieved (in terms of improved identification of previously undetermined or very generally determined specimens), they have been included in this work.

The studied contexts are described with varying detail depending on the published information available or the chances to access previously unpublished data. The sites studied are described following this outline:

First, the detailed geolocalisation, the type of site and its state of preservation, are noted. The exact localisation is given in UTM coordinates, datum WGS84. When this format is not given in the original data, a converter has been used.

Next, under the historiography section, the research history of the site is reviewed, with special emphasis on those archaeological interventions from which the studied samples originate.

Under the section stratigraphy the different archaeological units have been characterised. The stratigraphical description of the contexts tries to follow a chronological order, thus being described from the most ancient to the most recent.

At the section chronology, numerical dates are given when available; otherwise, the chronocultural estimation made by the excavators is given. All numerical dates available for the sampled contexts have
been included; in addition, dates from other non-sampled contexts within the same sites have been also listed, considering that they contribute to the understanding of the chronology of the site.

Numerical dates are given with a probability interval of 95.4 % (2σ). BCE thermoluminescence (TL) dates are given by subtracting the year of dating from the BP result. Aminoaciracemisation dates (AAR) are given following (Torres Pérez-Hidalgo, Ortiz Menéndez & Sánchez Palencia 2013). Radiocarbon dates are reported following the international conventions (Millard 2014) when the available information allows it. All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (updated the 6 March 2014 / 24 May 2014; Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013). Known values of ΔR (both 13C values from terrestrial samples/marine samples of the same age or as established by 14C dates of pairs of closely associated archaeological samples (marine shells/wood charcoal, seeds or bones, Stuiver & Braziunas 1993) from samples as near as possible in time and space have been used. When stable isotope (δ13C and δ15N) studies are available, the % of marine protein source has been tentatively estimated, taking into account the Southern European offset (Carvalho & Petchey 2013) and accounting with an uncertainty of about 10 % (Martins, Carvalho & Soares 2008). When possible, it is indicated whether δ13C values have been obtained by isotope-ratio mass spectrometry (IRMS), appropriate for dietary reconstructions or reservoir corrections, or by accelerator mass spectrometry (AMS), just a quality control measurement (Millard 2014). The contextual provenance of the material dated and its species is specified when known. This is done in order to ascertain, in the case of wood, possible old-wood effects, and in the case of samples of aquatic origin or diet, the importance of the reservoir effect. The confidence of the calibrated dates is evaluated according to different levels of quality and reliability, according to the quality of the information available (which often is not ideal, vid. Millard 2014) regarding the material dated, the context in which it was taken, the species to which it belongs, the potential existence of reservoir effects, etc. (vid. Table 3; López-Dóriga 2014; inspired in Carvalho 2010b; Fano, Cubas & Wood 2015; Waterbolk 1971 and Zilhão 2001).

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5 In the case of the Sado Valley, two different ΔR values exist (Vale de Romeiras), ΔR = –170 ± 60 yr, (Soares & Dias 2006) and ΔR = 100 ± 155 (Martins, Carvalho & Soares 2008). For the Cantabrian region, ΔR = 210 (Arias 2005).

6 % marine diet = [(δ13Ccoll – δ13Cmed) / (δ13Cmed)] × 100. δ13Ccoll is the C isotopic composition in bone collagen, δ13Cmed, is the median in terrestrial foods, δ13Cmed, or the median in marine foods and Δcol-diet, the fractionation (δ13Ccoll – δ13Cdiet) (Ambrose 1993 apud Martins, Carvalho & Soares 2008). For Southern Europe, the following values are assumed: δ13Cdiet = -20‰; δ13Ccoll = -12‰; Δcol-diet = 3.5‰ (Carvalho & Petchey 2013; Richards & Hedges 1999).
### Part I: Framework

<table>
<thead>
<tr>
<th>Type of context / sample</th>
<th>Samples from well defined archaeological structures of clear anthropic origin, or directly and unequivocally associated with them.</th>
<th>Samples from hearths, pits or silos, which are very often reused or refilled with sediments resulting from completely independent events.</th>
<th>Materials dispersed in sediments, or aggregated in concentrations but without direct association with any structure.</th>
<th>Materials dispersed in sediments, between contiguous anthropic layers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short lived samples of terrestrial (or aquatic that photosynthesise above water) plant remains (annuals such as seeds, fruits and tubers).</td>
<td>Best (absolute certainty)</td>
<td>High (uncertainty of decades, &lt;100 years)</td>
<td>Low (unknown uncertainty)</td>
<td></td>
</tr>
<tr>
<td>Relatively short-lived plant remains (charcoal from branches of long-lived species or of shrub species) and animal remains (terrestrial animals feeding on terrestrial resources).</td>
<td>High (uncertainty of decades, &lt;100 years)</td>
<td>High (uncertainty of decades, &lt;100 years)</td>
<td>Low (unknown uncertainty)</td>
<td></td>
</tr>
<tr>
<td>Short-lived remains that require reservoir effect correction (remains of aquatic animals or terrestrial animals feeding on them, with known diets; and aquatic plants that photosynthesise under water) and long-lived plant remains (charcoal from inner parts of tree trunks of long-lasting species).</td>
<td>Middle (uncertainty of centuries, &gt;100 years)</td>
<td>Middle (uncertainty of centuries, &gt;100 years)</td>
<td>Low (unknown uncertainty)</td>
<td></td>
</tr>
<tr>
<td>Taxonomically undetermined organic material, either charcoal, bone or shell, or composite material, such as cooking residues.</td>
<td>Low (unknown uncertainty)</td>
<td>Low (unknown uncertainty)</td>
<td>Low (unknown uncertainty)</td>
<td>Low (unknown uncertainty)</td>
</tr>
</tbody>
</table>

Table 3: Reliability of C14 dates accordingly to the type of sample and context of provenance (López-Dóriga 2014).

Under the section *archaeobotanical recovery strategy*, the type of sampling and the retrieval techniques employed have been detailed as precisely as possible.
3.1 Cantabrian sites

3.1.1 Arangas

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>AR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site type</td>
<td>Rock-shelter and cave</td>
</tr>
<tr>
<td>Site area</td>
<td>East oriented 7m rock-shelter, cave 25 m long × 6-7 m wide</td>
</tr>
<tr>
<td>Preservation</td>
<td>Eroded by furtive treasure seekers, now extensively excavated</td>
</tr>
<tr>
<td>Administration</td>
<td>Arangas, Cabrales, Asturias, Spain</td>
</tr>
<tr>
<td>Geography</td>
<td>340 m a.s.l., 29 km from the current seashore (12 km as the crow flies)</td>
</tr>
<tr>
<td>UTM (datum WGS84)</td>
<td>Zone 30 T; X: 0354176; Y: 4798770</td>
</tr>
</tbody>
</table>

Table 4: Arangas: site details.

Other caves with archaeological deposits are situated in the same karst system: Los Canes y El Tiu Llines.

3.1.1.1 Historiography

A team directed by Pablo Arias and Carlos Pérez, from the University of Oviedo, undertook in 1985 a small trial excavation, and between 1992 and 1998 more extensive excavations in 5 areas of the site (vid. Figure 8): the rock-shelter (Area A), near the opening of the cave (Areas B and C), at the end of the gallery (Area D), and a zone excavated by unknown treasure seekers (Area E). The excavation areas was divided into squares of 1 m². A complex and long stratigraphy was revealed in all areas so a trench was dug connecting the different areas in order to understand the sequence (Arias Cabal & Pérez Suárez 1995; Arias Cabal et al. 1999). Samples studied here were obtained during the 1992-1998 field seasons in Areas B to E. A further sampling programme was carried out in 2007 excavating a further 1m² (Arias et al. 2014).

3.1.1.2 Stratigraphy

Throughout the cave sequence, a long Holocene stratigraphy with Mesolithic, Neolithic, Chalcolithic and Bronze Age layers has been found, overlaying Pleistocene layers which have not been studied in this work. Whilst in Area B (vid. Figure 8), evidence of percolation of some archaeological materials has been observed, the other Areas (C, D and E) do not have any hint suggesting the occurrence of the same phenomenon. No samples from Area A have been studied here.

Several Mesolithic layers have been recognised in the site (Arias Cabal et al. 1999), and samples from two of them (Layers 4 and 3) have been studied in this work. The possible percolation of some of the archaeological remains from Layer 3 to Layer 4 was suggested upon excavation (and the available radiocarbon dates confirm the same chronology for the materials, vid. Table 5). Because living floors
have not been found, it has been proposed that the habitation area at this period was situated in the rock-shelter and the cave was used as a domestic refuse disposal area.

- Layer 4 is a short clayey layer of about 5 cm, with abundant stones and poor in archaeological remains. Samples of this layer come from Area C (\textit{vid.} Figure 8).

- Layer 3, is 15 cm deep, it contains abundant stones and archaeological remains (mammal bones, charred macroremains, shells and lithic industries). Samples of this layer come from Areas B, C and D. In Area B (\textit{vid.} Figure 8), percolation of more recent material has been observed in the archaeobotanical samples and has been confirmed by radiocarbon dates (\textit{vid.} Table 5).

- Layer 2B is an eroded residual layer which partially overlies layer 3. No samples have been studied from this layer.

More recent layers are often separated by a carbonate concretion, indicating the existence of a chronological hiatus in the occupation of the cave.

- The Neolithic context studied is layer D, of variable depth, between 5-60 cm, and limited extension. It has abundant stones and archaeological remains, mammal bones, lithic elements and pottery fragments. Samples attributed to this layer come mostly from Area E, with just one from Area B.

Several Bronze Age structures overlay most of the previous sequence, in some cases eroded in their upper part. A few intrusive remains from this period have been detected at some points of the Early Holocene sequence in some of the areas (Area B, \textit{vid.} Figure 8).
Figure 8: Arangas topographical survey with excavations areas. Modified, after original image by Luis Teira (Arias et al. 2014).
Part I: Framework

Figure 9: Modelled radiocarbon dates for the three mentioned sequential phases of occupation of Arangas.
3.1.1.3 Chronology

Radiocarbon dates from Arangas (vid. Table 5) confirm the ascription of the studied layers of the sequence to two phases of occupation, separated by a temporary hiatus of about 300 years, and with the existence of an intrusion from the Bronze Age layers (vid. Figure 9).

Whilst the modelled dates of the first phase (Mesolithic, layers 4, 3, and 2B) provide a relatively short duration (between ca. 7500 and 7000 cal BCE), those of the second phase (Neolithic, layer D) lapse a whole millennium (ca. 3800 to 2800 cal BCE).

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context (layer)</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date</th>
<th>δ¹³C (AMS)</th>
<th>Δ¹⁵N</th>
<th>cal BCE date (95.4 % probability)</th>
<th>Bibliography</th>
</tr>
</thead>
<tbody>
<tr>
<td>OxA-6888</td>
<td>¹⁴C AMS</td>
<td>4</td>
<td>Wood charcoal</td>
<td>Low</td>
<td>8280 ± 55</td>
<td>-25.4 %</td>
<td>-</td>
<td>7491-7142</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>OxA-6887</td>
<td>¹⁴C AMS</td>
<td>3 (base)</td>
<td>Wood charcoal</td>
<td>Low</td>
<td>8300 ± 50</td>
<td>-24.9 %</td>
<td>-</td>
<td>7492-7184</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>OxA-7149</td>
<td>¹⁴C AMS</td>
<td>3 (middle)</td>
<td>Bone</td>
<td>Low</td>
<td>8195 ± 60</td>
<td>-18.8 %</td>
<td>-</td>
<td>7447-7060</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>OxA-24799</td>
<td>¹⁴C AMS</td>
<td>2B</td>
<td>Bone (Homo sapiens)</td>
<td>Medium</td>
<td>8240 ± 40</td>
<td>-18 %</td>
<td>-</td>
<td>7451-7084</td>
<td>Arias et al. 2014</td>
</tr>
<tr>
<td>OxA-7160</td>
<td>¹⁴C AMS</td>
<td>2B</td>
<td>Bone</td>
<td>Low</td>
<td>8025 ± 80</td>
<td>?</td>
<td>-</td>
<td>7174-6686</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>UBAR-465</td>
<td>¹³C</td>
<td>E2</td>
<td>Charcoal</td>
<td>Low</td>
<td>7150 ± 470</td>
<td>?</td>
<td>-</td>
<td>7294-5211</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>AA-78187</td>
<td>¹⁴C AMS</td>
<td>D</td>
<td>Bone (Sus domesticus)</td>
<td>Low</td>
<td>4735 ± 59</td>
<td>?</td>
<td>-</td>
<td>3640-3372</td>
<td>Arias et al. 2014</td>
</tr>
<tr>
<td>AA-78188</td>
<td>¹⁴C AMS</td>
<td>D</td>
<td>Bone (Sus domesticus)</td>
<td>Low</td>
<td>4303 ± 60</td>
<td>?</td>
<td>-</td>
<td>3261-2699</td>
<td>Arias et al. 2014</td>
</tr>
<tr>
<td>AA-78190</td>
<td>¹⁴C AMS</td>
<td>D</td>
<td>Bone (Bos taurus)</td>
<td>High</td>
<td>4298 ± 55</td>
<td>?</td>
<td>-</td>
<td>3091-2706</td>
<td>Arias et al. 2014</td>
</tr>
<tr>
<td>AA-78189</td>
<td>¹⁴C AMS</td>
<td>D</td>
<td>Bone (Bos taurus)</td>
<td>High</td>
<td>4251 ± 57</td>
<td>?</td>
<td>-</td>
<td>3016-2639</td>
<td>Arias et al. 2014</td>
</tr>
<tr>
<td>OxA-24163</td>
<td>¹⁴C AMS</td>
<td>3</td>
<td>Seed (Hordeum vulgare)</td>
<td>Intrusive</td>
<td>3540 ± 29</td>
<td>-24.22 %</td>
<td>-</td>
<td>1951-1770</td>
<td>Arias et al. 2014</td>
</tr>
</tbody>
</table>

Table 5: Numerical dates available for the Mesolithic and Neolithic layers of Arangas.

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All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013). For the Cantabrian region, ΔR = 210 (Arias 2005).
3.1.1.4 Archaeobotanical recovery strategy

The site has been sampled according to two different aleatory strategies devised by the excavators, long before the start of this thesis. The excavation area has been divided into squares of 1 m$^2$ and each square has been subdivided into 9 subsquares of 33 cm$^2$, named with numbers from 1 to 9. In the first seasons of the 1992-1997 intervention, all the sediment from the subsquares named under odd numbers were floated (55 % of the square area); in the latter seasons of the 1990’s intervention, all the sediment from a diagonal row of 3 subsquares was floated (33 %) (vid. Table 6). Flotation was carried out with a Siraf-type machine (Williams 1973) with 200 micron mesh size for the light fraction. Unfortunately, sorting of the light fraction of flotation samples was carried out at the field-lab by members of the excavating team, without the aid of magnification tools.

<table>
<thead>
<tr>
<th>Mesolithic phase</th>
<th>Neolithic phase</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 4</td>
<td>Layer 3</td>
<td>Total</td>
</tr>
<tr>
<td>No. of samples</td>
<td>2</td>
<td>37</td>
</tr>
<tr>
<td>Excavated % sampled</td>
<td>50 %</td>
<td>62 %</td>
</tr>
</tbody>
</table>

Table 6: Archaeobotanical sampling strategy developed at Arangas.

A short report on the archaeobotanical sampling strategy and preliminary results has already been published (Arias et al. 2014). The results from the present study can be seen at p. 355.

3.1.2 El Carabión

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative name</td>
<td>Cueva del Puente de San Mamés</td>
</tr>
<tr>
<td>Site type</td>
<td>Rock-shelter</td>
</tr>
<tr>
<td>Site area</td>
<td>South-East oriented, 18m high and 30 m deep</td>
</tr>
<tr>
<td>Preservation</td>
<td>Highly eroded (due to river and kept animals)</td>
</tr>
<tr>
<td>Administration</td>
<td>San Mamés de Arás, Voto, Cantabria, Spain</td>
</tr>
<tr>
<td>Geography</td>
<td>20 m a.s.l., 2 km from the current seashore, near Clarón river</td>
</tr>
<tr>
<td>UTM (datum WGS84)</td>
<td>Zone 30 T; X: 0458970, Y: 4800730</td>
</tr>
</tbody>
</table>

Table 7: El Carabión: site details.
3.1.2.1 Historiography

The site was partially excavated sometime in the 1950s (CAEAP), listed in a regional archaeological inventory in 1987 (Muñoz Fernández & Llamosas 1987) and partly excavated in 2009 by a team under the direction of Mercedes Pérez Bartolomé (Pérez Bartolomé 2010; Pérez Bartolomé 2014).

3.1.2.2 Stratigraphy

The deposit which has survived the erosion is 40 cm thick and 5 stratigraphical layers have been reported (Pérez Bartolomé 2010), of which 2 have evidence of human activities separated in time by at least 3 millennia.

The oldest anthropic layer, N3, is 25 cm thick and rich in charcoal, faunal remains and lithics.

Between this layer and the upper one, a 20 cm thick carbonate concretion ensures the separation in time of the two distinct human occupations.

The Mesolithic deposit, N1, 35 cm thick, consists of a shell-midden layer, rich in shells and other faunal remains.

The upper layer is a 5 cm thick carbonate concretion which ensures the intact state of the deposit immediately under it.

3.1.2.3 Chronology

Three samples from the two layers with evidence of anthropic activity at El Carabión have been submitted to radiocarbon dating (cid. Table 8).
## Part I: Framework

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date</th>
<th>$^{13}$C (AMS)</th>
<th>IRMS $^{13}$C</th>
<th>IRMS $^{15}$N</th>
<th>cal BCE date (95.4 % probability)</th>
<th>Bibliography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poz-30594</td>
<td>$^{14}$C AMS</td>
<td>N3 C5</td>
<td>Bone</td>
<td>Low</td>
<td>10310 ± 60</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>10450-9884</td>
<td>Pérez Bartolomé 2010; Pérez Bartolomé 2014</td>
</tr>
<tr>
<td>Poz-32691</td>
<td>$^{14}$C AMS</td>
<td>N1 C5</td>
<td>Bone</td>
<td>Low</td>
<td>7800 ± 50</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>6767-6496</td>
<td>Pérez Bartolomé 2010; Pérez Bartolomé 2014</td>
</tr>
<tr>
<td>Poz-18732</td>
<td>$^{14}$C AMS</td>
<td>N1 C5</td>
<td>Charcoal</td>
<td>Low</td>
<td>5750 ± 40</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>4701-4501</td>
<td>Pérez Bartolomé 2010; Pérez Bartolomé 2014</td>
</tr>
<tr>
<td>Poz-30592</td>
<td>$^{14}$C AMS</td>
<td>N1 I1</td>
<td>Bone</td>
<td>Low</td>
<td>5440 ± 40</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>4358-4233</td>
<td>Pérez Bartolomé 2014</td>
</tr>
</tbody>
</table>

Table 8: Numerical dates available for the studied layers of El Carabión.

These radiocarbon dates have confirmed the chronological hiatus between the two layers perceived upon excavation: the oldest layer (N3) has provided a radiocarbon date placing its formation in the 11th millennium cal BCE; whilst the more recent layer (N1) is from the 7th millennium cal BCE at the earliest. However, the dates from samples of this layer (N1) show a great divergence which suggests the existence of a long period of about 2 millennia in which materials from different occupations have become intermingled (vid. Figure 11).

---

10 All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013). For the Cantabrian region, $\Delta R = 210$ (Arias 2005).
Archaeobotanical recovery strategy

The sampling and retrieval strategy in this site has not been oriented by the interest of gaining archaeobotanical data. All sediment excavated has been wet-sieved with 3 and 1 mm meshes and plant remains have been picked with the naked eye by members of the excavating team; only samples positively containing plant macroremains have been available to the author of this thesis for further analysis (Table 9).

<table>
<thead>
<tr>
<th></th>
<th>Layer 3 (1st phase)</th>
<th>Layer 1 (2nd phase)</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of samples</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>No. of samples with plant macroremains</td>
<td>2</td>
<td>27</td>
<td>29</td>
</tr>
<tr>
<td>Excavated % sampled</td>
<td>100 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Archaeobotanical sampling strategy developed at El Carabión.

The results from the present study can be seen at p. 360.
3.1.3 El Mazo

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative name</td>
<td>Samportiella</td>
</tr>
<tr>
<td>Site type</td>
<td>Rock-shelter</td>
</tr>
<tr>
<td>Site area</td>
<td>18 m wide by 7 m deep</td>
</tr>
<tr>
<td>Preservation</td>
<td>Partly eroded and bioturbated</td>
</tr>
<tr>
<td>Administration</td>
<td>Andrín, Llanes, Asturias, Spain</td>
</tr>
<tr>
<td>Geography</td>
<td>In a depression on top of a small hill, 700 m from the current seashore, at 15 m a.s.l.</td>
</tr>
<tr>
<td>UTM (datum WGS84)</td>
<td>Zone 30 T</td>
</tr>
</tbody>
</table>

Table 10: El Mazo: Site details.

Figure 12: General view of El Mazo rock shelter. Photograph by Igor Gutiérrez Zugasti.

3.1.3.1 Historiography

The site was discovered in 2008 by a team led by Igor Gutiérrez Zugasti and Manuel González Morales (Gutiérrez Zugasti & Morales 2014; Gutiérrez Zugasti et al. 2014) and a small trial excavation (2.5 x 1 m) was carried out in 2009 and 2010 in two areas; the excavation was extended in 2012 and 2013, increasing the excavated surface by 0.5 m².
3.1.3.2 Stratigraphy

The two excavated areas have shown to preserve the remains of a large Asturian/Mesolithic shell midden (mostly, the inner test area) and one of them also has later prehistorical occupations (outer test area). It is one of the two shell middens in the Cantabrian region where a microstratigraphy has been detected, in which hearths, occupation floors and small accumulations of monospecific remains from a single gathering event (e.g. sea urchins) have been identified. Among the archaeological materials recovered, the most abundant remains are shells from molluscs, crustaceans and echinoderms, and a relatively high percentage of the mollusc shells have been transformed into tools and perforated for bead making. Some lithics and a few mammal, bird and fish bones have been recovered. Wood charcoal (mostly from *Quercus*, but also *Corylus avellana*) is abundant (unpublished data from Monica Ruiz Alonso).

Two areas of the rock-shelter have been excavated (Gutiérrez Zugasti & Morales 2014; *vid.* Figure 13):

- The interior rock-shelter area is undisturbed, except for the upper superficial layer. Its stratigraphy is very complex, in some cases understood after the excavation, through the examination of the profiles. The stratigraphy (*vid.* Figure 14), from which samples for the analysis of plant macroremains have been obtained (unless otherwise stated), covers a long Mesolithic chronology.

- SU 121: layer of brown soil with stones, only superficially excavated. Underlies SU 109. No samples have been studied from this layer.
Part I: Framework

- SU 109: shell-midden base, orange clayey layer with sparse archaeological remains and abundant stones. Samples from this layer have not been studied.

- SU 108: brown clayey and wet layer, with sparse quantities of shells but abundant lithics, bones and charred plant macroremains. Underlies SU 115.

- SU 115: layer rich in shells with sparse soil, light brown, between 1 and 15 cm depth. It underlies SU 114 and overlies SU 108.

- SU 114: layer of dark brown soil, very loose, about 2 cm depth, and rich in bones and shells. Underlies SU 107, overlies SU 115.

- SU 107: dark brown layer, very loose and rich in charred plant macroremains and shells, between 5 and 15 cm depth, with some stones. Overlies SU 114, underlies SU 105 and it is cut by SUs 111 and 110.

- SU 111: layer of light brown soil with stones, of a depth about 10 cm, partially solidified. It contains abundant shells and charred plant macroremains. It cuts SU 107 and underlies SU 110.

- SU 110: brown-greyish layer, sometimes yellow, between 11 and 16 cm depth, very loose and rich in shells and charred plant macroremains. Underlies SU 105 and overlies SU 111.

- SU 105: brown and yellow soil, with some stones, underlies SU 102 and overlies SUs 110 and 107, cutting SU 103.1. Variable depth between 15 and 30 cm, sparse shells.

- SU 113: layer between 10 and 20 cm depth, of brown loose soil, partially solidified, with abundant shells and charred plant macroremains. Underlies SU 112 and overlies SU 105.

- SU 112: shell-midden layer with dark soil and abundant shells and charred plant macroremains. Underlies SU 103 and overlies SU 113. A microstratigraphy can be distinguished:
  
- a base of loose shells (about 5 cm depth) without almost any soil,

- a layer of dark brown soil, between 1-2 cm depth,

- a top thin layer (2-3 cm depth) rich in charred plant material.

- SU 103.1: small layer of about 5 and 10 cm depth composed of greyish loose soil and abundant shells. It is cut by SU 105. No samples have been studied from this layer.

- SU 120: layer of brown soil of 8 cm depth, contains shells.

- SU 103: dark brown-blackish loose layer of 5-15 cm depth, with abundant shell remains,

- SU 102: yellow crust of heterogeneous hardness, with some malacological material, between 6 and 15 cm depth. Underlies SUs 119, 101.1, and 116. Similar to SU 106 in V16, yellow crust of heterogeneous hardness, between 15 and 30 cm depth, containing some shells.
• SU 119: layer of brown-yellowish soil with stones, both loose and solidified, about 15 cm depth, rich in shells, bones, charred plant macroremains. Underlies SU 101 and overlies SU 102.

• SU 104: V16, ashy layer with thermoaltered pebbles, between 5 and 10 cm depth, interpreted as a hearth in primary or secondary position. Similar to SU 117.

• SU 101.1: small blackish layer, of maximum 20 cm depth, located around the hearth structure SU 117, between 1 and 10 cm depth, with abundant ashes, charred plant macroremains and shells, many of them thermoaltered. Underlies SU 101.

• SU 116: small layer, underlying SU 101, with light brown soil, maximum 10 cm depth, rich in echinoderm remains.

• SU 118: mixed bioturbated layer between 10 and 25 cm depth.

• SU 101: brown loose layer, with abundant shells and bones, charred plant macroremains and lithic elements, highly bioturbated, with a depth between 5 and 50 cm. Underlies SU 100, overlies 101.1.

• SU 100: superficial, between 5 and 20 cm depth, highly bioturbated and mixed. Overlies SU 101.

Figure 14: North profiles from the interior rock shelter area. Photograph by Igor Gutiérrez Zugasti.

• The exterior rock-shelter area, with 5 archaeological layers, one of which (SU 3) is a shell-midden. Only one sample from this area has been studied here.

3.1.3.3 Chronology

Radiocarbon and Aminoacid Racemisation dates (vid. Table 11) assign the remains from the inner area to the 8th and 7th millennia cal BCE, whilst those of the exterior area to the 6th (vid. Figure 15).
### Table 11: Numerical dates available for the studied layers of El Mazo.

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date</th>
<th>$\delta^{13}$C (AMS)</th>
<th>IRMS $\Delta^{13}$C</th>
<th>IRMS $\Delta^{15}$N</th>
<th>cal BCE date (95.4 % probability)</th>
<th>Bibliography</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEB-9445 a 9454</td>
<td>AAR</td>
<td>Int. SU107 (V16)</td>
<td>Shell (Patella sp.)</td>
<td>Low</td>
<td>9067 ± 1415</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>10482-7652</td>
<td>Gutiérrez Zugasti &amp; Morales 2014</td>
</tr>
<tr>
<td>LEB-8765 a 8773</td>
<td>AAR</td>
<td>Int. SU 103 (V16)</td>
<td>Shell (Patella sp.)</td>
<td>Low</td>
<td>7152 ± 599</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>7751-6553</td>
<td>Gutiérrez Zugasti &amp; Morales 2014</td>
</tr>
<tr>
<td>LEB-8790 a 8798</td>
<td>AAR</td>
<td>Ext. SU3 (S10)</td>
<td>Shell (Patella sp.)</td>
<td>Low</td>
<td>6467 ± 778</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>7245-5689</td>
<td>Gutiérrez Zugasti &amp; Morales 2014</td>
</tr>
<tr>
<td>LEB-8915 a 8924</td>
<td>AAR</td>
<td>Int. SU105 (V15)</td>
<td>Shell (Patella sp.)</td>
<td>Low</td>
<td>6495 ± 582</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>7077-5913</td>
<td>Gutiérrez Zugasti &amp; Morales 2014</td>
</tr>
<tr>
<td>LEB-8770 a 8789</td>
<td>AAR</td>
<td>Int. SU107 (V15)</td>
<td>Shell (Patella sp.)</td>
<td>Low</td>
<td>6280 ± 517</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>6797-5763</td>
<td>Gutiérrez Zugasti &amp; Morales 2014</td>
</tr>
<tr>
<td>LEB-8774 a 8779</td>
<td>AAR</td>
<td>Int. SU103.1 (V15)</td>
<td>Shell (Patella sp.)</td>
<td>Low</td>
<td>6070 ± 582</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>6652-5488</td>
<td>Gutiérrez Zugasti &amp; Morales 2014</td>
</tr>
<tr>
<td>UGAMS-5408</td>
<td>$^{14}$C AMS</td>
<td>Int. SU105 (V15)</td>
<td>Wood charcoal</td>
<td>Low</td>
<td>7640 ± 30</td>
<td>-25.6</td>
<td>%a</td>
<td>-</td>
<td>6568-6435</td>
<td>Gutiérrez Zugasti &amp; Morales 2014</td>
</tr>
<tr>
<td>UGAMS-5407</td>
<td>$^{14}$C AMS</td>
<td>Ext. SU3 (S10)</td>
<td>Bone (Cervus)</td>
<td>Medium</td>
<td>6790 ± 30</td>
<td>-21.1</td>
<td>%a</td>
<td>-</td>
<td>5727-5638</td>
<td>Gutiérrez Zugasti &amp; Morales 2014</td>
</tr>
<tr>
<td>UGAMS-5406</td>
<td>$^{14}$C AMS</td>
<td>Ext. SU2 (S9)</td>
<td>Bone (Bos taurus)</td>
<td>Intrusivel</td>
<td>260 ± 20</td>
<td>-20.5</td>
<td>%a</td>
<td>-</td>
<td>-</td>
<td>Gutiérrez Zugasti &amp; Morales 2014</td>
</tr>
</tbody>
</table>

Note: All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013). For the Cantabrian region, $\Delta R = 210$ (Arias 2005).
3.1.3.4 Archaeobotanical recovery strategy

Whilst at the beginning of this project, gaining archaeobotanical data was not one of the main purposes of the research, the situation evolved and archaeobotanically-oriented sampling and retrieval strategies were eventually applied. Sediment excavated in the surveys of 2009 and 2010 has been wet-sieved with a 2mm mesh and all plant macroremains have been picked with the naked eye, sorting between charcoal and seeds and fruits has been carried out with magnification (but both “seed” and “charcoal” bags have been re-examined by the author of this thesis). Sediment excavated in 2012 has been floated. Plant macroremains have been obtained from both the light and heavy fractions of the flotation samples; however, charred plant material resulting from the sorting of the heavy fraction was not available from all SUs at the time of finishing this thesis (vid. Table 12). Additionally, some concentrations of charred plant material were perceived upon excavation and were collected as in situ samples (vid. p. 121).

<table>
<thead>
<tr>
<th>SUs</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 10 8 11 1</td>
<td>1 1 1 1 0 1 0 5 1 1 1 2 0 1 0 0 2 1 1 0 1 7</td>
</tr>
</tbody>
</table>

| No. of samples | 1 8 2 1 9 3 6 1 2 4 1 4 4 1 2 1 1 4 2 2 6 2 4 86 |
| No. of light flotation fractions | 0 4 2 1 7 3 6 1 2 4 1 2 2 0 2 0 0 4 2 2 6 0 4 68 |
| No. of heavy flotation fractions | 0 4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 |
| No. of wet-sieved samples | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 13 |
| No. of in situ samples | 1 0 0 0 2 0 0 2 0 0 0 2 2 1 0 1 0 0 0 0 2 0 1 |
| Excavated % sampled | 17 % |

Table 12: Archaeobotanical sampling strategy developed at El Mazo.

The results from the present study can be seen at p. 362.

3.1.4 El Toral III

| Abbreviation | - |
| Site type | Rock-shelter |
| Site area | 13 m² |
| Preservation | Partly eroded, now completely excavated |
| Administration | Andrín, Llanes, Asturias, Spain |
| Geography | North border of A-8 highway, PK 4980, 45 m a.s.l. |
3.1.4.1 Historiography

The site was excavated as a rescue excavation in 2009 by a team composed of María A. Naval Fonseca, Igor Gutiérrez Zugasti and Orlando Morán Fernández (Gutiérrez Zugasti, Morales & Fonseca 2009; Noval Fonseca 2014) in the framework of the rescue interventions related to extensive roadworks in the area. The cave formed part of a complex karst system with 8 cave openings, among which 2 were listed as containing archaeological deposits in their rock-shelters. El Toral III was directly affected by the works and was completely excavated (25 m², of which 13 m² proved to have evidence of anthropic activity). A layer of mixed chronological origin covered most of the site, under which the remainder of a shell-midden deposit, a diverse assemblage of pottery from different periods (from the Chalcolithic to the Middle Ages), Mesolithic-like stone tools and a few mammal bones were recovered.

3.1.4.2 Stratigraphy

It is one of the two shell middens in the Cantabrian region where a microstratigraphy has been detected (Gutiérrez-Zugasti, González-Morales & Noval-Fonseca 2013), although the understanding of its deposition has not been thoroughly achieved, due to postdepositional alterations which complicated the excavation process (Gutiérrez Zugasti, Morales & Fonseca 2009). Two different Mesolithic occupations have been detected in different areas (vid. Figure 16), and unless otherwise stated, samples for archaeobotanical analysis from all layers have been examined. Mixed layers and layers from other chronologies have been identified upon excavation but have not been archaeobotanically studied.

- Zone A, partially eroded and excavated by unknown persons, directly outside the rock-shelter: 1st Mesolithic occupation: SUs 4, 8, 6, 13, and 10 are shell midden layers, scarcely affected by postdepositional events, intercalated with sterile clayey and concretion layers (SUs 5, 7, 7.1, and 9).

– SU 9: Layer of yellow clay, almost sterile.

– SUs 5 and 7: An alternation of concretions and orange clay layers, between 10-20 cm depth, with disturbed shell-midden remains.

– SU 8: Concreted shell-midden layer, with black soil, in which three potential post-holes have been identified (SUs 8.1, 8.2, and 8.3). Underlies SU 7.1. No plant macroremains samples have been examined from this layer.

– SU 7.1: Small round layer of whitish clay, within subsquare A in M4, archaeologically sterile.

– SU 6: Shell-midden layer, between 5 and 15 cm depth, with black-brownish soil, small stones and small shell concretions. Underlies SU 4, overlies SU 7.1.

– SU 4: Shell-midden layer with blackish soil and small stones, between 5 and 10 cm depth. Overlies SU 6, underlies SU 3 (mixed layer).

– SU 13: Shell-midden layer, between 5 and 40 cm depth, with loose black-brownish soil and small stones. Similar to SU 4 but with unclear stratigraphical relationship. Underlies SU 3.

Zone B, well preserved and isolated, rock-shelter area directly in front of the cave mouth:

– 2nd Mesolithic phase: SUs 17, 18, 19, 20, 21, 22, shell-midden layers. Finds: Ochre stained cobbles, local lithic raw material, an Asturian pick, human skull and pelvis (it is still unknown if they belong to the same individual) and fauna (molluses, crustaceans, echinoderms, fish, birds and mammals, including a roe deer skull).

– Square M9:

– SU 19: Shell-midden layer between 20-30 cm depth, with sparse soil and highly cemented in some areas. Underlies SU 19.

– SU 18: Concreted shell-midden layer, of about 10 cm depth. Underlies SU 17 and overlies SU 19.

– SU 17: Shell-midden layer, between 10 and 30 cm depth, with sparse soil and extremely solidified in some areas. Overlies SU 18 and underlies SU 16 (concreted upper layers).

– Square O8:

– SU 22: Shell-midden layer up to 30 cm depth, without soil and with large stones. Underlies SU 21.

– SU 21: Shell-midden later of about 20 cm depth, without soil and with small stones. Underlies SU 20 and overlies SU 22.

– SU 20: Shell-midden layer of about 10 cm depth, with black clayey soil. Overlies SU 21 and underlies SU 3 (clayey, and mostly sterile, upper layer).
The upper altered layers evidence a Neolithic-Chalcolithic funerary structure (SU 23) with bones and pottery. Samples from these layers have not been analysed for plant remains. Abundant shell remains, particularly from limpets (*Patella* spp.), snails (*Phorcus lineatus*) and mussels (*Mytilus galloprovincialis*), have been recovered. Prominent among them are the several shell tools or shells with use-wear (near 2% of the remains, mostly in *Patella* spp.), most of which have probably been used to work non-woody plant matter, probably scrapping and cutting fibres (Cuenca Solana 2012). On their part, anthracological remains belong to the following taxa (unpublished data from Monica Ruiz Alonso): *Corylus avellana*; *cf. Ericaceae*; *Fraxinus* sp.; *Prunus* sp. and *Quercus* subg. *Quercus*.

### 3.1.4.3 Chronology

Radiocarbon dates obtained from remains of El Toral III (*vid. Table 14*) have provided two phases of occupation in the Mesolithic, separated by a hiatus of roughly two thousand years: the first phase taking place at about 7500 cal BCE and the second during the first half of the 6th millennium (*vid. Figure 17*). In addition, further activities in the 4th millennium have been evidenced.
All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013). For the Cantabrian region, ΔR = 210 (Arias 2005).
3.1.4.4 Archaeobotanical recovery strategy

Although this project was a rescue intervention carried out before the start of this thesis, the sampling strategies developed by the excavating team have allowed for an archaeobotanical analysis in fairly good conditions. The excavated area (25 m²) was divided into 1 m² squares, each subdivided into 4 subsquares of 50 × 50 cm each (A, B, C and D). At least the sediment from a subsquare of 50 × 50 cm of every layer has been floated, amounting to 4.5 m² (35 % of the shell-midden). The remainder of the soil not subjected to flotation was wet sieved with 2 mm meshes. A selection of samples from the light flotation fraction from the main stratigraphical units (1.5 m², or 11.5 % of the shell-midden, excluding sterile layers) has been made available by the excavating team and analysed by the author of this thesis (vid. Table 15). All wet-sieved and heavy fractions, retrieved in 2 mm sized meshes, have been sorted with the naked eye by members or the excavating team. Sorting of all plant macroremains in both the heavy and light fractions has been carried out with the aid of magnification instruments.

<table>
<thead>
<tr>
<th>1st phase (SUs from zone A)</th>
<th>2nd phase (SUs from zone B)</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 9 5 7 7.1 6 4 13 Total</td>
<td>17 18 19 20 21 22 Total</td>
<td>57 19 38</td>
</tr>
<tr>
<td>No. of samples</td>
<td>No. of light flotation fractions</td>
<td>No. of heavy fraction flotation / wet-sieved samples</td>
</tr>
<tr>
<td>1 1 1 1 1 1 4 6 14 29</td>
<td>1 1 1 1 1 4 2 3 11</td>
<td>0 0 0 0 3 4 11 18</td>
</tr>
<tr>
<td>Excavated % sampled</td>
<td>Excavated % analysed</td>
<td>35 %</td>
</tr>
</tbody>
</table>

Table 15: Archaeobotanical sampling strategy developed at El Toral III.

The results from the present study can be seen at p. 372.

3.1.5 Mazaculos II

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>MZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative name</td>
<td>La Franca, Los Antiguos</td>
</tr>
</tbody>
</table>

Figure 18: Outside view of Mazaculos II.
3.1.5.1 Historiography

The site was discovered in 1908 by Alcalde del Rio; partly excavated in a small survey by Vega del Sella in 1915 and others in indeterminate times (González Morales 1978) and finally by Manuel R. González Morales between 1976 and 1983 (González Morales 1978; González Morales & Márquez Uría 1978). A small sampling programme was carried out later (González Morales 1995).

3.1.5.2 Stratigraphy

The site stratigraphy is formed by several Asturian (Mesolithic) layers, at the bottom of which a living floor was recognised (Straus 2008), and an overlying Neolithic layer. About 3 m$^2$ by 0.5 m depth have been found intact under mixed layers.

Occupation all year long, via isotopic studies showing complementary activities of shellfish gathering and herbivore hunting in autumn, winter and early spring and late spring and summer, respectively (Gonzalez Morales & Arnaud 1990).

- Sector 1, exterior rock-shelter (vid. Figure 19), several Asturian layers below the most recent and mixed (Layers 0) (González Morales 1978):
  - Layers 3:
    - 3.3. Shell-midden layer rich in bones, plant macroremains, lithic remains and small limestone blocks. A living floor and a hearth had been identified at the bottom of the layer. Underlies Layer 3.2, and overlies Layer 4 (sterile clays).
    - 3.2. Soil layer. Overlies Layer 3.2 and underlies Layer 3.1.
  - Layers 2: Soil layer (Layer 2.1.) with abundant shells and sparse archaeological materials with dispersed charcoalified masses (Layer 2.2.). Underlies Layer 1.3 and overlies Layer 3.1.
  - Layers 1:
Part I: Framework

- 1.3. Shell-midden layer with sparse soil. Underlies Layer 1.2. and overlies Layer 2.
- 1.2. Soil layer. Underlies 1.1. and overlies Layer 1.2.
- 1.1. Shell-midden layer with sparse soil and other archaeological remains. Overlies Layer 1.2. and underlies Layer 0.4.

![Figure 19: Mazaculos II topographical survey with excavation areas. Modified from González Morales 1995.](image)

- Sector 3, interior (vid. Figure 19):
  - Layer A2: Neolithic.

Lithic and bone tools have been recovered through the sequence. Among the mammalogical remains, an isolated mandible of an adult male (*H. sapiens*) has been found. Anthracological remains from this latter sector have been published (Uzquiano 1992), with more than 25 taxa: oaks (*Quercus* spp. (*Q. robur, Q. petraea, Q. pyrenaica, Q. cf. suber, Q. ilex*)), hazel (*Corylus avellana*), ash (*Fraxinus excelsior*), Scots pine (*Pinus sylvestris*), yew (*Taxus baccata*), birch (*Betula* sp.), elm (*Ulmus minor*), willow or poplar (*Salix* sp./*Populus* sp.), beech (*Fagus sylvatica*), rowans/wild service trees and hawthorns (*Sorbus aria/torminalis, Sorbus cf. aucuparia, Sorbus cf. domestica, Sorbus sp./*Crataegus* sp.), cherries, sloes or almonds (*Prunus mahaleb, Prunus spinosa/amygdalus*), heath-tree (*Erica arborea*), strawberry tree (*Arbutus unedo*), and legumes (tp. *Cytisus* sp., *Ulex* sp.).
3.1.5.3 Chronology

Radiocarbon dates (vid. Table 17) from the exterior area of Mazaculos II, albeit imprecise, give a pre-6th millennium chronology, whilst those of the inner area lapse, with a temporary hiatus, at the beginning of the 6th and 4th millennia respectively (vid. Figure 20).

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date (AMS)</th>
<th>δ¹³C (AMS)</th>
<th>IRMS cal BCE date (95.4 % probability)</th>
<th>Bibliography</th>
</tr>
</thead>
<tbody>
<tr>
<td>GaK-15221</td>
<td>¹⁴C</td>
<td>A2</td>
<td>Wood charcoal</td>
<td>Low</td>
<td>5050 ± 120</td>
<td>?</td>
<td>4226-3635</td>
<td>González Morales 1995</td>
</tr>
</tbody>
</table>

Table 17: Numerical dates available for the studied layers of Mazaculos II.

---

All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin.
3.1.5.4 Archaeobotanical recovery strategy

This excavation project was developed a long time before the start of this thesis and at a time when archaeobotanical analyses were not among the priorities of archaeological research projects. All the soil was dry-sieved with a 2 mm mesh-size sieve but several samples from the different layers were preserved for wet sieving in a 0.5 mm-sized mesh (vid. Table 18). Plant remains were sorted with the naked eye by members of the excavating team and were later made available to the author of this thesis.

<table>
<thead>
<tr>
<th>No. of samples</th>
<th>Exterior layers</th>
<th>Interior layers</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>2-3</td>
<td>1/3</td>
</tr>
<tr>
<td>No. of samples with plant macromains</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Excavated % sampled</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 18: Archaeobotanical sampling strategy developed at Mazaculos II.

The results from the present study can be seen at p. 380.

3.1.6 Los Gitanos

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site type</td>
<td>Cave</td>
</tr>
<tr>
<td>Site area</td>
<td>West oriented, 25 m length</td>
</tr>
<tr>
<td>Preservation</td>
<td>Partly eroded and illegally excavated, now protected by a fence</td>
</tr>
<tr>
<td>Administration</td>
<td>Sámano, Castro Urdiales, Cantabria, Spain</td>
</tr>
<tr>
<td>Geography</td>
<td>95 m a.s.l., 4 km from the current seashore</td>
</tr>
<tr>
<td>UTM (datum WGS84)</td>
<td>Zone 30 T; X: 0479813; Y: 4801480</td>
</tr>
</tbody>
</table>

Table 19: Los Gitanos: site details.

3.1.6.1 Historiography

It is one of the few Neolithic contexts known in the Cantabrian region, excavated in the 1990s by a team led by R. Ontañón, of which some general and specialist reports have been published (Arias Cabal et al. 1999; Ontañón Peredo 2000; Ontañón-Peredo 2005; Ontañón Peredo 2008; Ontañón et al. 2013).
3.1.6.2 Stratigraphy

From the 3 small trial pits which were excavated in the excavation seasons of the 90s, the one near the North cave wall (Pit 1) provided a 4-layer stratigraphy (vid. Figure 22):

- Layer B, sterile.
- Layer A, subdivided into further sublayers of Neolithic and Chalcolithic chronology (A1, A2, A3 and A4), it has a depth between 120 and 110 cm and has evidence of postdepositional bioturbation (rodent galleries and hides). Samples from sublayers A1 to A4 have been chosen for study.
- Layer P, a mixed filling of a ditch that cuts layer A and underlies layer S.
- A modern superficial layer (sublayers S3, S2 and S1).

The studied sublayers are rich in echinoderm, molluse and crustacean shells, mammal and fish bones, pottery, lithic instruments and a few bone tools. Whilst most of the consumed mammalogical fauna in sublayers A4 and A3 is wild (mostly red deer, but also boar and roe deer), that of sublayers A2 and A1 is primarily domesticated (cattle and ovicaprids, mostly, but also pig); remains of carnivores without human consumption marks have also been found (Álvarez-Fernández et al. 2014). Marine animals (mainly gastropods, but also crustaceans, echinoderms and fishes, point to a probable size-biased gathering strategy (at least for gastropods) carried out on the neighbouring shore (Álvarez-Fernández et al. 2014). Pottery is scarce but diverse, in terms of morphology, firing conditions and raw materials,
pointing to a probable local production (Cubas & Ontañón 2009). Preliminary pollen and charcoal analyses evidence a surrounding open landscape with abundant grasses, some deciduous forest areas with hazel and oak, and a riverine forest with alder and willow); cereal pollen has been determined in all sublayers, although those in sublayer A4 are particularly poorly preserved (Ontañón-Peredo 2005). The site habitation area in the Holocene has been tentatively hypothesised to have been located in the rock-shelter (untested, as it has not been excavated); whilst the cave might have served as a stable for domestic pigs (Álvarez-Fernández et al. 2014) or a domestic refuse dumping area (Cubas & Ontañón 2009).

3.1.6.3 Chronology

Numerical dates for los Gitanos are rather imprecise but have the advantage of safely ascertaining the ante-quem limits for each of the layers separated by a calcium concretion (vid. Table 20). The late prehistorical use of the cave can be placed, at the latest, around the end of the 4th millennium and the beginning of the 3rd (vid. Figure 23).

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date (AMS)</th>
<th>$^2$HAMS</th>
<th>IRMS $^13$C</th>
<th>$^15$N</th>
<th>cal BCE date (95.4% probability)$^{14}$</th>
<th>Bibliography</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAD-860</td>
<td>TL</td>
<td>A4</td>
<td>Carbonate</td>
<td>Low</td>
<td>5834 ± 566</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4969-2705</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>AA-29113</td>
<td>AMS</td>
<td>A3</td>
<td>Bone</td>
<td>Low</td>
<td>5945 ± 55</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>4964-4709</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>MAD-656</td>
<td>TL</td>
<td>A3</td>
<td>Pottery</td>
<td>Low</td>
<td>5771</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4773-2777</td>
<td>Arias Cabal et al.</td>
</tr>
</tbody>
</table>

$^{14}$ All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013). For the Cantabrian region, $\Delta R = 210$ (Arias 2005).
Inés L. López-Dóriga

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date</th>
<th>$\delta^{13}$C (AMS)</th>
<th>IRMS $\Delta^{13}$C</th>
<th>$\Delta^{15}$N</th>
<th>cal BCE date (95.4 % probability)</th>
<th>Bibliography</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBAR-521</td>
<td>$^{14}$C</td>
<td>A3</td>
<td>Charcoal</td>
<td>Low</td>
<td>± 499</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>4232-3712</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>MAD-654</td>
<td>TL</td>
<td>A2</td>
<td>Pottery</td>
<td>Low</td>
<td>5669 ± 541</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4760-2591</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>UBAR-469</td>
<td>$^{14}$C</td>
<td>A2</td>
<td>Charcoal</td>
<td>Low</td>
<td>4370 ± 150</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>3498-2584</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>MAD-859</td>
<td>TL</td>
<td>A2/A1</td>
<td>Carbonate</td>
<td>Low</td>
<td>4516 ± 469</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3457-1581</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>AA-29111</td>
<td>$^{14}$C</td>
<td>A1</td>
<td>Bone</td>
<td>Low</td>
<td>4200 ± 65</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>3625-3098</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>MAD-655</td>
<td>TL</td>
<td>surface</td>
<td>Carbonate</td>
<td>Low</td>
<td>4407 ± 418</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3247-1575</td>
<td>Arias Cabal et al. 1999</td>
</tr>
<tr>
<td>MAD-861</td>
<td>TL</td>
<td>surface</td>
<td>Carbonate</td>
<td>Low</td>
<td>4321 ± 430</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3185-1465</td>
<td>Arias Cabal et al. 1999</td>
</tr>
</tbody>
</table>

Table 20: Numerical dates available for the studied layers of Los Gitanos.

![Modelled radiocarbon dates for the sequence of Los Gitanos.](image)

Figure 23: Modelled radiocarbon dates for the sequence of Los Gitanos.

### 3.1.6.4 Archaeobotanical recovery strategy

Although this project was carried out long before the start of this thesis, the sampling strategies oriented by the excavating team were ideal for the archaeobotanical analysis now developed. Several samples have been hand-picked *in situ* upon excavation (*vid.* p. 121). Furthermore, 100 % of the sediment excavated from Pit 1 (4 m$^3$) has been floated, either with buckets or with a Syraf-type flotation...
Part I: Framework

machine (vid. Table 21). The light fraction of the flotation samples was screened with a column of sieves with mesh-sizes from 2 mm to 250 µm, the 500-250 µm fraction has been subsampled to save time and effort: 50 cc from each sample has been examined. Sorting has been carried out with the aid of low-power optical magnification instruments\(^{15}\). The heavy fraction from the flotation samples had been sorted with the naked eye into “charcoal” and “seed” categories, which were reviewed with magnification.

<table>
<thead>
<tr>
<th>Sublayers from 1st phase</th>
<th>Sublayers from 2nd phase</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4</td>
<td>A3</td>
<td>Total</td>
</tr>
<tr>
<td>No. of samples</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>No. of light flotation fractions</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>No. of heavy flotation fractions</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>No. of in situ samples</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 21: Archaeobotanical sampling strategy developed at Los Gitanos.

The results from the present study can be seen at p. 382.

3.2 Portuguese sites

3.2.1 Cabeço do Pez

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Site type</th>
<th>Site area</th>
<th>Preservation</th>
<th>Administration</th>
<th>Geography</th>
<th>UTM (datum WGS84)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>Open-air</td>
<td>4000-8000 m(^2)</td>
<td>Superficially eroded, bioturbated; now, extensively excavated</td>
<td>Torrão, Alcácer do Sal, Setúbal, Portugal</td>
<td>52 m a.s.l.</td>
<td>Zone 29 S;</td>
</tr>
</tbody>
</table>

Table 22: Cabeço do Pez: site details.

It is the largest and most recent shell-midden in the Sado Valley, a little separated from the river but near some freshwater streams. This group of shell-middens are not conspicuous in the landscape, because they are formed by the juxtaposition of small mounds (Arnaud 1990), and have sight control over the valley (Diniz & Arias 2012, vid. Figure 24).

\(^{15}\) A few of the samples had been initially analysed by Lydia Zapata, which later made available her results and the remainder unstudied samples.
3.2.1.1 Historiography

The site, then named as Quinta de Baixo, was discovered in the 1930s by J.A. Barradas, who published a short report on his finds (Barradas 1936). It was excavated in 1958 by a team from the Museu Nacional de Antropologia e Etnologia at Lisbon, lead by its director Manuel Heleno. Information from that period is limited to a report by Farinha dos Santos (Farinha dos Santos, Soares & Silva 1974). The shell midden was re-excavated in 1983 by the IPPAR, under the direction of José Morais Arnaud (Arnaud 2000). A new dig was carried out in 2010 in the framework of the Sado-Meso project (Diniz & Arias 2012; Arias & Diniz 2013), from which the studied samples arise.

3.2.1.2 Stratigraphy

The site possesses several Mesolithic shell-midden layers alternating with sterile layers belonging to hiatuses in the occupation. According to the old excavations, several hearth structures were identified, delimited with small and regularly placed stones (Arnaud 1987) and the archaeological remains recovered were, in addition to shells from molluscs and crustaceans, mammal bones (wild animals and dogs), lithic and bone industries and human remains; a few ichthyological bones occur. It was considered a seasonally inhabited site (autumn and winter) in which molluscs were the main exploited resources, complemented with herbivore meat and some carnivores (wolf/dog undetermined). Lithic raw material is local and transformed into geometrical microliths. Several perforated shell and fish vertebra have been found. The site was also used with a sepulchral function, with several burials (minimum number of individuals = 27) concentrated in small groups around the shell-midden layers. The site was later reoccupied in the Early Neolithic by populations using pottery technology, characterised by a varied decoration, and pounding and milling stones (Arnaud 1985; Arnaud 1989).
Recent excavations in 2010 have been extremely difficult due to the complexity of the stratigraphy and postdepositional processes: two survey pits have been excavated and partially sampled for plant macroremains. Trench 1 (vid. Figure 25), a survey pit of 2 x 1 m, has been excavated revealing a complex stratigraphy which is still under assessment. Only samples from SUs 1 and 2, which show an horizontal profile, have been studied.

3.2.1.3 Chronology

Radiocarbon dates confirm the ascription of the layers of the sequence to two occupation phases, the former in the Mesolithic and the latter in the Early Neolithic (vid. Table 23).

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date</th>
<th>δ¹³C (AMS)</th>
<th>IRMS Δ¹³C</th>
<th>Δ¹⁵N</th>
<th>cal BCE date (95.4 % probability)¹⁶</th>
<th>Bibliography</th>
</tr>
</thead>
</table>

¹⁶ All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013). For the Sado Valley, two different ΔR values exist (Vale de Romeiras), ΔR = – 170 ± 60 yr, (Soares & Dias 2006) and ΔR = 100 ± 155 (Martins, Carvalho & Soares 2008). Where a mixture of shell and charcoal dates was used, the two charcoal dates were calibrated individually and then pooled with the uncalibrated shell date. The weighted mean of all dates was used for the plot. Shell samples have been calculated with a 100% marine reservoir offset.
Table 23: Numerical dates available for Cabeço do Pez.

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date</th>
<th>$\delta^{13}C$ (AMS)</th>
<th>$\Delta^{13}C$</th>
<th>$\Delta^{15}N$</th>
<th>cal BCE date (95.4% probability)</th>
<th>Bibliography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta-125109</td>
<td>$^{14}C$</td>
<td>AMS</td>
<td>Burial 4 (Homo sapiens)</td>
<td>Bone</td>
<td>Medium</td>
<td>6760 ± 40</td>
<td>-22.6%</td>
<td>-</td>
<td>-</td>
<td>5726-5621</td>
</tr>
<tr>
<td>Q-2497</td>
<td>$^{14}C$</td>
<td>Middle layer</td>
<td>Shells</td>
<td>Medium</td>
<td>6730 ± 75</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5627-5287 / 5516-4787</td>
<td>Arnaud 1989</td>
</tr>
<tr>
<td>Q-2496</td>
<td>$^{14}C$</td>
<td>Middle layer</td>
<td>Shells</td>
<td>Medium</td>
<td>6430 ± 65</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5616-5349 / 5234-4459</td>
<td>Arnaud 1989</td>
</tr>
<tr>
<td>Q-2499</td>
<td>$^{14}C$</td>
<td>Upper layer</td>
<td>Bones</td>
<td>Low</td>
<td>5535 ± 130</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>4684-4054</td>
<td>Arnaud 1989</td>
</tr>
<tr>
<td>Q-2498</td>
<td>$^{14}C$</td>
<td>Lower layer</td>
<td>Shells and wood charcoal</td>
<td>Low</td>
<td>3565 ± 50</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>1975-1630 / 1907-1350</td>
<td>Arnaud 1989</td>
</tr>
</tbody>
</table>

3.2.1.4 Archaeobotanical recovery strategy

The sampling and retrieval strategy of this project has been oriented by the author of this thesis having in mind the intention of retrieving as much archaeobotanical data as possible. 100% of the non-superficial soil was floated with a Siraf-type machine (Williams 1973), with a mesh of 200 microns for the recovery of the light fraction. All flotation samples (vid. Table 24) were examined and sorted with the aid of optical magnification. A preliminary list of taxa has been published (López-Dóriga, Diniz & Arias 2015).
Table 24: Archaeobotanical sampling strategy developed at Cabeço do Pez.

The results from the present study can be seen at p. 387.

3.2.2 Poças de São Bento

The site is, after Cabeço do Pez, the second biggest shell-midden in the Sado valley system. Like the other shell-middens in the same system, its height is not conspicuous, being at the most 1.5 m, thus the visual identification of the site was achieved because of the shells brought to the surface by agricultural work. To explain the small height, it has been argued that these type of shell-middens were created from the juxtaposition of small depositional mounds, instead of the massive accumulation of detritus in the same mound as happens in shell-middens in other regions such as Muge (Arnaud 1985; Arnaud 1990; Arnaud 1993; Arnaud 2000; Diniz & Arias 2012). Other explanations (Arias, pers. comm.) stress the

![Figure 26: General view of the central area of Poças de São Bento before the intervention. Photograph by Mariana Diniz.](image)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>PSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site type</td>
<td>Open-air</td>
</tr>
<tr>
<td>Site area</td>
<td>4000m²</td>
</tr>
<tr>
<td>Preservation</td>
<td>Superficially eroded, bioturbated; now, extensively excavated</td>
</tr>
<tr>
<td>Administration</td>
<td>Torrão, Alcácer do Sal, Setúbal, Portugal</td>
</tr>
<tr>
<td>Geography</td>
<td>85 m a.s.l., 3 km South from the Sado estuary, near freshwater springs</td>
</tr>
<tr>
<td>UTM (datum WGS84)</td>
<td>Zone 29 S</td>
</tr>
</tbody>
</table>

Table 25: Poças de São Bento: site details.
predominance of a type of shell, *Scrobicularia plana*, over more bulky ones, such as *Cerastoderma edule*, and the effect of erosion due to agricultural activities.

3.2.2.1 Historiography

The site was first excavated in the late 1950s by Manuel Heleno, the director of the Museu Nacional de Antropologia e Etnologia at Lisbon, but the data regarding the intervention was never published and is preserved in only a fragmentary state. Later research included a test pit in 1986 and a partial excavation between 1987 and 1988, by a team lead by José Morais Arnaud, from the Portuguese Institute of Archaeology, and Lars Larsson, from Lund University in Sweden (Arnaud 2000). Finally, more recent research seasons started in 2010 and are still ongoing, within the Spanish-Portuguese project *Sado-Meso*, under the direction of Pablo Arias and Mariana Diniz from the universities of Cantabria and Lisbon (Diniz & Arias 2012; Arias & Diniz 2013; *vid.* Figure 27).
3.2.2.2  Stratigraphy

The old excavation in the 1980s established a site with oval shape in which a complex stratigraphy, formed by the juxtaposition of small shell-midden mounds intercalated with occupation layers rich in archaeological artefacts and hearths, was accumulated seasonally (in spring and summer) in the Late Mesolithic (Arnaud 1990; Arnaud 2000; Larsson 2010). Faunal remains are malacological and ichthyological, and in a lesser degree, mammalogical (deer, auroch, horse, boar, rabbit and hare) (Arnaud 1989). A small proportion of the bones were found to have been transformed into tools and several perforated shells and fish vertebra were also identified. Lithic raw material is primarily local and was transformed \textit{in situ} into microliths. “Other resources may have tempted people to settle there, such as vegetables, which are not preserved” (Larsson 1996). Fire-cracked rocks, small concentrations of fire-altered shells and wood charcoal fragments, mostly from \textit{Pinus pinea}, have served to identify several small hearths. Moreover, several \textit{post-holes} were tentatively identified at the base of the shell-midden but the absence of patterning made the excavators doubt about their anthropic origin (Gonzalez Morales & Arnaud 1990). Under and in the shell-midden layer, several burials were identified (12 or 13) concentrated in small groups. A further occupation of Neolithic chronology, separated by a chronological hiatus or about 5 centuries, was identified in the upper layers above the shell-midden, with pottery sherds and pounding and milling stones.

The most recent excavations between 2010 and 2013 consisted of several trenches, one of which (Trench 1 or S1, \textit{vid.} Figure 27 and Figure 28) has been excavated extensively (2 m$^2$ in 2010; 6 m$^2$ in 2011 of which 4.5 m$^2$ were shell-midden; 12 m$^2$ in 2012 and 2013), has provided a lengthy and complex stratigraphy (Diniz & Arias 2011; Diniz, Arias & Teira 2012; Diniz \textit{et al.} 2013) and has been chosen for the archaeobotanical study. Other trenches have also been preliminary and partially analysed (Trench 2, Trench 3, Trench 4 and Trench 5) but will not be taken into account further in this work. Micromorphological analyses (Simões \textit{et al.} 2015) complement the stratigraphical description of Trench 1 (\textit{vid.} Figure 29), which has been organised into chronological phases.

- Substrate: Pliocene.

- SU 4 is the geological substrate of sand dunes, which in the micromorphological analysis has been identified as \textit{G Horizon}, without vegetation nor soil formation processes. As it is archaeologically sterile, this layer has been partially excavated as a survey and has not been sampled for plant remains. It is possibly correlative to the layers \textit{E} and \textit{F} of the old excavations (\textit{vid.} Larsson 2010).
SU 22 is a interface layer with low density of shells, between the shell-midden layers (SUs 3/7 and 12) and underlying fossil dune sands (SU 4). Samples from this layer have not been chosen for study in this work. It is possibly correlative to the layer D of the old excavations (vid. Larsson 2010).

- Phase A: This possible Early Mesolithic layer has not been identified in Trench 1.
- Phase B: Late Mesolithic.
  - SUs 21 and 5 are a pit and their infilling, the pit cuts the geological substrate (SU 4), they are overlaid by the shell-midden (SU 3/7). The excavation of this structure has provided one flotation sample that has been examined and was found to contain a large number of rodent pellets, pointing to its character of burrow.
  - SUs 3/7 (equivalent) and 12 are shell-midden layers, the lesser density of shells in SU 12 with respect to that in SUs 3/7 being their main difference. They seem to be formed by the juxtaposition of small mounds of shells of varying depths between 30-40 cm, with scarce artefacts (with the exception of a possible lithic knapping area in the limits, pointing to the existence of several functional areas between the shell mounds). At the micromorphological analysis has been identified as E Horizon and F Horizon, with high Calcium values related to the presence of shells. It is possibly correlative to the layer C of the old excavations (vid. Larsson 2010). These layers have been extensively sampled (number of samples with plant remains examined = 103).
- Phase C: Early Neolithic.
  - SUs 23 and 24, SUs 15/16 and 17, and SUs 26 and 6, pits and their respective fillings, which due to the abundance of animal dung pellets (rodent type) seen upon flotation and the unstructured morphology are interpreted as animal burrows excavated from SU 2 to SU 3/7. Samples from these layers have not been studied in this work.
  - SU 2 is a large black layer of 30 cm depth under the topsoil, with bioturbation (animal hides) and mechanical anthropic admixture. It has some archaeological remains in different preservation conditions (faunal, lithics, pottery). In the micromorphological analysis, it has been
identified as *D Horizon*, with high Bromine values, related to the decomposition of organic matter. Because of its admixture, samples from this layer have not been studied extensively. It is possibly correlative to the *layer B* of the old excavations (*vid. Larsson 2010*).

- **Phase D: Historical.**
  - SU 25 is a superficial layer of small extension, partially overlaying SU 2, of probable historical chronology, due to the presence of on-the-wheel pottery fragments. Samples from this layer have not been studied in this work. It is possibly related to what was called *layer A1* in the old excavations (*vid. Larsson 2010*).

- **Surface: Contemporary.**
  - SU 1 is the top soil of 20-30 cm depth, not sampled for plant remains. In the micromorphological analysis, it has been identified as *C Horizon*, with high Bromine values, related to the decomposition of organic matter. This was known as *layer T* in the old excavations (Larsson 2010).

The first results of these excavations are already available: ichthyofaunal remains belong to 4 main fish families, most of which of are marine origin and a few freshwater (Gabriel, Diniz & Arias 2013); geological analyses have shown that the saline tidewater did not reach the neighbouring river valley and salinity gradually decreased during the Mesolithic occupation time (Freitas et al. 2013).

### 3.2.2.3 Chronology

Radiocarbon dates ascribe the formation of layers of Poças de São Bento to the 6th and 5th millennia cal BCE (*vid. Table 26*). Bones from different mammals and non-woody plant macroremains from the
Mesolithic layers have been submitted for radiocarbon dating but, due to insufficient carbon or collagen, dating has ultimately not been possible.

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date</th>
<th>2δ13C (AMS)</th>
<th>IRMS Δ13C</th>
<th>Δ15N</th>
<th>cal BCE date (95.4% probability)</th>
<th>Bibliography</th>
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<tr>
<td>OxA-29113</td>
<td>14C AMS SU 613</td>
<td>Bone (Homo sapiens)</td>
<td>Medium</td>
<td>7238 ± 35</td>
<td>?</td>
<td>-17.2</td>
<td>11.3</td>
<td></td>
<td>6211-6031</td>
<td>Unpublished</td>
</tr>
<tr>
<td>Lu-2769</td>
<td>14C AMS 45-50 cm</td>
<td>Shells</td>
<td>Medium</td>
<td>7150 ± 70</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>6006-5666 / 5923-5281</td>
<td>Larsson 2010</td>
<td></td>
</tr>
<tr>
<td>OxA-29114</td>
<td>14C AMS SU 403</td>
<td>Shell (Scrobicularia plana)</td>
<td>Medium</td>
<td>7121 ± 35</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5960-5666 / 5874-5275</td>
<td>Unpublished</td>
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</tr>
<tr>
<td>OxA-24652</td>
<td>14C AMS SU 3/7</td>
<td>Shell (Cerastoderma edule)</td>
<td>Medium</td>
<td>7107 ± 37</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5951-5653 / 5861-5256</td>
<td>Unpublished</td>
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<tr>
<td>OxA-24650</td>
<td>14C AMS SU 3/7</td>
<td>Shell (Cerastoderma edule)</td>
<td>Medium</td>
<td>7070 ± 35</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5901-5620 / 5817-5212</td>
<td>Unpublished</td>
<td></td>
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<tr>
<td>OxA-24651</td>
<td>14C AMS SU 3/7</td>
<td>Shell (Cerastoderma edule)</td>
<td>Medium</td>
<td>7053 ± 37</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5890-5610 / 5806-5200</td>
<td>Unpublished</td>
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<tr>
<td>Lu-2770</td>
<td>14C AMS 65-70 cm</td>
<td>Shells</td>
<td>Medium</td>
<td>7050 ± 60</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5921-5582 / 5831-5186</td>
<td>Larsson 2010</td>
<td></td>
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<tr>
<td>Q-2493</td>
<td>14C Lower layer (3)</td>
<td>Shells</td>
<td>Medium</td>
<td>7040 ± 70</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5921-5556 / 5829-5160</td>
<td>Arnaud 1989</td>
<td></td>
</tr>
<tr>
<td>OxA-29235</td>
<td>14C AMS SU 3/7</td>
<td>Bone (Meles meles)</td>
<td>Medium</td>
<td>6962 ± 37</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5974-5744</td>
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<td></td>
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<tr>
<td>Q-2494</td>
<td>14C Middle layer (2)</td>
<td>Wood charcoal</td>
<td>Low</td>
<td>6780 ± 65</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5807-5561</td>
<td>Arnaud 1989</td>
<td></td>
</tr>
<tr>
<td>Q-2495</td>
<td>14C Middle</td>
<td>Shells</td>
<td>Medium</td>
<td>6850 ± 80</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5724-5393 / 5622</td>
<td>Arnaud 1989</td>
<td></td>
</tr>
</tbody>
</table>

17 All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013). Where a mixture of shell and charcoal dates was used, the two charcoal dates were calibrated individually and then pooled with the uncalibrated shell date. The weighted mean of all dates was used for the plot. For the Sado Valley, two different ΔR values exist (Vale de Romeiras), ΔR = –170 ± 60 yr, (Soares & Dias 2006) and ΔR = 100 ± 155 (Martins, Carvalho & Soares 2008). Shell samples have been calculated with a 100% marine reservoir offset.

18 Unpublished references have been obtained in the framework of Sado-Meso project, a collaborative project funded by COASTTRAN (vid. p. 5) and the Fundação para a Ciência e a Tecnologia of the Portuguese Ministry of Education and Science ["Retorno ao Sado: Um caso entre os últimos caçadores-recolectores e a emergência das sociedades agropastorais no sul de Portugal" (PTDC/HIS-ARQ/121592/2010)].


### Part I: Framework

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date</th>
<th>$\Delta^{13}C$ (AMS)</th>
<th>IRMS $\Delta^{15}N$</th>
<th>cal BCE date (95.4 % probability)</th>
<th>Bibliography</th>
</tr>
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<tbody>
<tr>
<td>OxA-26094</td>
<td>$^{14}C$ AMS</td>
<td>SU 8</td>
<td>Bone (Canis familiaris)</td>
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<td>6866 ± 33</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5837-5672</td>
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<tr>
<td>OxA-29169</td>
<td>$^{14}C$ AMS</td>
<td>SU 603</td>
<td>Soil</td>
<td>Low</td>
<td>6045 ± 39</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5048-4840</td>
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<td>OxA-29170</td>
<td>$^{14}C$ AMS</td>
<td>SU 603</td>
<td>Soil</td>
<td>Low</td>
<td>5511 ± 34</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>4453-4344</td>
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<tr>
<td>Ua-425</td>
<td>$^{14}C$ AMS</td>
<td>Burial 11</td>
<td>Bone (Homo sapiens)</td>
<td>Low</td>
<td>5390 ± 110</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>4448-3984</td>
</tr>
<tr>
<td>OxA-25905</td>
<td>$^{14}C$ AMS</td>
<td>SU 204</td>
<td>Seed (Triticum &quot;nudum&quot;)</td>
<td>Intrusive</td>
<td>295 ± 60</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 26: Numerical dates available for Poças de São Bento.

#### 3.2.2.4 Archaeobotanical recovery strategy

This site has been sampled for plant macroremains in the framework of two of the three research projects developed in it. Firstly, “despite extensive flotation, no fruits or seeds could be identified” (Larsson 1996; Larsson 2010) in the 1980s seasons. However, flotation was carried out only in a portion of the sandy lower layers (because layers with a high content of shell were considered difficult to float) (Larsson, pers. comm.).

In the framework of the Sado-Meso project developed from 2010, under the orientation of the author of this thesis, an extensive sampling and retrieval strategy for plant macroremains has been carried out. 100 % of the non-superficial soil, excavated from 2010, has been stored in 10l. samples and has been later floated with a Siraf-type machine (Williams 1973), with a mesh of 250 microns for the recovery of the light fraction. A subsampling of random light flotation fractions have been chosen for study (vid. Table 27) and have been sorted with the aid of optical magnification instruments. The heavy fraction of each light flotation sample has been examined. A preliminary list of taxa has been published, to which some corrections and additions have been made here (López-Dóriga, Diniz & Arias 2015).

<table>
<thead>
<tr>
<th>Trench 1</th>
<th>Trench 2</th>
<th>Trench 3</th>
<th>Trench 4</th>
<th>Trench 5</th>
<th>Trench 6</th>
<th>Trench 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUs from Phase B (1st phase)</td>
<td>Phase C (2nd phase)</td>
<td>Whole sequence</td>
<td>SUs 2, 9, 14, 18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/7</td>
<td>8</td>
<td>12</td>
<td>Total</td>
<td>238</td>
<td>510</td>
<td>748</td>
</tr>
<tr>
<td>Excavated % sampled</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
</tr>
<tr>
<td>No. of analysed samples with</td>
<td>120</td>
<td>13</td>
<td>55</td>
<td>188</td>
<td>68</td>
<td>256</td>
</tr>
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</table>
### 3.2.3 São Pedro de Canaferrim

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>CSP</th>
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<td>Site type</td>
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</tr>
<tr>
<td>Site area</td>
<td>Unknown</td>
</tr>
<tr>
<td>Preservation</td>
<td>Partially excavated</td>
</tr>
<tr>
<td>Administration</td>
<td>Sintra, Estremadura, Portugal</td>
</tr>
<tr>
<td>Geography</td>
<td>SE side of Serra de Sintra, 395-402 m a.s.l., 8 km from the seashore</td>
</tr>
<tr>
<td>UTM (datum WGS84)</td>
<td>Zone 29 S; X: 0464145 Y: 4293775</td>
</tr>
</tbody>
</table>

Table 28: São Pedro de Canaferrim: site details.

It is an area protected from the dominant NNW winds, frequently foggy, protected from outside view but which allows a sight control over the valley and with a stream nearby. Because of the abrupt relief and abundant large granite blocks, habitat in extension is not possible. The chain is an abrupt massif more than 500 m high but with an average of 200 m a.s.l., over a karst plain with cliffs of about 150 m. Currently, a Mediterranean with oceanic influence microclimate exists. Humidity is almost tropical, temperatures are inferior to the nearby areas, rains are more abundant in autumn and winter, soils are loose, sandy, and permeable, humic cambisols. The current autochthonous vegetation is primarily forest, composed of *Quercus robur*, *Quercus pyrenaica* and other Mediterranean-Atlantic groupings, with *Quercus ilex*, *Quercus suber*, *Arbutus unedo* and *Pinus pinea*. Of the autochthonous vegetation, about 50 % is Mediterranean, 10 % is Mediterranean-Atlantic, 5 % Atlantic and 18 % Euroasiatic; and 8 % endemisms. Medieval documentation mentions the cultivation of vines, olives, wheat and barley. (Simões 1999; Simões 2003)

#### 3.2.3.1 Historiography

The site has 4 areas (*Loci* 1, 2, 3, and 4, *vid. Figure 30) with Neolithic layers, and was first discovered in 1981; *Locus* 1 was partially excavated in 1981 and 1993, *Locus* 2 was excavated between
1993-1995 and between 1998-2000 following the Barker-Harris-Carandini methods, Locus 3 was surveyed by gathering archaeological materials from the surface (Simões 1999; Simões 2003).

3.2.3.2 Stratigraphy

The site has a prehistorical occupation from the Early Neolithic, consisting of a series of pits with microstratified fillings. Although some of the pits are intact, others have been eroded, mainly at their upper parts, by later historical occupations from the Andalusian period to the 19th century. Most of the pits, which are thought to have been initially used as silos or hearths, are filled with detritic materials from different activities. The absence of occupation floors and other functional structures is explained either by the character of the site as a specific functional area detached from the habitation nucleus, or
due to erosion by the later historical reoccupation of the site. The pits contain pottery fragments (some with cereal ear-shaped decoration), lithic materials (including sickle elements with cereal polish and milling stones), plant macroremains and scarce and very fragmented faunal remains (possibly ovicaprines), one of them contains a post-hole and undisturbed hearth remains. According to the material evidence, Locus 1 was thought to have been a storage location whilst Locus 2 a domestic area (for hearth use, lithic knapping, plant and animal resource processing, etc.). The site is conceived as a specialised occupation site integrated in a wider regional habitational web. (Simões 1999; Simões 2003)

Anthracological analyses point to the existence, at the time of occupation, of a deciduous sclerophyll shrub forest with oaks (*Quercus faginea*, *Quercus coccifera*), maple (*Acer monspessulanum*), olive (*Olea europaea* subsp. *sylvestris*), strawberry-tree (*Arbutus unedo*), hawthorn (*Crataegus monogyna*), *Phillyrea* sp., *Rhamnus* sp., flax-leaved daphne (*Daphne gnidium*), mastic tree (*Pistacia lentiscus*) and tree heath (*Erica arborea*); a riverine deciduous forest with ash (*Fraxinus angustifolia*), poplar (*Populus* sp.), willow (*Salix* sp.) and elm (*Ulmus* sp.); and a maquis with legumes (*Ulex* sp., *Leguminosae.*) and heaths (*Erica umbellata*) (Queiroz & Mateus 2001). The mammalogical evidence shows the processing of a large mammal and several small even-toed ungulates (*Artiodactylae*), one of which was a newborn *Sus* sp. (Simões 2003).

It is the stratigraphical sequence from the last excavation season (1999-2000) in Locus 2 that has been studied here, consisting of four negative structures and their infillings (*vid.* Figure 31).

- **SU 60** was a pit of prehistorical typology but its filling had been completely eroded by medieval activities. No samples have been obtained from this pit.
- **SU 63** was a pit with asymmetrical bell or pear shape of 62-85 depth. At its bottom, a hearth structure with abundant stones and fire-reddened soil was documented; it was rich in archaeological materials, and cut by medieval structures.

---

**Figure 31:** General topography of Locus 2 in São Pedro de Canaferrim after the excavations. Photograph by Simões 2003.
Part I: Framework

• SU 49, subdivided in several sublayers. The studied samples come from SUs 49-0, 49-1, 49-3, 49-4, 49-5, 49-7, and 49-8.

• SU 64, a small layer from which only one sample has been studied.

• SU 68, the top layer filling the pit, which has provided two samples for archaeobotanical study.

• SU 58 was a pit of 120 cm depth with straight walls and concave bottom. Its infilling was rich in archaeological materials. Because of its capacity (volume 1356 l) it is thought to have initially been a storage pit.

• SU 70, further subdivided into sublayers of variable depth, of which the following have been sampled: SUs 70-0, 70-1, 70-2, and 70-4.

• SU 57, a homogeneous layer from which a few samples have been studied.

• SU 66 was a shallow pit of 20 cm depth, with convergent walls and concave bottom, filled with a homogeneous filling, SU 65, with scarce archaeological remains.

• SU 67 was a pit of 62-85 cm depth with a bell or pear shape. It was initially used as a hearth and later filled by dark and sandy soils, with scarce archaeological remains.

• SU 62, a thick layer further subdivided into sublayers, of which three have been sampled (SUs 62-0, 62-1, and 62-2).

• SU 71, of which no samples have been studied.

• SU 72, one sample comes from this layer.

• SU 75, of which no samples have been studied.

3.2.3.3 Chronology

Radiocarbon dates very precisely confirm the ascription of the studied layers to the Early Neolithic, in the second half of the 6th millennium cal BCE (see Table 29).

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date</th>
<th>²¹³C (AMS)</th>
<th>IRMS Δ¹³C</th>
<th>Δ¹⁵N</th>
<th>cal BCE date (95.4 % probability)²⁰</th>
<th>Bibliography²¹</th>
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<tbody>
<tr>
<td>Beta-164712</td>
<td>¹⁴C AMS</td>
<td>75?</td>
<td>Wood charcoal (Erica umbellata)</td>
<td>Low</td>
<td>7750 ± 50</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>6656-6471 Simões 2003</td>
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<td>OxA-24906</td>
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<td>High</td>
<td>6257 ± 35</td>
<td>-23.05 ‰</td>
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<td>-</td>
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<td>Beta-164712</td>
<td>¹⁴C AMS</td>
<td>70-12</td>
<td>Wood charcoal</td>
<td>Medium</td>
<td>6230 ± 40</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5306-5061 Simões 2003</td>
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</table>

²⁰ All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013).

²¹ Unpublished references have been obtained in the framework of Sado-Meso project, a collaborative project funded by COASTTRAN (see p. 5) and the Fundação para a Ciência e a Tecnologia of the Portuguese Ministry of Education and Science ["Retorno ao Sado: Um caso entre os últimos caçadores-recolectores e a emergência das sociedades agropastorais no sul de Portugal" (PTDC/HIS-ARQ/121592/2010)].
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<th>Context</th>
<th>Material</th>
<th>Confidence</th>
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<th>$^{13}$C (AMS)</th>
<th>$\Delta^{13}$C</th>
<th>$\Delta^{15}$N</th>
<th>cal BCE date (95.4 % probability)</th>
<th>Bibliography</th>
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<tr>
<td>164713</td>
<td>(AMS)</td>
<td></td>
<td>(Erica umbellata)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>OxA-24894</td>
<td>$^{13}$C</td>
<td>70-1</td>
<td>Seed (Triticum monococcum)</td>
<td>High</td>
<td>6220 ± 45</td>
<td>-22.52 %</td>
<td>-</td>
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<td>Beta-146714</td>
<td>$^{13}$C</td>
<td>49-7</td>
<td>Wood charcoal (Erica umbellata)</td>
<td>Medium</td>
<td>6240 ± 40</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5311-5066</td>
<td>Simões 2003</td>
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<tr>
<td>OxA-24834</td>
<td>$^{13}$C</td>
<td>62</td>
<td>Seed (Hordeum vulgare)</td>
<td>High</td>
<td>6179 ± 33</td>
<td>-23.07 %</td>
<td>-</td>
<td>-</td>
<td>5221-5025</td>
<td>Unpublished</td>
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<tr>
<td>OxA-24835</td>
<td>$^{13}$C</td>
<td>49-3</td>
<td>Seed (Triticum &quot;nudum&quot;)</td>
<td>High</td>
<td>6176 ± 32</td>
<td>-23.15 %</td>
<td>-</td>
<td>-</td>
<td>5220-5030</td>
<td>Unpublished</td>
</tr>
<tr>
<td>ICEN-1152</td>
<td>$^{14}$C</td>
<td>4</td>
<td>Wood charcoal</td>
<td>Low</td>
<td>6070 ± 60</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5208-4836</td>
<td>Simões 1999</td>
</tr>
<tr>
<td>ICEN-1151</td>
<td>$^{14}$C</td>
<td>4</td>
<td>Wood charcoal</td>
<td>Low</td>
<td>6020 ± 60</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>5196-4744</td>
<td>Simões 1999</td>
</tr>
</tbody>
</table>

Table 29: Numerical dates available for São Pedro de Canaferrim.

### 3.2.3.4 Archaeobotanical recovery strategy

Two strategies have been carried out for the prehistorical contexts of this site. Several samples with carbonised plant material were recovered from the excavations in 1993, a portion of the samples was subjected to sieving with mesh sizes of 5mm, another portion was floated; only wood charcoal fragments were retrieved in these samples (Queiroz & Mateus 2001).

This study concerns the samples (vid. Table 30) obtained from the last excavation season (1999-2000) of Locus 2. All excavated sediment filling the negative structures was put into 10 l bags, of which 1 l per sediment sample was left unprocessed. Although the sampling strategy was carried out during the excavation long before the start of this thesis, the author had the chance of taking part on part of the retrieval of plant macroremains from the stored samples. Initially, processing of soil samples consisted of wet-sieving, with a mesh column with 375 µm mesh size; which was eventually turned into flotation, with 250 µm mesh size for the light fraction and 2 mm mesh size for the heavy fraction. Selection of plant macroremains in wet-sieved samples has been carried out with the naked eye, sorting between charcoal and seeds and fruits with the aid of optical magnification instruments. The light fractions of the floated samples have been sorted with the aid of magnification instruments (sorting the heavy fraction of those samples had not been finished at the time of this work so dense plant macroremains have not been analysed).
Table 30: Archaeobotanical sampling strategy developed at São Pedro de Canaferrim.

A preliminary list of taxa has been published, amendments and additions have since been made to that list (López-Dóriga & Simões 2012; López-Dóriga & Simões in press). The results from the present study can be seen at p. 399.
3.2.4 Lapiás das Lameiras

<table>
<thead>
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<th>Abbreviation</th>
<th>LL</th>
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<tr>
<td>Site type</td>
<td>Open-air</td>
</tr>
<tr>
<td>Site area</td>
<td>Unknown</td>
</tr>
<tr>
<td>Preservation</td>
<td>Partially excavated, mostly destroyed</td>
</tr>
<tr>
<td>Administration</td>
<td>Lameiras, Estremadura, Portugal</td>
</tr>
<tr>
<td>Geography</td>
<td>143 m a.s.l., 10 km North from the Sierra de Sintra, 9 km from the current seashore</td>
</tr>
<tr>
<td>UTM (datum WGS84)</td>
<td>Zone 29 S; X: 0470200; Y: 4299738</td>
</tr>
</tbody>
</table>

Table 31: Lapiás das Lameiras: site details.

The site is located within an urban area that was traditionally part of a cropfield, on a limestone surface on a small hill, acting as frontier between two landscape units: to the South, an alluvial plain; to the North, deep valleys with abundant forests.

3.2.4.1 Historiography

The site was partially destroyed due to construction works and what was left was excavated as a rescue excavation between 2002 and 2005 under the direction of Teresa Simões.

3.2.4.2 Stratigraphy

The site was divided in four areas (N, S, E and W). In the W and S areas, an extensive excavation was carried out, in the N and E areas the upper part of the site had been destroyed and only the lower part of several pits, which were very well preserved, could be excavated.

A total of 11 pits with Early Neolithic infillings were excavated, 10 of which contained plant macroremains. The pits have a detritic microstratified filling and, in some cases, their primary use as silos has been suggested (Simões, pers. comm.). The archaeological materials recovered from them are pottery fragments, lithic (including milling stones) and bone tools, personal ornaments and animal and plant remains. Mammalogical remains are very abundant and primarily from domesticated species (sheep, goat and pig, mainly, also horse?) but wild animals have also been recovered (roe deer) (Davies, pers. comm.). Marine invertebrate remains are very diverse and particularly abundant in pits UC 34, 29, 28, and 40. Intertidal rocky species from the open coast predominate, mainly *Mytilus* sp. (mussel), *Stramonita haemastoma* (red-mouthed rock shell) and the crustacean *Pollicipes pollicipes*; whilst typical estuarine clams from muddy substrates, such as *Ruditapes decussatus* and *Scrobicularia plana* are less abundant (Alvarez-Fernandez et al. 2012; Álvarez-Fernández, pers. comm.).
• Pits and their infillings (*vide* Figure 32):

• SU 12 contains SUs 11, 13, 18, 19, and 20 (no samples with plant macroremains have been obtained from this structure),

• SU 42, contains SU 41, a layer of about 60 cm depth, in which a microstratigraphy, not tending to horizontality, has been recognised with the following sublayers: SU 41-0, SU 41-1, SU 41-3, SU 43-4.

• SU 40 which is filled by SU 39, a layer of about 80 cm depth in which several sublayers (not tending to an horizontal profile) have been detected: SUs 39-0, 39-1, 39-2, 39-3, 30-4, 39-5, 39-6, 39-7, and 39-8.

• SU 38 which contains SU 37, of about 120 depth, further subdivided in three sublayers SUs 37-1, 37-2, and 37-3 with non-horizontal profiles.

• SU 32 which contains SU 31, a layer of about 60 cm depth, in which four non-horizontal sublayers have been detected: SUs 31-0, 31-1, 31-3, 31-4.

• SU 28 contains SU 27, of about 60 cm depth, in which the following sublayers have been identified with a strong non-horizontal profile: SUs 27-0, 27-2, 27-3, 27-5, 27-7, 27-8, and 27-9.

• SU 29 contains SU 26, a layer of about 80 cm depth, in which several sublayers have been distinguished: SUs 26-0, 26-1, 26-2, 26-3, 26-4, 26-5, 26-6, 26-7, and 26-8.

Figure 32: General view of Lapiás das Lameiras with pits SUs 28, 29 and 38. Photograph by Teresa Simões.
• SU 34 is filled by a 60 cm deep layer, SU 10, subdivided into several sublayers: SUs 10-0, 10-1, 10-2, and 10-6.
• SU 36 contains SU 35, with a sublayer SU 35-1 of just 20 cm depth.
• SU 48 contains SU 47, a single layer of about 10 cm depth.
• SU 122 is filled by SU 118, a 40 cm depth layer, subdivided into two sublayers: SU 118-0 and 118-4.
  • A hearth structure, SU 43, and its infillings (SU 46) and surroundings (SUs 44 and 45).

### 3.2.4.3 Chronology

Radiocarbon dates from the studied layers of Lapiás das Lameiras confirm with precision the Early Neolithic chronology of the occupation in the second half of the 6th millennium cal BCE (vid. Table 32).

<table>
<thead>
<tr>
<th>Lab. reference</th>
<th>Method</th>
<th>Context</th>
<th>Material</th>
<th>Confidence</th>
<th>BP date</th>
<th>(^{14}\text{C} (\text{AMS}))</th>
<th>IRMS (\Delta^{13}\text{C})</th>
<th>cal BCE date (95.4 % probability) (^{21})</th>
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<tr>
<td>OxA-24829</td>
<td>(^{14}\text{C} \text{AMS})</td>
<td>SU 39</td>
<td>Seed (Hordeum vulgare var. nudum)</td>
<td>High</td>
<td>6424 ± 32</td>
<td>-22.74 ‰</td>
<td>? ?</td>
<td>5474-5331 Unpublished</td>
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</tr>
<tr>
<td>OxA-24832</td>
<td>(^{14}\text{C} \text{AMS})</td>
<td>SU 27</td>
<td>Seed (Triticum dicoccum)</td>
<td>High</td>
<td>6381 ± 34</td>
<td>-22.86 ‰</td>
<td>? ?</td>
<td>5469-5309 Unpublished</td>
<td></td>
</tr>
<tr>
<td>OxA-24830</td>
<td>(^{14}\text{C} \text{AMS})</td>
<td>SU 10</td>
<td>Seed (Hordeum vulgare var. vulgare)</td>
<td>High</td>
<td>6327 ± 32</td>
<td>-22.23 ‰</td>
<td>? ?</td>
<td>5368-5222 Unpublished</td>
<td></td>
</tr>
<tr>
<td>OxA-24833</td>
<td>(^{14}\text{C} \text{AMS})</td>
<td>SU 39</td>
<td>Seed (Triticum monococcum)</td>
<td>High</td>
<td>6310 ± 33</td>
<td>-21.45 ‰</td>
<td>? ?</td>
<td>5354-5218 Unpublished</td>
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<tr>
<td>OxA-24831</td>
<td>(^{14}\text{C} \text{AMS})</td>
<td>SU 26</td>
<td>Seed (Triticum “nudum”)</td>
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<td>-21.96 ‰</td>
<td>? ?</td>
<td>5316-5079 Unpublished</td>
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<tr>
<td>OxA-24533</td>
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<td>SU 1</td>
<td>Bone (Homo sapiens)</td>
<td>Medium</td>
<td>6256 ± 35</td>
<td>-19.39 ‰</td>
<td>? ?</td>
<td>5316-5077 Unpublished</td>
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</table>

Table 32: Numerical dates available for Lapiás das Lameiras.

### 3.2.4.4 Archaeobotanical recovery strategy

Sampling and retrieval in this site, intervened as a rescue excavation, took place long before the start of this thesis and without having an archaeobotanical analysis particularly in mind. All excavated sediment filling the negative structures was put into 10 l bags, of which 1 l per sediment sample was left unprocessed (vid. Table 33). Processing consisted of wet-sieving with a mesh column with 375 µm

\(^{21}\) All radiocarbon dates have been calibrated with the online version of OxCal 4.2 (Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013).

\(^{22}\) Unpublished references have been obtained in the framework of Sado-Meso project, a collaborative project funded by COASTTRAN (vid. p. 5) and the Fundação para a Ciência e a Tecnologia of the Portuguese Ministry of Education and Science [‘Retorno ao Sado: Um caso entre os últimos caçadores-recolectores e a emergência das sociedades agropastorais no sul de Portugal’ (PTDC/HIS-ARQ/121592/2010)].
mesh size. Selection of plant macroremains has been carried out with the naked eye, sorting between charcoal and seeds and fruits with the aid of optical magnification instruments. One of the bags of 1 l was floated by the author in order to check if different methods for retrieval of small remains would provide different plant macroremains (particularly fragile cereal chaff). As it did not change the taxa and plant parts recovered, this experience was not continued. A preliminary list of taxa has been published; amendments and additions have since been made to that list (López-Dóriga & Simões 2012; López-Dóriga & Simões in press).

<table>
<thead>
<tr>
<th>SU 12</th>
<th>SU 22</th>
<th>SU 24</th>
<th>SU 36</th>
<th>SU 38</th>
<th>SU 28</th>
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<th>SU 25</th>
<th>SU 34</th>
<th>SU 36</th>
<th>SU 48</th>
<th>SU 42</th>
<th>SU 43</th>
<th>Who le sequence</th>
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<td>SU 11</td>
<td>SU 13</td>
<td>SU 19</td>
<td>SU 20</td>
<td>SU 41</td>
<td>SU 37</td>
<td>SU 31</td>
<td>SU 26</td>
<td>SU 21</td>
<td>SU 50</td>
<td>SU 47</td>
<td>SU 118</td>
<td>SU 43</td>
<td>SU 44</td>
</tr>
</tbody>
</table>

| No. of samples | 0 | 0 | 0 | 0 | 6 | 34 | 11 | 9 | 41 | 29 | 3 | 10 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 177 |

Table 33: Archaeobotanical sampling strategy developed at Lapiás das Lameiras.

The results from the present study can be seen at p. 413.
Inés L. López-Dóriga
### Part II: Methods

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Part I: Framework

In this chapter, a short introduction to archaeobotany, with particular emphasis in the study of plant macroremains, followed by a review of the evolution of the discipline, will be undertaken. Next, the methods employed in this thesis, placed within the context of the current general methods, will be thoroughly described and reflected upon.

4 Introduction to archaeobotany and the study of non-woody plant macroremains

Plant remains are “by-products of human cultural activities” and “represent all aspects of human affairs”; “what was used had a specific cultural meaning [...] might be unrelated to material needs or environmental conditions” (Ford 1978b). Archaeobotany, or palaeoethnobotany, can be defined as the study of plant remains in archaeological contexts and their uses by past societies. Definitions for the discipline are plentiful, according to different research traditions and theoretical positions (vid. Pearsall 2000). Whilst both terms, archaeobotany and palaeoethnobotany, are sometimes used as synonyms (e.g. Miksicek 1987); at times are used for denoting different fields of research (e.g. Giovannetti, Capparelli & Pochettino 2008; Hastorf & Popper 1998), in palaeoethnobotany being more important the ethnobotanical aspect of the matter and in archaeobotany the archaeological one (Ford 1979 apud Rivera Núñez & Obón de Castro 1991a; Rovira i Buendía 2007). In this work, both aspects are considered equally important and the terms are considered synonyms. Another term, phytanthropology (Sensarma & Ghosh 1995), refers to the effort to understand divergent attitudes towards the same plants by communities living in the same environments.

This is an archaeobotanical work with a methodological development in the study of plant macroremains (seeds and fruits). This is the one of the easiest and more traditional direct archaeobotanical study (Pennington & Weber 2004). However, this is not the exclusive approach for researching past human-plant relationships, many other direct and indirect sources and complementary methods exist (vid. López-Dóriga 2012). These methods study different plant parts that preserve and accumulate in their own way in the archaeological record (Pennington & Weber 2004). Each of the archaeobotanical methods is biased in its own way, because of the type of preservation, the different technical requirements and their own particular potentials and limitations. Many species are only visible via one or two types of remains or are poorly represented in certain time periods due to the vagaries of preservation and human behaviour (Dickau 2010). For these reason, if several methods are combined, complementary information about different plant taxa and uses can be obtained. “Ethnographic and contemporary data clearly show that the majority of all material culture is composed of materials which do not survive well in temperate conditions; thus, perishable material culture is therefore the ‘missing majority’ of archaeological material culture” (Hurcombe 2008). The study of plants in archaeological contexts is particularly affected by this issue, which makes it necessary to include indirect sources of archaeobotanical information such as the more prevalent inorganic materials. “The challenge, thus, becomes one of getting the most out of what we have” (VanDerwarker & Peres 2010). Thus, results from all other direct and indirect methods of obtaining archaeobotanical information related to the use of plant by humans are going to be considered for the state of the art, as multiproxy archaeobotanical studies seem the best for understanding the relationships between human societies and plants (López-Dóriga 2012).
The study of plant macroremains (seeds and fruits) is commonly referred to as “carpology” in the literature in languages of Latin origin (French, Spanish) (Buxó & Marinval 1984; Rovira i Buendía 2007), but this term is regrettably not very widespread in English literature despite the usefulness of its precision (its separation from anthracology). This term, etymologically referring to seeds, is a simplification or vernacularisation of a biologically heterogeneous group of remains, belonging to the dispersal reproductive unit of the plant (Cappers & Bekker 2013): seeds, fruits, nutshells, nutlets, achenes, caryopses, etc. Archaeobotanists specialised in “non-woody plant macroremains” (e.g. McClatchie 2007) often study other parts of the plants which adhere to these seeds in a broad sense, depending on the reproductive strategy of each species, such as the chaff of cereals, the stalk in fruits, the pods in legumes or the scales of pine cones. Other plant macroremains which require different technical analyses and are excluded from this subdiscipline are charcoal and parenchymae. However, since all these macroremains are obtained in the same way, the same specialist often studies all the plant macroremains at a site.

Although the importance of multiproxy studies has already been discussed, and the study of plant macroremains is a very time-consuming and sometimes minimally productive method, it must be the essential nucleus of the research of past plant consumption (diet, medicine, etc.), as it deals with the very objects of use and has the advantage of sometimes allowing for a very precise taxonomical and taphonomical identification.

4.1 Historiography

Palaeoethnobotany, as an ethnographical subdiscipline (Clément 1998), has existed as a literary genre since the Renaissance period in the 16th century (Davis 1995). As a literary genre, long before it was given a name (Ford 1978b) and an epistemological scientific framework, it was developed by explorers, naturalists, botanists, archaeologists and ethnologists. In a scientific framework, it was first defined as ethnographie botanique (de Rochebrune 1879), aboriginal botany (e.g. Powers 1875), botanique appliquée (de Candolle 1819 [1813]) or plant-lore (i.a. Ella-Combe 1884) until the term ethnobotany was decided upon (Harshberger 1896) and became widespread (vid. Clément 1998; Ford 1978b). Most ethnobotanists of that initial phase of the formative period were interested in non-literate societies, but a broader approach was soon developed: “the study of plants in their relations to human culture” (Hough 1898 apud Ford 1978b). Within the framework of what might be called historical ethnobotany, an interest was developed towards the research of ancient plant uses through old written sources (e.g. Ella-Combe 1884; Laza Palacios 1958; Moldenke 1954; Tabor 1970) and later through archaeological deposits (Jones 1941 apud Ford 1978b). Thus, the history of archaeobotany is deeply linked to that of ethnobotany (Ford 1978a). These early researchers soon realised that humans do not passively use just what the environment offers but make an impact on their surroundings by introducing, eliminating and changing the quantities of certain plants (Gilmore 1919 apud Ford 1978b), and choice within available plants is a culturally meaning activity (Kroeber 1920 apud Ford 1978b).

The foundations of carpological archaeobotanical studies within archaeological research were laid during the 19th century, when the first studies were carried out by a small number of European researchers with interests that might be considered exceptional for the context. These works consisted mainly of the descriptive compilation of well-preserved finds, including, in some cases, accounts of the
known ethnobotanical uses for the species (Kunth 1826; Unger & Hruschauer 1851; Heer 1866; Mills 1901; Saffray 1876; de Rochebrune 1879; Wittmack 1888). The flotation technique was invented and applied to the recovery of botanical remains within adobe and bricks by Unger in 1860 (apud Wittmack 1905) and the first archaeological experimentations on taphonomy were carried out by carbonising seeds (Wittmack 1886; Neuweiler 1905). The usefulness of the analysis of plant remains for the study of plant domestication was also vindicated at that time (de Candolle 1886).

From these early times up to more recent ones, depending on the regions, “a formative scientist-consultant phase of archaeobotany” (Fuller & Colledge 2007) can be identified. It was characterised by punctual analyses, carried out whenever a plant remain was recovered, frequently by chance. Often, it were botanists without any archaeological interests who identified the remains, thus providing simple taxonomical lists without much interpretative value (Pennington & Weber 2004). This phase lasted until the appearance of consolidated and specific archaeobotanical research agendas. In the Iberian Peninsula, it started with the Belgian archaeologist Luis Siret at the turn of century (Siret & Siret 1888) and was followed in a handful of archaeological sites, most of them in the Mediterranean region (e.g. Hopf 1966; Netolitzky 1935 apud Bouchaud 2006) and a few in Portugal (e.g. Pinto da Silva 1988), sometimes even including experimentations on taphonomy (Téllez & Ciferri 1954). As late as the 1970s, some Iberian archaeologists were beginning to stress the importance of carpological studies to understand the Neolithisation process and ancient economies (Rubio de Miguel 1974).

The professionalisation of archaeobotany (Fuller & Colledge 2007) began with the development of specific archaeobotanical research agendas. This started with the interest in ancient evidence of plant domestication by the archaeobotanists of the first half of the 20th century. They were particularly focused in South-West Asia (e.g. Maria Hopf and Willem Van Zeist), as a consequence of the potential centres of plant domestication being presumably identified there (Vavilov 1926; Childe 1936 (1925)). It was within this framework that the term palaeoethnobotany was first used by a Danish researcher in the 1950-60s (Helbaek 1960), who also developed the first controlled taphonomical study concerning the carbonisation of fruits (Helbaek 1952a). The development of the so-called New Archaeology and the economical school of Cambridge, focused on the reconstruction of human adaptations to the environment brought a methodological improvement in archaeobotanical practice. On the one hand, the flotation technique was reinvented through its application to archaeological soils in the 1950s by the North American archaeologist Cutler (apud Watson 1976) and this technique of systematical recovery of plant macroremains became popularised and widespread at the end of the 1960s both in Eurasia and America, with continuous technical improvements (e.g. Gumerman & Umemoto 1987; Lange & Carty 1975; Leonard 1995; Limp 1974; Minnis & LeBlanc 1976; de Moulins 1996; Jarman, Legge & Charles 1972; Ramenofsky et al. 1986; Struever 1968; Wagner 1982), which are still ongoing (Shelton & White 2010). Moreover, taphonomical issues and the search for detection methods of archaeological and archaeobotanical formation processes became a widespread concern. On the other hand, aseptic and objective ways of interpreting the archaeological record were looked for, through the development of numerical and statistical analyses specifically conceived for archaeological remains. At the same time, ethnographical and experimental sources began to be a more important ground for archaeological research in general and archaeobotany in particular. All these developments have been extensively dealt with separately for the European (Renfrew 1973) and North American traditions (Ford 1979).
With the development of post-processualism, several new views in methodologies and objectives appeared. This did not mean that previous approaches disappeared but that they were enriched and complemented, beginning with the blurring of the boundaries between the dichotomous archaeobotanical research traditions in Europe and North America. In the former, research had focused on the taxonomical evolution of domesticated plants, whilst in the latter, on the cultural aspects of plant exploitation (Pearsall 2000). First, an archaeology of food interested in vegetable resources as sociocultural proxies was reinforced over the strictly biological, economical and ecological approaches. Furthermore, depositional factors (mainly cultural) were recognised as being as important as postdepositional ones (mainly natural but also cultural) in the relativisation of the representativeness of archaeobotanical assemblages, regardless of the efforts in systematical recovery (never perfect) and objective interpretation.

The professionalisation of archaeobotany started in the Iberian Peninsula in the 1980s, when some Iberian researchers, most of them trained abroad, laid the foundations of the first carpological archaeobotanical research cores in Spain (e.g. Buxó 1991; Cubero Corpas 1990), whilst in Portugal, the first impulses (Pinto da Silva 1954) had very little local continuity. The lack of specialised archaeobotanists in this phase allowed for important contributions by scholars from other related disciplines (e.g. Ramil Rego & Aira Rodríguez 1998; Rivera Núñez, Obón de Castro & Asencio-Martínez 1988). The development of early agricultural practices has been relatively well studied in the Mediterranean Iberian Peninsula, coinciding with the location of most Spanish researchers (e.g. Alonso i Martínez 1997; Buxó i Capdevila et al. 1997; Peña-Chocarro 1999; Pérez-Jordà 2005; Rovira i Buendía 2007). The Atlantic region of the Iberian Peninsula has been comparatively understudied until very recently, with very few specific studies, developed by archaeologists from foreign missions (Cushman 1986; Freeman et al. 1988) or centred in protohistorical periods (Cubero Corpas 1991; Vázquez Varela 1975) who did not create permanent laboratories. In the last decade, Iberian archaeobotany has gained importance and research centres: the first archaeobotanical tradition in the Cantabrian region has been created (Zapata Peña 1995), recently followed by another two laboratories (Martín Seijo et al. 2011). In Portugal, there has been a renewed and discontinuous effort, now apparently successful, to create an archaeobotanical laboratory (Martín Seijo et al. 2011; Mateus, Queirós & van Leeuwaarden 2003; Tereso 2007).

The main research lines at the beginning of the 21st century involve the origin and spread of domesticated plants, agricultural practices, plant uses and environmental reconstruction (Rovira i Buendía 2007). These research lines have benefited from recent technical and methodological developments, which continue to evolve: AMS radiocarbon dating, DNA studies, stable isotopes, etc. Experimental archaeology and ethnoarchaeology have been given a redoubled impulse, as improved ways of looking at sources in search for analogies of human behaviour and taphonomical processes are being developed. Moreover, the collaboration of different research groups within general research projects is contributing to a better development of the discipline and state of knowledge (e.g. Peña-Chocarro et al. 2013). New previously understudied areas of the world are starting to be extensively researched: Australia (e.g. Denham et al. 2009), South-East continental Asia (Yang, Xia & Cui 2005), whilst Africa is still dependent on foreign researchers (e.g. Cappers 2007). Although the methods of ethnobotanical fieldwork are not strictly applicable to historical information, a line of research in the light of anthropobotanical studies still persists (Pardo-de-Santayana et al. 2006; Pardo de Santayana et al. 2011). It becomes particularly interesting for archaeobotany when efforts are made to compare and
complement the (naturally biased) written sources and their corresponding archaeological counterparts, especially in what concerns the way in which plants were used and conceived: e.g. Iberian protohistorical cultures (Cubero Corpas 1994), early (Hillman 1984-1986), classical (Iriti & Faoro 2008; Zohary, Hopf & Weiss 2012) and biblical civilisations (Goor 1965; Goor 1966; Goor 1967).

The state of knowledge in the Iberian Atlantic region still has many blanks, particularly for specific chronologies and regions. Part of the ongoing archaeobotanical studies are still dependent on foreign researchers who are not fully dedicated to Iberian archaeology (e.g. Stika 2005; Wollstonecroft et al. 2006) or on a still-insufficient number of peninsular archaeobotanists dedicated to covering as many research fronts as possible, somehow contributing to a richer grey literature (reports, etc.) but a still limited corpus of specific research publications. Moreover, neither in Spain nor in Portugal national organisms regulating the conduction of rescue interventions have been created as in other countries (e.g. U.K. and Historic England), although some regional initiatives exist with more restricted impact (Martín Seijo et al. 2011). Therefore, archaeobotanical studies are carried out in a minority of cases, often only when chance allows for conspicuous macroremain deposits to be seen, and consequently lacking systematic retrieval, meaning the destruction of an important part of the archaeological record. Moreover, archaeobotany has still to make a considerable effort to become widespread as a fully accepted part of archaeological research and be considered in general archaeological interpretations other than a gift appendix.

Nevertheless, the existence of blanks in the carpological record forms part of a more general problem not restricted to the Atlantic region of the Iberian Peninsula, related with the evolution of broader historiographical trends, both within archaeology in general and also within archaeobotany in particular.

Firstly, archaeobotanical remains have traditionally been regarded by most archaeologists as scarcely important, thus, archaeobotanical studies have been only sporadically and unsystematically carried out (inappropriate recovery techniques and sampling strategies, vague methodological and result description type “many fragments” or “the smallest mesh is capable of catching pollen”, etc.). This might have been caused by three types of factors: the low visibility and relative scarceness of plant remains in the archaeological record (Zapata Peña 2000), the undervaluation of plant exploitation activities in contrast to hunting in prehistorical societies which is sometimes seen as a result of the association of plant exploitation with female work and its consequent undervaluation (Berihuete Azorín & Piqué i Huerta 2006; Owen 2002; Stone 2009), and the ignorance of the explanatory potential of archaeobotanical remains for the reconstruction of past societies and not just climates, for purely archaeological issues (such as the taphonomy of deposits: hearth-fire temperature, type of deposition, degree of bioturbation, microstratigraphy, diverse functionality of formally similar structures, etc.) and as the most precise radiocarbon sampling material [far better than the traditional wood charcoal typical from the earlier days of radiocarbon use, when pre-AMS techniques required samples with large amounts of material and originator of the charcoal prejudice (Carvalho 2010b) in the research about the Mesolithic–Neolithic transition, but vid. infra in more detail].

Within archaeobotanical research trends, plants with a seed-based reproduction and use have traditionally been better studied than the rest, core regions of domestication are better studied that the rest of the world and hunter-gatherer contexts have been traditionally understudied, because a combination of factors: a supposition that wild plants did not have much importance and that their remains would not be preserved for such a long time.
Most archaeobotanists are concerned about these information blanks and try to convince archaeologists to include archaeobotanical sampling strategies and recovery techniques within their research methodologies. Unfortunately, efforts are heterogeneous, geographically (vid. p. 114) but also chronologically [e.g. whilst for Upper Palaeolithic archaeologists in the Cantabrian region flotation is an unquestionable part of their excavation procedure, for archaeologists of the same institutions but different research periods, such as Lower Palaeolithic, Protohistorians and Historian archaeologists, it is rarely conceivable: when existent at all, plant remain retrieval is subjectively biased: focused on features defined during excavation and areas where carbon can be seen or is expected (Lennstrom & Hastorf 1995)].

Archaeologists and archaeobotanists should not be discouraged when, after having applied appropriate recovery and sampling techniques, plant remains prove to be effectively scarce in some contexts (e.g. Ramil-Rego, Dopazo Martínez & Fernández Rodríguez 1996) or even inexistent (e.g. Arnanz 2006; Ramil 1993). “Knowing where archaeobotanical remains do not occur is just as important as knowing where they are found” (Lennstrom & Hastorf 1995), so making explicit that appropriate recovery and sampling strategies have been undertaken is important even when plant remains are not recovered. This is the only way to stop the vicious circle of supposing remains are absent – not sampling correctly – not recovering anything. In fact, the scarceness of plant remains in specific regions, such as the Cantabrian, might be the result of the concentration of the research in caves and shell-middens, which have particular problems regarding the preservation of plant remains (palimpsest stratigraphies in which extreme trampling is frequent, eroding plant remains until they become unrecognisable and reducing the chances of retrieving primary or secondary deposits, vid. p. 132, and alkaline middens which might increase the erosion of charcoalified plant material23). Furthermore, caves were not likely the main scenery for the development of daily resource exploitation activities during the Holocene (Zapata Peña 2005-2006), but rather storage facilities, livestock pens, hunting shelters or sepulchral and ritual places.

23 The high level of calcium carbonate in shells decaying in shell-middens tends to make the middens alkaline. Alkaline soils usually reduce the normal rate of decay caused by soil acidity, leaving a relatively high proportion of organic material, but charcoalified plant material follows a different trend, resulting more easily eroded because of density loss (Braadbaart, Poole & van Brussel 2009).
4.2 Study of non-woody plant macroremains preserved by carbonisation

Starting with the purely analytical biases (from retrieval to identification and quantification), induced by the state of the art in archaeological techniques, the interpretation of plant macroremain data is a controverted issue. First, it is necessary to consider the representativeness of the remains recovered from the whole range of activities involving plants developed by the past society studied (i.e. taphonomy). The circumstances influencing how different plants are preserved (if preserved) in the archaeological record (in terms of quantity and quality) are wide. So wide that some authors consider it almost impossible to extract reliable conclusions about the importance of certain resources over others, as the apparent abundance of some might be a result of better chances to be preserved rather than more use (Legge 1989). Later, the potential uses of each taxa and their ecological significance have to be taken into account. Summarising all factors involved (Wright 2010):

- Not all human behaviours and values result in patterned plant remains;
- Of those which do, not all will occur where opportunities for inclusion in archaeological contexts occur;
- Of those which are included, not all will be preserved;
- Of those which are preserved, not all will be exposed to, or by, the archaeologist; and
- Among the plant remains exposed to the archaeologist, not all will be perceived or properly identified.

4.2.1 Sampling strategies for the recovery of plant remains

An ideal retrieval of plant remains from archaeological sites is unachievable for a long series or reasons (Marinval 1986a). Some researchers try to minimise the bias introduced during recovery by processing all the sediment (e.g. French 1971; Jarman, Legge & Charles 1972; Zapata Peña 1999a) and sampling strategies determined by the author in the framework of this thesis have followed that premise (Cabeço do Pez and Poças de São Bento, vid. Table 34). The underlying idea of this total sampling or antisampling is that it is better to recover more samples than necessary than recovering fewer, as this is always established a posteriori, when more sampling is often impossible (Hastorf & Popper 1998).

Unfortunately, sampling is necessary in most archaeological research projects, for the goal of maximizing information whilst minimizing the expense of limited resources such as funding and labour. The issue centres on which approach to use systematically without biasing the record (van der Veen 1984). In general, the bigger the sample size, the larger the number of remains and species richness, thus the better its representativeness. Any sampling scheme must be flexible enough to contend with unexpected events in the field (Lennstrom & Hastorf 1995). Different sampling strategies, varying according to the number and amount of samples per feature (Jacomet & Brombacher 2005), exist. Because of many of the studied sites having been already excavated and sampled before the start of this thesis, the author has not had the option to orientate the sampling strategy, which has been decided...
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according to criteria not necessarily determined by the purpose of obtaining archaeobotanical data, with the exception of a few cases (El Mazo and Los Gitanos). This has resulted in an availability of samples for analysis obtained by heterogeneous sampling strategies (vid. Table 34), but fortunately all of which have the main characteristic of being systematical (vid. Jacomet & Brombacher 2005).

Systematical samples, as opposed to judgemental samples, are those in which all features are equally sampled (van der Veen 1985; Jones 1991). Judgemental samples can be of two types, either those arising from features where plant remains are seen upon excavation, or those (“judgemental systematic samples”) arising from features where plant remains are expected to appear. Focusing the sampling efforts on features defined during excavation and areas where carbon can be seen or is expected (Lennstrom & Hastorf 1995) might induce to incorrect interpretations of specific features without proper sampling and analysis of adjacent deposits. However, random sampling (van der Veen 1984) will, with high probabilities, fail to recover class A and B assemblages (vid. p. 132) which occur only rarely in discrete locations throughout a site (Fuller, Stevens & McClatchie 2014). Therefore, common practice is a combination of systematic and judgemental sampling (Campbell, Moffett & Straker 2011).

The way in which the different features are sampled allows the distinction of random systematical samples (Hastorf & Popper 1998):

- **Pinch or grab**: Several small samples are taken at random from each context. Whilst all the soil has been processed by flotation at Poças de São Bento, only a portion of the samples has been analysed in this work.

- **Column**: It consists of taking samples vertically, at one or several spots, from a deposit with a sequence of archaeological layers. This is only representative when chronological changes are sought on homogeneous layers, but it is hardly representative for diverse archaeological layers. This sampling strategy is the one which has been applied at several of the studied sites (Arangas; El Mazo; and El Toral III, vid. Table 34).

- **Blanket or bulk**: A standard amount of sediment is collected from all excavated contexts, as is the case of São Pedro de Canaferrim and Lapiás das Lameiras (vid. Table 34).

### 4.2.2 Analysis techniques

The techniques of analysis of plant macroremains should vary according to taphonomy (form of preservation, postdepositional events, etc.), although in practice it mostly varies according to the available resources (time, personnel, etc.). Ideally, it is the archaeobotanist who controls all the analysis techniques employed, from beginning to end, in order to ensure that everything is carried out appropriately for each specific case and answering pre-established research questions. In some cases, as in those of old excavations, the archaeobotanist needs to adapt to the available materials (and this is partially the case of this thesis), taking into account how the results would vary if the techniques had been different. Several works deal with this matter, vid. Alonso Martínez 2006; Banning 2002; Beaudoin 2000; Buxó & Marinval 1984; Hall & Kenward 1982; Jones 2002b; Martín Seijo et al. 2011; Pearsall 2000; Tereso 2008. The author of this thesis has not always been able to have a direct involvement in all the stages of the analysis of all the studied sites, but in many cases just in the later more specialised stages (identification, taxonomical determination, description, documentation and
quantification of the plant remains). The first stages of the analyses have often been decided by the different excavating teams conducting the fieldwork and therefore some heterogeneity results (*vide*. Table 34).

<table>
<thead>
<tr>
<th>Region, Chronology</th>
<th>Sampling</th>
<th>Retrieval</th>
<th>Sorting</th>
<th>Subsampling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arangas</strong></td>
<td>Cantabrian, Meso &amp; Neo</td>
<td>Systematic, column</td>
<td>Flotation</td>
<td>Naked eye</td>
</tr>
<tr>
<td><strong>El Carabión</strong></td>
<td>Cantabrian, Meso</td>
<td>Systematic, total</td>
<td>Wet sieving</td>
<td>Naked eye</td>
</tr>
<tr>
<td><strong>El Mazo</strong></td>
<td>Cantabrian, Meso</td>
<td>Systematic, column</td>
<td>Wet sieving + flotation</td>
<td>Naked eye + Magnification</td>
</tr>
<tr>
<td><strong>El Toral III</strong></td>
<td>Cantabrian, Meso</td>
<td>Systematic, column</td>
<td>Wet sieving + flotation</td>
<td>Naked eye + Magnification</td>
</tr>
<tr>
<td><strong>Mazaculos II</strong></td>
<td>Cantabrian, Meso</td>
<td>Systematic, total</td>
<td>Wet sieving</td>
<td>Naked eye</td>
</tr>
<tr>
<td><strong>Los Gitanos</strong></td>
<td>Cantabrian, Meso &amp; Neo</td>
<td>Systematic, total</td>
<td>In situ + flotation</td>
<td>Magnification</td>
</tr>
<tr>
<td><strong>Cabeço do Pez</strong></td>
<td>Portugal, Meso</td>
<td>Systematic, total</td>
<td>Flotation</td>
<td>Magnification</td>
</tr>
<tr>
<td><strong>Poças de São Bento</strong></td>
<td>Portugal, Meso</td>
<td>Systematic, total (*judgemental + pinch/grab)</td>
<td>Flotation</td>
<td>Magnification</td>
</tr>
<tr>
<td><strong>São Pedro de Canaferrim</strong></td>
<td>Portugal, Neo</td>
<td>Systematic, bulk</td>
<td>Wet sieving + flotation</td>
<td>Naked eye + Magnification</td>
</tr>
<tr>
<td><strong>Lapiás das Lameiras</strong></td>
<td>Portugal, Neo</td>
<td>Systematic, bulk</td>
<td>Wet sieving</td>
<td>Naked eye</td>
</tr>
</tbody>
</table>

Table 34: Synopsis of the different recovery strategies employed at the studied contexts of this thesis.

4.2.2.1 Retrieval techniques

Retrieval of plant remains from archaeological deposits is carried out through various means and applying different recovery strategies, depending on the availability of resources (time, personnel, water) and the type of preservation at the site. The studied samples in this work have arisen from almost all types of techniques (*vide*. Table 34).

4.2.2.1.1 In situ

Some plant remains might be perceived upon excavation of a site, and can thus be isolated for further study without running the risk of loss on soil processing. However, the exclusive employment of *in situ* recovery is not quantitatively and qualitatively enough for an appropriate evaluation of the plants exploited, because of size (only big seeds and fruits are seen) and familiarity (only typical shapes are recognised) biases. *In situ* samples have been prominent in the first stages of archaeobotanical evidence gathering (*vide*. Table 121), and this thesis reports of *in situ* samples (in combination with samples obtained by other retrieval techniques) from El Mazo and Los Gitanos.
4.2.2.1.2 Dry-sieving

This technique allows a better recovery than *in situ* picking, but it is still biased by the low visibility of the smallest remains because it requires the employment of large-sized meshes. Furthermore, it generally affects negatively the quality of preservation of charred plant remains. In clayey deposits, it is ineffective; however, it might be advisable for arid regions where the materials have never before or for a long time been humidified (Ford 1979 *apud* Rivera Núñez & Obón de Castro 1991a). This technique has not been employed in any of the studied sites in this thesis.

4.2.2.1.3 Water-sieving

Water sieving allows the mesh size to be reduced to the minimum desired and increases the visibility of plant remains. However, the friction required increases enormously charred plant-remain fragmentation. Nevertheless, this seems to be the best method for the recovery of mineralised remains, as they do not float in water (Rivera Núñez & Obón de Castro 1991a). Some of the samples from El Mazo, El Toral III and São Pedro de Canaferrim, and all samples from a number of the studied sites, such as El Carabión, Mazaculos II and Lameiras (*vid.* Table 34), have been obtained by water-sieving.

4.2.2.1.4 Flotation

This technique consists in the separation of light and heavy materials by density with water as a medium (sometimes additional substances might be employed, if pollution of the environment is not at stake). It produces two fractions: a dense and a light one. Whilst most carpological remains are light and recovered in the “flot” (floating fraction), the heavy fraction is susceptible of containing dense fruits and seeds (acorns, broad beans), mineral-replaced remains, and porous remains in which calcium carbonate might have precipitated (Greenlee 1992) and thus should be reviewed. Plant macroremains deposited in granitic environments might also experiment some flotation problems (pers. obs.).

Despite this technique being much more gentle than sieving, many carbonised plant remains are fragmented during flotation (Greenlee 1992); remains such as cow and horse dung pellets are usually destroyed in flotation because of their looseness. About 36 and 52 % of the carpological remains are lost during flotation (Wright 2005); the probability of recovery depends on the different flotation systems and the strength of the remains (variable according to structure, shape and size, gravity and environment of deposition) relative to the mechanical forces of water flotation (impact and internal static stresses) (Brady 1989). Potential sources of information loss or contamination are small remains stalled in corners, removed by random events such as air currents or splashing water, or simply destroyed. The mesh sizes of the catch screens are among the main contingencies impacting recovery. “There is no excuse for not employing this vital technique” (Higham 2001).

Figure 33: Outline of the flotation machines employed within COASTTRAN project.
Part I: Framework

Bucket flotation

Bucket flotation consists in the utilisation of a bucket full of water in which the sediment is poured and when carbonised plant material is floating, it is retrieved with a strainer or poured over a mesh (this latter the most advisable of the two). This technique is time and water consuming. This technique has been employed, in combination with the use of a flotation machine, at Los Gitanos.

Flotation tanks

Flotation tanks are ideal for processing great quantities of sediment in which the preservation of macrobotanical remains is by charring. Manual and automatic flotation tanks exist. Among the manual ones, which are usually manufactured by archaeologists according to their specific necessities, several types are used, according to the force of separation [compressed-air pumps (Cambridge-type) or water (Ankara-type)], the retrieval of the heavy fraction (Cambridge-type) or loss (Ankara-type)], the continual input of water or re-circulation. In the framework of the project in which this thesis has been carried out, a Syraf or SMAP-type flotation machine has been used (vid. Figure 33). It involves water pumped from below the sample of sediment placed in a mesh within a tank, mixing it and agitating it. The flot spills over a spout into the collecting sieve (250 or 300 μm) and the mesh inside the tank retrieves most heavy archaeological remains (usually 1, 2, 4 or 5 mm). Similar tanks have been employed for the flotation of soil samples studied in this thesis (Table 34).

4.2.2.2 Sorting

Samples with plant remains are sorted in order to select the carpological remains from the remainder of the sample, which might well have anthracological and parenchymatical plant tissues and other items of environmental proxies, such as animal microremains. To aid selection, a column of small sieves of different mesh sizes should preferably be used (e.g. 2 mm, 1 mm, 500, and 250 μm) and a magnifier instrument, type stereomicroscope, should be used to the correct identification of remains within the smaller mesh fractions (Campbell, Moffett & Straker 2011) without introducing size biases. In this thesis, the samples collected by the author or those which have remained unsorted have undergone this

Some projects include in their preliminary laboratory work (usually in the field-lab) the sorting of all remains from the samples, in order to be able to make an inventory of all the recovered types of remains to deposit in regional museums and include in preliminary reports. Whilst in theory this would, in addition, greatly facilitate the work of the specialists involved in the study of the different archaeological materials; in practice it often produces a complication of the laboratory analyses which are already complicated enough, and even worse, serious losses of information. Plant macroremains are often picked with the naked eye and packed in different bags labelled “charcoal” and “seeds”, which are sometimes sent to different specialists. This practice is virtually a waste of time: no one (independently of training level) can effectively separate with the naked eye wood charcoal fragments from other plant tissue, which might be seeds, fruits, fragments of any of them, or parenchymae. The best solution to this problem would be simply to not sort plant macroremains unless a correct undertaking can be ensured. This would require the use of optical magnification instruments in the field-lab and personnel with a certain basic training in plant macroremains enabling them to separate the different categories correctly. As in many cases this type of personnel or facilities would not be available in the field-lab, the best solution is to simply place all charcoalified items from the heavy-flotation or sieved fractions in the same bag and, the light flotation samples untouched, leaving them to be sorted by adequate means by each specialist.

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processing, but unfortunately a number of samples had been previously processed less rigorously (Table 34).

Sorting involves knowledge of other biological remains that might externally resemble seeds and might be misidentified as such, like eroded wood charcoal fragments, dark mineral spherules, soil accretions, plant and fungi galls (Scott et al. 2010), fungi sclerotia particularly from mycorrhizal fungi such as *Cenococcum geophilum* (Alonso & López 2008; Scott et al. 2010), small mammal dung pellets or deadwood termite and other arthropod or grub faecal pellets (Adams 1984; Scott et al. 2011).

Uncharred plant remains often appear in samples, but “unless there is a specific reason to believe otherwise, only charred remains will be considered prehistoric” (Minnis 1981) and the normal procedure is “to reject all uncharred seeds as modern in origin” (Keepax 1977)\(^{25}\). This is so because in temperate climates such as in the Iberian Peninsula, and cave or rock-shelter and open-air (not waterlogged) sites, the only possible way of preservation of ancient botanical material is carbonisation. Thus, uncharred seeds are intrusions, either strictly contemporary to the excavation time or historic. Four sources of modern seed contamination can affect archaeological sediments during the stages of research (Keepax 1977): careless flotation, cross-contamination in flotation apparatus, aerial contamination of exposed samples, and seeds in soils before excavation.

As in the case of sampling, sorting more than necessary and as carefully as possible is better than sorting less and without care. Sorting without low-power magnification instruments for the smallest fractions results in doubling the time necessary for this part of the analysis, as different plant macroremains (seeds, fruits, charcoal, parenchymae, etc.) are not always correctly separated from each other. When the archaeobotanists studying these remains are dispersed in different laboratories, this can result in a loss of information.

#### 4.2.2.2.1 Subsampling

When flotation or sieving samples, already sorted or not, are too voluminous or time-consuming to be studied, different subsampling strategies might be applied (van der Veen & Fieller 1982), usually according to the type of sample. Efforts should be taken so as to ensure that subsampling is random, avoiding conscious or unconscious biases, and therefore representative of the whole assemblage (van der Veen & Fieller 1982). Subsampling can be carried out to the whole sample or to fractions of each sample; being advisable to take into account the chronology, the type of preservation and the type of context. For some types of samples (archaeobotanically rich samples, generally) subsampling might be carried out by counting plant remains until a statistically representative number, in terms of diversity and quantity, is reached (e.g. van der Veen 1992). On the contrary, in archaeobotanically poor samples, such as the ones in which subsambling has been carried out in this work, subsampling has been undertook because the big size of the samples in comparison to the low number of remains is too time-consuming (Zapata Peña 1999a).

\(^{25}\) Although a substantial debate exists regarding the potential preservation of uncharred seeds in some not-very-old sites without special preservation conditions (e.g. Lopinot & Brussell 1982; Lyons & Orchard 2007), this discussion does not affect the type of sites (chronologically and climatically) studied here.
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In the case of Los Gitanos, a subdivision of the sample or fraction has been carried out with the help of a riffle-box. Flot fractions above 1 mm have been wholly examined, whilst the smaller fractions have been subsampled: <1 mm flot fractions have been divided into 2 or 4 random subsamples and each \( \frac{1}{2} \) or \( \frac{1}{4} \) has been examined, continuing to examine the remainder if determinable remains prove to be present (Zapata Peña 1999a).

4.2.2.3 Taxonomical determination

The taxon is the basic unit of classification of botanical remains that can be determined to group, family, genus or species. Taxonomical determination is carried out through the macroscopical examination (with a stereomicroscope) of different aspects of the plant remains, such as morphology (absolute shape and size), biometric proportions (relative size, sometimes via ratios) and anatomy (superficial traits and tissue structure). In some cases, the examination is destructive, as is necessary to split the remains to examine the internal structure and reach a precise identification. Obviously, it is preferable to document the remain and determine it as thoroughly as possible before splitting it. Determination involves the knowledge of the potential species present in a region at a specific moment and finding clear correspondences between the charred plant macroremains and the potential taxa, taking into account the possible disturbing effects of use and preservation factors.

The determination procedure can be direct or automatic (going to look at particular taxa) or inductive (with a dichotomous key or scanning through pictures and specimens). The characteristics observed in the macroscopical examination are compared to pictures and descriptions in seed atlases (Arenas-Posada & García-Martín 1993; Beijerinck 1947; Berggren & Anderberg 1969, 1981, 1994; Bertsch 1941; Bojnansky & Fargasova 2007; Cappers, Bekker & Jans 2006; Cappers, R.Neef & Bekker 2009; Kirkbride, Gunn & Dallwitz 2006; Knapp 2006; Korsmo 1935; Legagneux, Duhart & Schricke 2007; Nesbitt & Goddard 2006; Parkinson & Smith 1953; Schoch, Pawlik & Schweingruber 1988; Szilard 1967), plant atlases (Flora iberica 1986+) and specific publications (Brinkkemper 1991; Butler 1996; Hillman et al. 1996; Jacomet 2006) but must always be later checked with real specimens in reference collections. Specimens in reference collections are usually preserved in a natural form but in the case of problematical determinations, it is advisable to char some specimens of the potential taxa. Charring can be carried out wrapping the specimens in tin-foil and leaving them in an oven at maximum temperature until smoke ceases to appear, between 5 and 15 minutes, generally. However, for precise taphonomical analysis in which it is intended to reproduce the original actions in which the archaeological assemblages were created, it is advisable to char different specimens in different fire conditions (temperature, oxidation, length, etc.).

For this thesis, a reference collection of seeds has been created \textit{ex novo} at the Cantabria International Institute of Prehistoric Research of the University of Cantabria. The specimens have been obtained from several botanical gardens within The International Plant Exchange Network (IPEN) through their annual or biannual plant-lists (\textit{Index seminum}), and by gathering in the field (\textit{vid. Appendix 2: Sources of the IIIPC seed reference collection}). The administration of the reference collection has been carried out with the software Bauble, according to the taxonomical conventions of The Species 2000 & ITIS Catalogue of Life. Reference collections of other institutions have also been checked: Institute of Archaeology at the University of Oxford; Instituto de Historia at the Centro de Ciencias Humanas y
When possible, determination reaches species and even subspecies or variety levels (“ssp.” or “subsp.” and “var.”). It is very important to follow a homogeneous taxonomical convention to name the taxa determined. Taxonomical nomenclature follows the convention as in *Flora iberica* (*Flora iberica* 1986+) and, when lacking, those of *Flora Europaea* (*Tutin et al.* 1964-2001) (*e.g.* grasses). For domesticated plants, both the traditional morphologically-based binomial nomenclature and the new genetic-based trinomial nomenclature are used (*Zohary, Hopf & Weiss* 2012). The authority is mentioned on the first mention of the species name. Taxonomical determination is not always precise to species level, because of preservation issues or limitations in modern seed reference collections (*e.g.* species that have disappeared), and a great deal of variation exists between different plant groups. Remains belonging to small but diverse families with morphologically divergent genera and species are easily determined; whilst in wide families with large numbers of genera and species with morphologically similar seeds (*e.g.* Compositae), identification is slower and more difficult. Often, determination is carried out to a superior taxonomical level than species, such as family, subfamily, tribe, genus (genus name + “sp.”) or subgenus. When the distinction between two taxa is not clear or impossible, the possibilities are enumerated separated by a slash (/); when determination is not absolutely clear but the archaeological specimen is very close to a genus or species, this is indicated by the abbreviation “cf.” (*confer*) or “tp.” (*type*); some remains cannot be determined to any taxa. It is convenient to elude too cautious or too adventurous positions. All reasonable possibilities must be considered, without discarding them in light of what, at the current state of the art, is thought to be safely excluded, as this might lead to the necessity of reviewing lots of materials if the state of the art evolves in a different line or can hinder the detection of contamination of deposits (*e.g.* the case of rye in *Chambers* 1989).

### 4.2.2.4 Description

The state of preservation of plant remains can provide useful insights into taphonomy: it can help understand if the remains belong to a homogeneous assemblage, the conditions before carbonisation, the firing circumstances (the relative temperature and quantity of oxygen), etc. and consequently infer the activities from which the remains might have originated by comparison with experimental results (*e.g.* *Antolín i Tutusaus* 2012; *Boardman & Jones* 1990; *Braadbaart* 2004; *Valamoti* 2002). A distinction between remains well, regular or poorly preserved, has been made taking into account the condition (preservation of the epidermis); quality (distortion) and fragmentation, following the suggestions for cereals and nutshell (*Antolín & Buxó* 2011; *Fairbairn, Kulakoglu & Atici* 2014).

### 4.2.2.5 Quantification and data treatment

The quality and quantity of the taxa recorded might provide insights for the interpretation of the archaeobotanical data (*Jones* 1991). Numerous quantitative and statistical analyses have been often
applied in archaeobotanical studies (presence/absence or ubiquity analyses, proportions or rations, groupings, diversity, indirect gradient, regression, variance, correspondence, redundancy, discriminant, correlation coefficients, T-test, etc.) but a distinction should be made between descriptive and interpretative analyses (Jones 1991).

Whilst the purpose of quantification is accurate description (Hubbard & Clapham 1992) and descriptive analyses might be useful in understanding some aspects of the assemblage taphonomy; in turn, interpretative analyses based on numerical descriptions have a series of serious methodological problems (Hastorf & Popper 1998), concerning both statistical reliance and representativeness, which unsettle their strength. An essential requisite for significant statistical analyses is the size of the unit of analysis, and in the contexts studied the number of remains is usually a strongly limiting factor (vid. Part III B: Results: the carpological assemblages). Then, the variables chosen need to be relevant, i.e., socioeconomically significant, to the question asked: the distinction between units of observation (a remain), analysis (a sample) and interpretation (a site, a period) is essential (Jones 1991). Nevertheless, the main obstacle is that archaeobotanical assemblages, particularly those preserved by charring (vid. p. 130), are per se strongly biased samples (Drennan 2001) and rarely belong to primary or secondary deposition types (Hubbard & Clapham 1992) so the assumption that contexts are comparable is often made lightly. Authors who acknowledge these problems are often caught between the dilemma of presenting a mere list of the documented taxa, almost devoid of cultural meaning (e.g. Hubbard 1976; Banning 2002), or presenting quantitative analyses despite their significance being often seriously questioned (e.g. Dennell 1976).

Semi-quantitative approaches: relative scale

Whilst the abundance of determined non-woody plant remains has been recorded with absolute values (vid. infra), the abundance of indeterminate plant remains (non-woody vegetative tissue) has been assessed semi-quantitatively, with a relative scale (Jones 1991) distinguishing between mere presence and relative abundance.

Absolute count

An absolute count of the number of determined remains (NDR) has been carried out in this thesis, for purely descriptive and taphonomically interpretative objectives only. Generating cultural interpretations based on absolute counts and weights assumes that those measures accurately reflect human–plant interrelationships (Hastorf & Popper 1998), rather than recovery and taphonomical biases (vid. p. 130). “There can be no justification for estimating the economic status of a plant by its numerical frequency alone” (Dennell 1976).

The minimal number of individuals (MNI) has been estimated for determined plant remains; seeds or fruits (depending on the type of remain) being understood as the units of observation (Jones 1991). It is not possible to count number of plants or even fruits because of diaspolorph (Tereso 2008), i.e., each plant produces a variable and unpredictable number of fruits and seeds and each fruit might contain an unpredictable number of seeds. In the case of fragmentary remains, different methodologies for the
calculation of the MNI have been followed, according to the type of remain and the degree of fragmentation (described in each taxa epigraph, *vid.* Part III A: Results: the identified taxa). In general, the count of the minimal number of identifiable parts or behavioural relevance (Jones 1991) is the underlying idea, but this is not always straightforward nor generalisable (Drennan 2001). Other methods involve the division of the number of fragments by different dividers, according to the type of taxa (*e.g.* Buxó 1997; Ruas, Laurent & Bénédicte 2005-2006). In addition, MNI estimations with and without the dominant taxon have been calculated in the cases where a very abundant and fragmented taxon might be biasing the overall appreciation of the assemblage (*e.g.* *Corylus avellana* hazelnut shells in sites from the Cantabrian region) (*vid.* Part III B: Results: the carpological assemblages).

**Presence/absence analyses or ubiquity/frequency indices**

Ubiquity or presence analyses describes the number of provenances in which a plant resource is recovered (Hastorf & Popper 1998). Some researchers prefer ubiquity to absolute counts and weights, because “a change in the number of samples in which a taxon is present is an imprecise but useful measure of the relative change in the use of that resource” (Minnis 1985) and allow the comparison of heterogeneous types of plant resources (Hubbard 1975) and quantifications which do not allow for comparisons are seen as valueless (Hubbard 1975). The author has been reticent to employ this type of analysis because of the presumed incomparability of the samples of different sites due to the heterogeneous recovery strategies (different sampling and retrieval methods employed), which are even patent within the samples of the same site (contexts with very few samples or represented by samples arising from different retrieval techniques).

**Ranking**

Ranking is considered a more precise means for measuring plant frequencies than ubiquity (Hastorf & Popper 1998). With ranking, absolute counts are translated into an ordinal scale. Advantages: it allows for independent evaluations of taxa. Disadvantages: a need for good preservation and high counts of taxa per sample; limited to samples collected from similar contexts. For obvious reasons which will be seen later (Part III B: Results: the carpological assemblages, the absence of high counts of taxa per sample, with the exception of a few taxa which mostly offer quantification problems), this method has not been employed in this thesis for quantification of plant remains, although it has been useful for assessing the different chances of different plant taxa of being carbonised and recovered in the charred archaeobotanical record (*vid.* Part III A: Results: the identified taxa and Figure 89).

**Proportions (ratios)**

Ratios (densities, percentages, and comparisons) are proposed as a means to standardise the data and compare samples of different size or taphonomical circumstances, and “quantities of different categories of material that are equivalent in some respect” (Miller 1998). This quantification strategy standardises taxa counts across samples of different original size, but interdependent percentage values might be
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problematical, i.e., the effect of dominant taxa (Lennstrom & Hastorf 1995) whose weight might need to be transformed to be statistically significant (Jones 1991). A minimum number of 25 items is advisable for each element in the ratio (van der Veen 2007). Comparisons by plant percentages are usually expressed in pie charts. The variables usually mentioned in the literature are:

- **species richness** (the number of different types in a subset with respect to the whole number of types in a set); an index of species richness has been calculated here, with a distinction between minimum number of species (MNS) and number of taxa (NT) [vid. p. 125 for a clarification of the concept of taxon] for each SU within each context (vid. Part III B: Results: the carpological assemblages) and for each context within each region (vid. Table 121); it might be termed a heterogeneity index in Class C or tertiary assemblages (Hubbard & Clapham 1992);

- **diversity** (richness and evenness: the distribution of individuals among the different species or taxa, with the advantage of escaping from the effect of sample size in the number or species, Jones 1991);

- **relative abundance** (the number of seeds of one taxon by the total number of all seeds recovered, Renfrew 1973);

- **density** (the number of plant fragments per litre of excavated soil or the number of seeds vs. volume of charcoal, Popper 1998; Miller 1998), which in certain contexts might partly reflect the rate of deposition (Jones 1991), and as such has been interpreted in the cases of São Pedro de Canaferrim (vid. p. 399) and Lapiás das Lameiras (vid. p. 413);

- and the **degree of fragmentation** (Jones 1991) which here has been calculated as a fragmentation index, the ratio between the MNI (vid. minimal number of individuals) and the NDR (vid. number of determined remains), has been considered as an important observation for the general assessment of the contexts (vid. Part III B: Results: the carpological assemblages).

4.2.2.6 Documentation

Document a representative sample of the identified remains is crucial, at least by photography: “proper photographic illustration ideally forms the least subjective means of presenting the ‘data’” (Kerp & Bomfleur 2011), which advisably can be complemented with drawings, in which particular diagnostic features are emphasised (Goddard & Nesbitt 1997). Documentation is crucial as it allows other specialists to validate the identifications, to present new specimens or with particular features. Photography is a popular method for its relative easiness and quickness, although “many palaeobotanical objects are notoriously difficult to photograph due to the lack of contrast” Kerp & Bomfleur 2011), and this is particularly true for charred plants. Technically, nowadays, only a digital photographic camera adapted to a magnifying binocular instrument is needed, and additionally appropriate computer software allows retouching to improve the appearance (strictly restricted to cropping, cleaning and changing background, inserting a scale and adjusting brightness and contrast). An additional feature for macrophotography is image or focus stacking; in consists of a series of images taken at successive focusing levels; then, those portions of the individual images in which the parts of the object are in focus are merged together into a single image file by specialised software. SEM photography is also very useful, except for the fact that samples require a metal covering which might
make them useless for radiocarbon dating or further study. On the other hand, drawings are more costly to produce in terms of time and ability, and have an important subjective character.

In this thesis, a Canon EOS450D photo camera and software connected to a Leica S8APO binocular macroscope has been used, photo-stacking has been carried out with the software Helicon Focus and final processing (background cleaning and scaling) has been done with GIMP 2.6 (vid. p. 519).

4.2.2.7 Biomolecular analyses

Charred plant remains might be subjected to several laboratory analyses, some of which have been applied in this work. Two of the potential biomolecular analyses which could be carried out on plant remains, DNA and stable isotopes, will be discussed elsewhere (vid. p. 166).

Most carpological remains (with a minimum carbon mass of 15 mg) are interesting archaeological remains datable by numerical direct dating ($^{14}$C AMS). They are interesting from the purely archaeobotanical standpoint (as the establishment of precise chronologies of introduction of allochthonous species) and more generally archaeological (for obtaining precise and accurate dates on short-lived samples from specific contexts). These are unquestionably the best materials to directly date whenever charred plant material is preserved (e.g. Tereso 2008; Wild et al. 2013). Hazelnuts have been considered excellent samples for radiocarbon dating Mesolithic contexts (Crombé et al. 2013). The research project in which this thesis has been involved (COASTTRAN, vid. p. 5) have radiocarbon dated the largest possible number of plant macroremains, both from sites studied in this work and others relevant for the state of the art.

4.3 Interpretation: taphonomy of charred plant macroremain assemblages

Understanding the formation processes of plant macroremain assemblages (vid. Figure 34) is essential for interpreting archaeobotanical data. “The study of formation processes is fundamentally a study of routine practice, and that socially structured behaviour can be detected through a study of the formation processes of plant remains” (van der Veen 2007).
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A key aspect in the taphonomy of carpological remains is preservation, which in this work is always carbonisation. This form of preservation has very important representativeness issues absent in other preservation ways. These are cases in which the decomposition processes of the organic matter is stopped because of the deposition in special conditions (waterlogged, peat bogs, frozen, desiccated, etc.) or because they suffer transformations (mineralisation: metallisation, calcification, etc.) (vid. Deforce 2006). Carbonisation is always an accidental process to which not all plant resources exploited are subjected to; nor able to survive it: it is calculated that around 20% or the assemblage exploited is preserved by charring (van der Veen 2007). It is a very common phenomenon that in sites where charring and waterlogging are the forms of preservation, the taxa quantity and richness recovered is often larger in waterlogged state and a larger proportion of the assemblage is of wild species (possibly the same phenomenon occurs where desiccation exists, Colledge & Conolly 2014). Although this may bias our understanding of plant subsistence towards certain taxa, it is still possible to consider changes in space and/or time in the relative use of those taxa that are routinely recovered (VanDerwarker & Peres 2010), comparing plant assemblages from different spaces and/or times that have similar preservational histories.
So, “absence of evidence is not evidence of absence”. Absence of specific taxa or plant types can be explained through various means, (*vid.* Figure 35):

- the existence of selective deposition and preservation factors,
- the kind and seasonality of the deposit,
- the variability of processing methods and uses,
- absence of use.

Because of taphonomy, the reconstruction of past diets is sometimes thought to be impossible (Miksicek 1987).

The richness of remains could be directly related to the length of the occupation (*Clarke effect*, Miksicek 1987).

### 4.3.1 Taphonomical proxies

#### 4.3.1.1 Type

The way in which plant remains are distributed in archaeological sites and the composition of the assemblages they form is important in regard of the activities that created and shaped the deposition.

The first step in the research into the path of arrival is to establish the type of assemblage or deposition (Fuller, Stevens & McClatchie 2014; Hubbard & Clapham 1992): primary (Class A), secondary (Class B) and tertiary (Class C). The ideal cases for the reconstruction of past activities are Class A and B depositional assemblages, which show a discrete distribution (*vid.* p. 134), and in which each assemblage is the result of a single carbonisation event (Fuller, Stevens & McClatchie 2014; Hubbard & Clapham 1992; Minnis 1981), which might or might not be the result of a single plant processing activity, *primary refuse* (Fuller, Stevens & McClatchie 2014). Unfortunately contexts of these types are the least frequent, as they are the less archaeologically visible (Hastorf 1998b).

#### 4.3.1.1.1 Class A / Primary depositional contexts

Assemblages of this type can be individualised, as they arise from a single carbonisation event that has taken place *in situ* (Hubbard & Clapham 1992) and the context itself must therefore show signs of burning (Fuller, Stevens & McClatchie 2014). Unfortunately, this does not necessarily mean that a single carbonisation event has charred plant products or plant-processing by-products arising from a single processing activity or *primary refuse* (Fuller, Stevens & McClatchie 2014). In a cooking primary context, plant foods are expected to be a moderately dense assemblage of food seeds that had low distortion and low fragmentation; whilst plants used for fuel might have high distortion but moderate fragmentation. If plant materials were burned outside of a cooking setting, such as burnt midden, a moderate density of highly distorted plant remains would be expected (Moore *et al.* 2010).
• *de facto* deposition: caches and stored products charred by accidental fires (Rathje & Schiffer 1982).

### 4.3.1.1.2 Class B / Secondary depositional contexts

Assemblages of this type arise from a single carbonisation event without evidence of *in situ* charring, thus indicating that the assemblage has been displaced from the original place where it was burned, which might sometimes be recognised somewhere else (Hubbard & Clapham 1992). These are usually both products or by-products and fuel plants with the same range of distortion and high fragmentation (Moore et al. 2010). As there are at least three distinct groups of activities (those that created the assemblage before it became charred; its burning, and its deposition) (Fuller, Stevens & McClatchie 2014), remains from different processing activities (primary refuse) might become mixed before becoming charred in a single carbonisation event.

### 4.3.1.1.3 Class C / Tertiary depositional contexts

The most frequent type of assemblages recovered from prehistorical sites, *ordinary samples*, arise from different activities that have become mixed and carbonisation events that have taken place somewhere else (*e.g.* Hubbard 1976). They might be recognised when different degrees of distortion are observed in the same type of remains (*i.e.* not affected by differential preservation: fire resistant or non resistant items); however, a single charring event might produce remains with differing degrees of distortion according to their distance to the fire (Hubbard & Clapham 1992). If the assemblage was buried immediately, the fragmentation would be low, but if it was left exposed the fragmentation would be high (Moore et al. 2010). These assemblages are more likely recovered in disperse distributions (*vid.* p. 133).

### 4.3.1.2 Distribution

The information regarding actual use provided by plant remains and assemblages vary according to the way in which they are distributed in archaeological sites: dispersed in occupation floors and concentrated. Several types of contexts of accumulation (Rivera Núñez & Obón de Castro 1991a) exist: stores, floors, hearths, ovens, middens, latrines and fillings. In the case of charred plant material from old excavations (fortunately, not the case of this work), their contextual information might not have been recorded and therefore the information they offer is very limited (*vid.* Grade 1 assemblages, Fuller & Weber 2005).

#### 4.3.1.2.1 Dispersed

Often, plant macroremains are recovered spread all over archaeological layers mixed with other archaeological material. This is the typical recovery context in most archaeological sites and particularly
in caves (cf. Zapata). For assemblages with this type of distributions, behavioural interpretations must be tentative (Fuller & Weber 2005), as although they might arise from routine activities (Fuller, Stevens & McClatchie 2014), their individualisation is difficult to achieve. These assemblages can be the result of a specific activity (regular sweeping of functional areas and dispersal of very small remains on occupation floors, McKellar hypothesis, Miksicok 1987) or a postabandonment alteration of the site and functional areas by natural causes (animal trampling or water and wind displacements) (Fuller, Stevens & McClatchie 2014). The size of the plant macroremains in these assemblages might help to distinguish between the two previous options (Antolín i Tutusaus 2010b): whilst small plant remains are likely to be left in the floors after sweeping, large plant remains are more likely to remain in situ when environmental factors disperse the small ones in abandoned sites. Unfortunately, radiocarbon dating has proved that intrusive charred materials often occur in these types of disperse distributions (Crombé et al. 2013), particularly in palimpsest-like sites (again, most cave sites) where fertile archaeological layers are vertically contiguous between one another. Moreover, although highly unlikely, a natural origin cannot be wholly discarded as a possibility: in the case of plant remains from a fluvial or colluvial origin, an abraded and rolled surface might allow its distinction (Hansen 2001). Megalithic mounds might also contain dispersed plant remains, although the relationship between them and the structure might be inexistent (Zapata Peña 1999b).

4.3.1.2.2 Concentrated

Plant remains might appear forming small rubbish mounds nearby occupation floors. In this case, the by-products of different activities often appear mixed and, consequently, plant assemblages are difficult to individualise. However, in some cases in which the depositional rate is rapid, individual plant assemblages can be preserved as such and isolated from other depositional events. Plant remains can appear in concentrations, associated to or within structures or items related with their use, thus being much more informative than when appearing dispersed over occupation floors, as behavioural interpretation can be more easily obtained (Fuller & Weber 2005): in hearths, within pottery vessels (often in the shape of crusts), acting as tempering or adhered to the exterior of building elements (bricks, pisé); or within pits.

Pits are anthropic negative stratigraphical units (Barker 1977; Harris 1979 (1997)) and one of the most cited types of archaeological features containing plant macroremains (this might be a historiographical bias, because they are usually particularly sampled). Pits might have been planned and excavated for some single or multiple-use purposes, or pits might have not been planned but were by-products of other activities (Boschian & Colombo 2009); whilst their infillings might be immediate, as in the case of burials and post-holes, in which the sediment used to refill is usually the same as that which was first removed; or be delayed, as in the case of storage pits, in which the infilling results from a secondary use and is usually domestic waste (Boschian & Colombo 2009). The rate of deposition might be inferred from the density of remains within (Jones 1991) and from its uniformity: the sediment is uniform if the rate of deposition is high, whilst layered stratigraphical units are the result of low deposition rates (Kreuz 2007).

Pits are known to have very diverse functions, and those which involve the use of plants are usually the cooking of food (e.g. Wandsnider 1997), resource-storage (e.g. Takahashi & Hosoya 2002),
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resource-hiding (e.g. Cunningham 2011), waste-deposition (e.g. Hellwig 1997) or burial, providing a symbol of death and regeneration (Thomas 1999). Sometimes, the functional interpretation of particular archaeological pits is endlessly debated [e.g. a pit-hearth or a pit with floor sweepings (Field, Matthews & Smith 1964); Staasnaig cooking pits or storage pits (Mithen & Score 2000 and Cunningham 2011)] because of the disagreement in what might be considered as functional proxies. External (as shape and size) and internal characteristics - the contents (types, homogeneity and preservation conditions) - are often discussed (e.g. Binford 1967; Houlder 1963). However, it is argued that, as with any other kind of technological item, morphology is not strictly correlated to function. Moreover, the original context of a pit rarely survives in the archaeological record and pits were filled with debris deliberately or naturally through erosion (DeBoer 1988). Most charred grains found in pits are of secondary origin and therefore bear no relationship to the function of the pit (Legge 1989).

Fine clayey lenses might be the result of the walls of the pits partially collapsing. Changes produced by environmental conditions start to affect the upper part of empty pit walls very soon after excavation producing a soft lens bottom, depending on factors such as rainfall, temperature, humidity, sun exposure, ground consistency and insect activity (Cavulli 2009). Although no universal pattern for botanical deposition in hearths exists, the contents of pits may be to some degree protected from degradation (Lennstrom & Hastorf 1995)

Pits might contain either domestic products, such as cereal grains, or wild food resources, such as nuts. In the latter case, it is particularly important to distinguish between an anthropic deposit of nuts [e.g. hazelnuts, acorns or water chestnuts (Cunningham 2011; Zvelebil 2008)] and a natural one, as some animals create underground stores for winter or middens in furrows. Remains from these latter might have gnawing marks which could enables to identify the animal that created it (Collinson & Hooker 2000).

4.3.1.3 Composition

When recovered in individualised assemblages (primary or Class A and secondary or Class B, vid. p. 132), plant remains might provide very valuable information about the activities that created them. For individualised agricultural processing assemblages that might be recovered in archaeological sites, their possible types composition can be related to specific phases of their processing (Table 35).

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Sample variable</th>
<th>Sample origin, if high value</th>
<th>Sample origin, if low value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cereal straw nodes/grains</td>
<td>By-product from early processing stage</td>
<td>Grain product</td>
</tr>
<tr>
<td>B</td>
<td>Free-threshing rachis internodes/grains (by species)</td>
<td>By-product from early processing stage</td>
<td>Grain product</td>
</tr>
<tr>
<td>C</td>
<td>Glume wheat glume bases/grains (by species)</td>
<td>By-product from late processing stage</td>
<td>Grain product</td>
</tr>
<tr>
<td>D</td>
<td>Weed seeds/cereal grains</td>
<td>By-product from late processing stage</td>
<td>Grain product</td>
</tr>
<tr>
<td>E</td>
<td>Small/large weed seeds</td>
<td>By-product from sieving</td>
<td>Product from sieving or by-product of hand cleaning</td>
</tr>
</tbody>
</table>
4.3.1.3.1 Products for consumption

The plant products that are intended to be used are sometimes recovered as whole unused assemblages, *e.g.* when destruction events affect sites and fires burn stored products or when an accident occurs upon preparation. They appear as (almost) pure concentrations of a single taxon or various taxa of which require similar processing for consumption. This is an ideal case for the recovery of plants in primary or secondary deposition (*vid.* p. 132) but unfortunately not very common, as usually remains from different activities result mixed upon the occupation of a site (*e.g.* Hubbard 1976). When several crop products appear mixed, it is possible that their mixing is either a result of their combined (maslin, *vid.* Butler 1999) cultivation (intentionally or not) or processing (if they might be processed similarly), or a result of postdepositional events. Relative percentages might be used to ascertain the practice of mixed cultivation: if the two crops appear in equivalent quantities, then it is likely they were intentionally grown, if one is much rarer, then it is likely a weed. Maslin products are often separated during sieving, but this is rarely achieved perfectly (Jones & Halstead 1995). A small proportion of the contaminants survive in the collected product until the very last stage of the threshing process (Antolín i Tutusaus 2012). Other accompanying weeds of different growing conditions or seasons might help to distinguish if the crops were grown together or only processed together (van der Veen 1995).

4.3.1.3.2 Processing by-products

Plant by-products arising from different stages of processing might be recognised in archaeological plant assemblages and might be quantified as an *index of rubbish* (Hubbard & Clapham 1992). They are very likely recognised as such when they by-products valued as fuel, usually when wood is scarce, and thus have more chances of becoming charred (van der Veen 1999). The different by-products and their processing stage they associate with are well-known in certain cases, such as those of cereals (Hillman 1981; Kislev, Weiss & Hartmann 2004), legumes (Jones 1984), flax (Andresen & Karg 2011), olives (Margaritis & Jones 2008) or vine (Margaritis & Jones 2006), but remains to be researched in the case of many other products. The presence or absence of weeds, in combination with other pieces of data, can be used to ascertain the gathering and cleaning methods (*e.g.* Fuller & Weber 2005; Peña-Chocarro 1993). However, provided weeds are not poisonous, only seed to sow needs to be cleaned of weed grains after gathering (Hubbard 1976). By-products from domestic crops can be given to domesticated animals selectively (Palmer 1998): the three types of white chaff (from cereals): soft chaff for sheep and goats,

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<table>
<thead>
<tr>
<th>Ratio</th>
<th>Sample variable</th>
<th>Sample origin, if high value</th>
<th>Sample origin, if low value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>No. of crop items/1 l of deposit; or number of ids/1 l of deposit</td>
<td>Rapid/single deposition (accident or deliberate conflagration)</td>
<td>Slow/repeated deposition (day-to-day activity)</td>
</tr>
<tr>
<td>G</td>
<td>No. of germinated/ non-germinated grains</td>
<td>Cleaning of storage pit or malting residue</td>
<td>Accidental grain spoilage</td>
</tr>
<tr>
<td>H</td>
<td>No. of diseased or insect damaged/ undamaged grains</td>
<td>Deliberate burning of spoiled grain</td>
<td>Accidental grain spoilage</td>
</tr>
</tbody>
</table>

Table 35: Charred plant macroremain ratios according to function (after van der Veen 2007).
coarse chaff for horses and donkeys and fine chaff for the fowl; red chaff (from pulses): crushed pieces: sheep, goats and cattle; chaff: sheep and goats.

4.3.2 Predepositional issues: potential entry routes

Some of the carpological remains entering an archaeological deposit might have their origin in plants that are part of the surrounding vegetation of the site and might thus get there by chance, either transported by unpredictable circumstances or by those inherent to the plant’s own dispersal strategy: autochory (deshiscent seed-pods with eject the seeds), barochory, (seeds simply fall to the ground), anemochory (winged seeds transported by the wind), hydrochory (light flat seeds floating in water), epizoochory (spiny fruits adhered to animal fur), endozoochory (fleshy berries within animal dung or preys) and zoochory (nuts in animal hoards; myrmecochory, by ants). However, to be preserved these seeds and fruits have to be charred and, although natural fires occur (e.g. Scott 2010) and land might be burnt to increase productivity, the real incidence of naturally charred seeds is rather low (Miksicek 1987). The spontaneous carbonisation of seeds and fruits is highly unlikely due to the fermentation action of bacteria (Helbaek 1952b; Renfrew 1973).

Therefore, most non-woody plant macroremains susceptible of being found charred at archaeological sites have an anthropic origin, and although preservation by charring in itself is an accident, the specimens can have arrived there either intentionally or accidentally (e.g. Rivera Núñez & Obón de Castro 1991a). The reason why certain species, especially those of wild origin, appear on site is very difficult to ascertain, as a wide range of possibilities might explain their presence (vid. Figure 36). “Interpretation is usually far from straightforward ” (Hall 1996).

4.3.2.1 Accidental

The plant, useful or not, may have resulted accidentally carbonised and deposited in the archaeological record:
• accompanying a crop or wild plant formation of interest (weeds): many useful plants might act as weeds in certain conditions. Hints for positively identifying potential weeds as veritable weeds might be found in their seasonality (if their fruiting time matches that of the crops) and the position of the grain within the plant (if collected with the crop or fodder or directly grazed by animals).

• forming part of a natural compound (peat, dung) present in the site for other reason other than plant use, as for example fuel: different fuel types produce varying numbers and proportions of plant parts and species. The colour of archaeological ash can be the first clue to the fuel source and the atmospherical conditions during the burning and postdepositional processes (Church, Peters & Batt 2007).

• dung from both wild and domesticated animals might be exploited by human societies for different purposes (Charles 1998): as fuel in dry climates where wood is scarce (Miller 1996; Hastorf & Wright 1998), sometimes elaborated as dung cakes for improving the calorific properties (Valamoti & Charles 2005), or preferred for its calorific qualities (slowness and stability) for specific domestic activities (ceramic manufacturing or vegetable temper (Ibáñez-Estévez et al. 2001; Lancelotti & Madella 2012), and ornamental motive (Lancelotti & Madella 2012). The paths of plant inclusion in dung cakes are via ingestion (primary inclusion) and manufacturing (secondary inclusion) (Lancelotti & Madella 2012).

• dung from kept domestic animals is trampled and transformed into dung layers, with 5 % dung and 95 % dumping (Akeret & Rentzel 2001), which might result charred:
  • in the periodical hygienic sty fires to reduce microorganism propagation,
  • in accidentally originated fires, due to high fungal and bacterial action (Badal-García & Atienza 2008).

4.3.2.2 Intentional

Plants might have been intentionally gathered, but for different purposes according to the time of gathering in the plant development cycle (Colledge 1994) and to the plant part gathered.

Moreover, carbonisation is always an accidental action which can affect:

• waste (Pearsall 1998): the incomplete burning of waste that is intended to disappear, used as fuel or transformed into ashes for manuring. “Much of our archaeo-botanical evidence might provide a more accurate indication of what was thrown away than of what was actually eaten” (Dennell 1976). Plants or plant parts appearing in low densities across different features of a site and mixed with other stuff might have been casual fuel objects, whilst concentrations in particular features might indicate the intentional use as fuel for a specific purpose (van der Veen 1999). This waste might be a part of a plant that it is not considered useful, or a plant or plant part that could have been used, but has gone bad or is no longer needed,

• the actual object of use, carbonised because of handling, such as a cleaning firing of the interior of silos/pits that affects the remaining wasted stored products or products falling into the fire (oven or hearth) when preparing for use or conservation for storage or transportation: milling, boiling,
roasting, smoking, etc.; or due to conflagrations, accidental or intentional, affecting structural materials, such as bricks and daub, thatching, beds, etc., stores or dumped materials.

4.3.2.2.1 Plant use

Plants might be used by humans by a long series of uses, either material (Dimbleby 1967(1978)) or immaterial (Fairbairn 2008). Among the first, three types of uses can be distinguished (Buxó & Piqué 2008): food (including beverages and additives), the production of heat and light (i.e. fuel) and the production of goods, among which the most conspicuous are building material, domestic use (tools and furniture, fibres, cordage, paper, glues, musical instruments, etc.), cloths (plant tissues and leather tanning), pharmaceutics (medicines, psychoactives, insecticides, etc.), cosmetics (perfumes, oils, dyes, etc.). Among the immaterial ones, the construction of identities, the personalisation of creationist beliefs or the contention of symbolical meaning. In this thesis, general information about the potential uses of specific plant taxa has been mainly obtained from a universal database which compiles a wide number of references (Fern 1992-2010), in combination with more specific references.

“A perennial problem for the archaeobotanist: determining whether remains recovered from a deposit had actually been used for a particular purpose” (Hall 1996). The actual purpose of the use of plants is often difficult to prove without further evidence (contextual, taphonomical, etc.) and can thus be only suggested as a possibility, as the same plants could have been used for very different purposes which could all be evidenced in a plant part discarded into fire or accidentally falling into it upon preparation or storage. It is only possible to speculate on certain plant uses on the basis of modern knowledge of the plants’ properties, ancient written sources and the ethnographical record (Valamoti 2009), always bearing in mind that plant use patterns are usually not static over time (Łuczaj et al. 2012). Plants or plant parts used as fuel, habitually or casually, and foods in which preparation requires the use of fire, are the usual routine activities originating remains in charred assemblages, whilst plants used for other activities are only accidentally present (Dennell 1976; van der Veen 2007; Zapata Peña 2000). The more primary plant processing, the more charred waste products (Schlepp effect, Miksicek 1987). The coincidental occurrence of plant remains with the same potential purpose of use might act as evidence for that use (Hall 1996).

Relatively wide ranges of techniques for processing plant resources are known. It is sometimes argued that ethnographically observed current or recent practices are not appropriate for presupposing their existence in the prehistorical past. That is a simple evolutionist argument, in which knowledge is supposed to have linearly accumulated over time. Although that might be true for certain cases, knowledge and the transmission of knowledge are typical of human societies, regardless of time and socioeconomical development. Traditional societies might recognise in practice the benefits of a specific plant or particular agricultural or processing practice, although the beneficial mechanism or property might not be properly understood: for example, Baktaman cultivators think taro plants like the smell of rotting plants nearby (Barth 2002). Their sometimes mistaken theoretical interpretation does not impede them to act in consequence of a well-recognised phenomenon.

Whilst domesticated plants are often straightforwardly, and at the same time sometimes erroneously, interpreted as used plants; it is often argued that in the case of seeds of wild plants, despite their potential usefulness, their actual past use should be “demonstrated” taking into account factors such as
Inés L. López-Dóriga

the context of the find and the form of preservation (in plant part and degree of fragmentation) (Dietsch 2007). Fruits and nuts often escape this prejudice: it is highly unlikely that fruits and nuts arrive unintentionally at archaeological sites. It could only be so in branches brought to the site for fuel, a possibility often suggested by archaeobotanically-sceptic archaeologists: this would imply the use of fresh wood as combustible, which is less easily lit and requires more effort and time and thus is rather improbable (Dietsch 2007).

Next, the potential uses of plants will be described, with particular detail to those elements which would allow their recognition in archaeological sites. An alphabetical order has been chosen, in order to break with “importance” lists in which a subjective bias is often introduced: solely because the use as food is one of the most important functions of plants (of the plants utilised by traditional societies, about half are used for food), the use of plants for food in archaeological contexts must not be directly inferred for every plant remain that is determined. Instead, the probable past plant use must be critically assessed by the careful examination of the context and its particular characteristics: homogeneity of the assemblage, state of preservation, alternative potential uses, etc.

**Bromatological use (food, beverages and condiments)**

One of the most important roles of plants in human societies is food, sometimes more than half of the plants exploited by human groups are to be eaten (e.g. Lee 1979). In agricultural societies breeding livestock, the distinction between what constitutes food and fodder is blurry, as the boundaries shift through time and among different cultures and social groups (vid. Charles, Halstead & Jones 1998; Halstead 1990; Jones & Halstead 1995; Valamoti 2009). Plants provide many things that are essential to our health, longevity and well-being such as vitamins, minerals and carbohydrates. Humans are well adapted for highly diverse foods without any dependence on particular proportions of plants versus meat (Lindeberg 2009); the traditional latitudinal ratios, which are often proposed, might be rather the result of representational biases (only few non-industrialised societies are still alive). However, traditional palaeodietary reconstructions have underestimated its sociocultural importance: eating is a cultural and social phenomenon: “we are what we eat” (Aranda Jiménez 2008; Álvarez-Fernández et al. 2012; Twiss 2007). Differences in food systems can be the result of social differences based on age, sex or gender, status (elite vs. common), caste or sect, religion, divisions of labour, ethnicity or economics: thus, food systems are a proxy for understanding broader social and cultural processes (Curet & Pestle 2010; Palmer & van der Veen 2002; Wetterstrom 1978). Still, there seem to be some trends in the appreciation of food: salty, spicy and sweet foods seem to provoke almost universally positive reactions whereas bitter and acidic foodstuffs are less desired (Curet & Pestle 2010).

“Food patterns are usually conservative” but not static (Wetterstrom 1978): frontiers between different foods are movable within time and space. In bad years, a resource conceived as fodder might return to human diet (vid. Jones & Halstead 1995), even potentially harmful foods might be exceptionally consumed in times of famine (vid. Lemessa Ocho et al. 2012). When new foods are introduced, people seem to place them within the categories they recognise (Wetterstrom 1978). But foods might also change their order in the hierarchies according to changes in values, as culture is not static. Many farming cultures share the concept of *main meal* which is eaten daily and in which two elements must be contained: the staple crop and the condiments that “embellish the food” and improve
the taste (Wetterstrom 1978). This seems to be not as rigid among hunter-gatherers, although the concept of a primary food category (in which the species might vary seasonally) seems important (Wetterstrom 1978). Plant condiments are well documented in classical sources but might have been used as such long before and have passed unrecorded (Zohary, Hopf & Weiss 2012). Many aromatic wild plants and fruits and flowers could have been used as species and sweeteners respectively (Wood 2001).

Many theoretical models about the exploitation of resources by past human groups have been proposed, usually based on the idea of least cost option (Clark 1987): optimal foraging theory and site catchment analysis. It relies on the idea that a selection process always operates in human groups, and it is often assumed that resource selection is related to resource costs. Plants, whilst highly productive, would rank lowest because they require higher labour investment for low caloric return. However, the nutritional value of a plant food varies according to the season and stage of development (Bouby & Ruas 2005). The main problem with this type of proposals is the consideration of human behaviour in strictly economical terms (Haws 2004) ignoring social food customs, such as taboos (Dennell 1979). “Optimal models allow us to visualise how people would behave if the conditions of the models were the only factors affecting their behaviour” (Jochim 1998). Furthermore, resource potential is not equivalent to actual resource use (their italics, Charles & Halstead 2001).

Plant archaeological remains confidently interpreted as food have to fulfil certain requisites: appearance in large and relatively pure assemblages (Behre 2008), or in a form indicating clearly its end use, such as processed stores or processing by-products (Charles 2011), within coprolites or dental deposits or stomach contents in bodies with organic preservation (bogs or mummies) (Behre 2008; Charles 2011; Hardy et al. 2012; but Hardy et al. 2012). From a taphonomical point of view, three types of plant macromerains used as food exist (Munson, Parmalee & Yarnell 1971):

- fruits with dense inedible parts (stones and nutshell) which are removed and used as fuel, surviving well because of their woody structure,
- edible seeds parched before consumption or storage (e.g. chenopods),
- non-dense plant foods with a high moisture content, such as leafy greens and edible tubers most of which are eaten fresh or boiled, prepared as beverages or used as condiments (Zohary, Hopf & Weiss 2012) and fruits with small seeds that are eaten whole (Dietsch 2007).

**Cosmetic use (dye, mordant, perfume, soap)**

Body, food and textile drying are usual practices invested with practical and symbolical meaning. For example, SE Asia women blacken their teeth by betel chewing (a mixture of beat leaf, slivers of areca palm nut and some lime paste wrapped in a leaf of the betel pepper vine): the betel chew is a mild stimulant and it relieves toothaches as well as suppresses the appetite.

Mordants, or colour-fixating substances, can also be obtained from diatoms or plants as such as *Salicornia, Suaeda or Saponaria*. Many dyes used in diverse colouring techniques are of organic origin, and within these, the most important are of vegetal origin (with the exception of some insects). The importance of the dying properties of some plants has been reflected in their scientific names, with the
epithets *tinctori-us/-a* and the colour-derived noun *Indigofera* spp. But in fact, any green plant will furnish at least a pale yellowish colour if a mordant is used (Hall 1996). Most of them are used for dying textiles, but also for colouring foods (Lowry & Chew 1974; Zohary, Hopf & Weiss 2012), body painting (van der Veen, Hall & May 1993), etc.

The uses of plants as perfumes and cosmetic is difficult to detect through the study of plant macroremains, but more appropriately carried out through the study of the chemical composition of organic residues. However, plant parts accidentally charred upon preparation of perfumes and cosmetics, which often involve distillation and need the help of fire, might be found in carbonised assemblages. The use of mostly vegetative perishable parts for dye production makes finds of plants used for dyeing extremely rare (Hall 1996), and dyed products might be preserved only in sites with particular preservation (e.g. Kvavadze et al. 2009) and the dyes themselves might be preserved in bulk within vessels. In plant macroremains, this usage can leave evidence in the case of plant parts accidentally falling to the fire whilst preparing the dye, which involves boiling the dyeing substance in water, or the discard of unused plant parts into the fire. However, as the reproductive plant parts might have many other uses, again, to actually prove the usage for this purpose is very difficult (Hall 1996).

**Pharmaceutical use (medicine, poison, psychoactive)**

Plants provide many substances of pharmaceutical properties which allow for their exploitation as medicines, poisons, psychoactives, insecticides, repellents, etc. Because the same substance might be used for different purposes, the identification of these practices is very difficult. Moreover, these substances are often beverages and ointments, rarely preserved, and their way of preparation allows few chances for plant macroremains to be charred.

“The distinction between food and medicine is an artifact of western specialization” (Ford 1978b) and this is particularly the case for beverages. Teas can be made out of every plant by pouring boiling water over it, and any herbal tea can be left to ferment and turn into an alcoholic drink (Wood 2001). In medicinal plant use, two distinct dimensions exist: the biochemical perspective and the symbolical alone (Messer 1978). The existence of certain wise people who have a specialised knowledge of an ample repertory of plants, particularly their properties, is quite likely a cross-cultural phenomenon (Schultes & Reis 1995). Medicinal herbs are often prepared as infusions and thus have few chances of being carbonised, unless falling to the fire accidentally whilst boiling. Even then, they have few chances of being preserved, as it is the leaves and roots which are more frequently used. Again, plants used for this purpose would be more likely preserved when the disposal of unused plant parts (seeds) took place or upon storage (accidental fire).

Plants provide several psychoactive elements, such as alkaloids, glycosides, essential oils (essences), gums and resins, greasy oils and antibiotics. Psychoactive substances can be stimulant, relaxant or hallucinogenic. Most societies, independently of their degree of socioeconomic development, have “institutionalised, culturally patterned forms an altered state of consciousness” and a large percentage of these altered states are produced through the consumption of psychoactive drug plant substances (Guerra-Doce 2006). Consumption is a medium for obtaining some specific end, such as communication with deities or ancestors, to fight tiredness or aches, as rites of passage or artistic inspiration; and it is often developed within a highly ritualised, ceremonial context, etc. (Merlin 2003), although some cases
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of hedonist consumption exist (Guerra-Doce 2006). Usually a division by sex, age and experience exists. In general, psychoactive consumption occurs among adults, in some cases it extends to children and dogs, and it is structured according to social, of status, gender or contextual differences (Messer 1978). Unless recovered in clear symbolical contexts or with very specific use-wear marks (e.g. *Papaver somniferum* capsules with incisions for the extraction of the latex), the identification of plants for psychoactive uses must be also hypothetical.

**Symbolical use**

The immaterial roles of plants might be as important as the material ones (Fairbairn 2008), although for the archaeological record this usage could be merely hypothesised and never tested. Plants play an important role in creation myths in many cultures and are indispensable to ritual practices (providing a devotional ambience or symbolising connections with the divinities) and social interaction (sharing food, drinking alcoholic beverages, smoking and presenting flowers, showing off) (Ford 1978b). The use of plants by past societies might be used as a political instrument: it is sometimes used to reinforce modern national identities through a sense of continuity between the distant past, the present and the future (Valamoti 2009).

The selection of certain plants might be carried out according to the symbolism attributed to particular characteristics, such as the Pueblo Indians have done with the heterogeneous colours of maize grains (Wetterstrom 1978), which would be impossible to detect in archaeological charred specimens. In the Iberian Peninsula, many plants are burnt to make *sahumerios*, a kind of smoke considered an important preventive against the evil eye (González et al. 2012). Plants might be luxury goods, and thus used symbolically, if certain conditions are met, such as scarcity, over-abundance, diversity, labour-intensity in acquisition or preparation, periodicity, exoticism, taste and symbolical strength (vid. Bakels & Jacomet 2003; Curet & Pestle 2010; van der Veen 2003).

Only through very careful consideration of contextual information in cases of structured deposition would this type of use could be possibly suggested. Plants in themselves might be used as *decoration*, graphical motive or symbol. The only safe chance to identify this use is through transformed plants or plant parts, as for example, perforated fruit stones to make beads (e.g. *Prunus avium*, Antolín & Buxó 2011a). More often, this use is detected when plants are used as decorative motives, by impression in pottery (e.g. Tegel et al. 2012) and daub; and when metallic or ceramic ornaments and pictorial scenes depict plants or plant parts. However, the symbolism behind this practices would remain unattainable to grasp.

**Technological use (bark, fibre, fuel, glue, wood, seal)**

Fibres extracted from several plants and plant parts (leaves, stems trunks) are frequently used in a series of technological activities: basketry, textile weaving, etc. A wide range of plants have barks that are usually exploited for fibre production, among the most common are hazel (*Corylus avellana*), lime, oak (*Quercus* sp.), willow (*Salix* sp.), ash and elm (*Ulmus* sp.). Among non-woody plants, flax (*Linum usitatissimum*), nettle (*Urtica dioica*), and hemp (*Cannabis sativa*) are commonly used for the extraction
of fibres from their stems for weaving. Moreover, various grasses, including domestic cereals such as wheat (*Triticum* sp.), reeds and rushes, such as cat-tails (*Typha* sp.), bulrush (*Scirpus lacustris*), bur-reed (*Sparganium* sp.), rushes (*Juncus* sp.) and common reeds (*Phragmites* sp.) are usually exploited for their fibres. Besides, plants and plant parts rich in oil (*e.g.* Cruciferae, *Linum usitatissimum* and *Papaver somniferum* seeds or *Corylus avellana* hazelnuts) might be used for the preparation of oils for the maintenance of bone and antler tools (Spangenberg et al. 2014). The use of plants for their fibres is very difficult to detect in archaeological sites with preservation of organic matter by charring, as the only chance of seeds being carbonised would be the disposal of the unused plant parts after extraction of the fibres and this extraction would be nearly impossible to prove without further evidence, as fibre plants could have been used for other purposes. A few attempts to identify a functional selection of plants have been made based on seed size in the case of flax (Larsson 2013): as it can be both an oil-plant and a fibre-plant, a particular seed-size would indicate a selection towards bigger seeds for oil production, whilst the lack of selection would point to fibre-exploitation. This is a very dubious approach, as charred seed size varies upon a series of factors, prominently charring conditions, which can be completely unrelated with actual past plant use. Furthermore, the same crop could serve different purposes as the necessities of the cultivating population would change.

The wood and other plant parts from many plants may have been potentially brought to archaeological sites for their use as fuel. This practice is difficult to detect in plant macroremains studies centred on carbonised seeds and fruits, as these would probably be completely burnt out and turn into ashes. The original sources of ash might be detected through chemical analyses (Church, Peters & Batt 2007). Some cases exist in which plant macroremains within peat cut for fuel are recovered in a charred state: “peaty turf usually produces relatively large quantities of small culm bases and rhizome fragments, fibrous burnt peat, and some seeds of the heathers (Ericaceae), grasses (Gramineae), and the sedges (*Carex* spp.). However, well-humified peat produces relatively large quantities of a much more amorphous burnt peat and very few residual plant macrofossils, usually consisting of rhizome fragments.” (Church, Peters & Batt 2007), but this would be a rare case in the Iberian Peninsula. Underdeveloped fruits and nuts are rarely preserved in archaeological contexts (*e.g.* Mason & Hather 2000). The use of fresh wood for fuel is rather improbable, because it is less easily lit and its gathering requires more time and effort than dry or deadwood (*e.g.* Dietsch 2007; Moskal del Hoyo, Wachowiak & Blanchette 2010; Théry-Parisot, Chabal & Chrzażewz 2010), plentifully available in the region we are dealing with. The “Principle of least effort” model (Shackleton & Prins 1992) is considered to usually work for wood fuel acquisition.

Plant glues might be recovered when used for attaching lithic points to wooden spears, to repair ceramic vessels (Tegel et al. 2012), etc. The preparation of these glues and sealing substances often include the use of fire. Thus, the only chance of detecting this usage by plant macroremains is when they result accidentally charred upon the preparation of the glue or sealing matter. Otherwise, the analysis of the chemical composition of organic residues must be resorted to.

### 4.3.2.2 Plant processing

Hunting-gathering and farming processing activities depend heavily upon human preferences and technology on the one hand, and on the biological features (including productivity and distribution) of
the relevant target resource on the other hand (Abbo et al. 2009). A correspondence between culture and the way plants are prepared has been found (Ford 1978a). Whilst certain plant processing practices certain stages of the processing series of activities might be relatively easy recognised in the archaeological record, others are relatively hidden. Some of these practices might be recognised by analysing the contextual evidence or the composition of the assemblages of plant remains (vid. p. 135), others by the recognition of use-wear marks in the remains themselves (vid. infra, but caution must be taken in order to correctly differentiate anthropic use-wear marks from animal digestion marks, vid. p. 151).

**Procurement: cultivation and gathering**

The archaeological record can provide clues about plant procurement practices through indirect means, more easily for gathering practices than for cultivation practices. Cultivation practices can be inferred when plants appear outside their natural distribution. Limited ways of gathering plants or plant parts in traditional societies are assumed to exist, and that this repertoire can be thoroughly known through the study of analogical evidence, both from experimental archaeology and ethnoarchaeology (vid. p. 157). In the case of arable crops, the type of gathering technique can be inferred through the taxonomical identification of the weeds accompanying the crop, i.e. the different weeds of every typical crop weed assemblage have different stem heights (e.g. Charles, Jones & Hodgson 1997), and the gathering techniques that might be employed can collect all weeds or a few of them: uprooting and low sickle-cutting affects all weeds present, whilst high sickle-cutting, hand-plucking or mesoria-use affects only weeds as high as the crops themselves (Hillman 1984-1986).

**Storing**

Plant evidence is sometimes used as evidence of seasonality in nomadic occupation sites, usually in hunter-gatherer societies. It is true that plants and particularly flowering usually have very precise timings; this fact can be taken into account to consider the time in which the site was surely, but not exclusively, occupied, as many plant products are susceptible of storage for very variable lengths, from short-term to long-term. Three types of motivations for storage can be distinguished: ecological, practical and social storage (Ingold 1983). Ecological storage refers to a concentration of nutrients at a particular point in the flow of energy from plants to animals; practical storage is a series of rational solutions to the problems of activity scheduling, which includes activities that do not give any immediate return; social storage is the appropriation of resources and materials that give rights to their distribution; consequently, stored resources become a symbol of property. Social storage plays a very important role in theorisations about the appearance of social inequalities in hunter-gatherer societies (e.g. Price & Brown 1985). Regardless of this social aspect of storage, storage facilities are crucial to the organisation of household economies. Material storage is the accumulation and processing of the storable resource, whilst permanent storage involves the construction of immovable storage features such as storehouses and pits (Soffer 1989). Based on quantity and/or duration (Cunningham 2011): long-term storage (the storage of food beyond three months, taking most foodstuffs beyond their season of natural availability); short-term storage (storage for a period of less than three months, allowing
stored food to be eaten within its natural availability, require fewer facilities and simpler preparation); large-scale storage (the storage of a surplus that can be used for risk buffering, replanting and exchange or creating social alliances); and small-scale storage (the storage of small amounts of resources such as food for lean seasons, medicines or alcoholic drinks for events or the storage of large amounts of food using different methods and in different locations as a form of spreading the risk of loss).

Plants and plant products might be stored for later use in a variety of ways, the most easily detected in prehistoric archaeological sites is in underground storage structures. Other less visible or even invisible storage techniques are wooden granaries and suchlike buildings, which might have been equally abundant in past societies, but in the best cases, are visible only through post-holes (Groenewoudt 2009). However, underground storage structures might have other uses than storing; it is necessary to pool different pieces of data to definitely infer the functional use of the structures or containers. This might be carried out by looking at the composition (the taxonomical or functional homogeneity) or the state of preservation of the assemblage. Pits are, not only frequent but, the only structure detected in many cases. Although pits might be missed in shell middens because of their difficult stratigraphy and in small-scale excavations, they are easily detected in large and moderate-scale excavations (Ames, Smith & Bourdeau 2008). Storage pits are known from the Upper Palaeolithic (Soffer 1989) and become abundant in Late Prehistory (e.g. Tereso et al. 2013).

The apparent over-representation of pits over other type of storage structures might also be the result of their efficiency, as either short-term but especially long-term stores, and added advantages over other methods: a good storage pit might be made easily with little effort and it can easily be hidden from unwanted discovery (Bouby, Fages & Treffort 2005). Two types of caches in underground pits exist: those made regularly along travel routes (Stopp 2002), ensuring that resources would be available when returning to an area as part of the seasonal rounds (Dunham 2000; Rowley-Conwy & Zvelebil 1989) and those made in times of social instability, when caves with difficult access and visibility are employed (Bouby, Fages & Treffort 2005). However, storage pits might have certain disadvantages: infiltrations, rodent attacks and wall tumbling (Alcalde i Gurt & Buxó i Capdevila 1991; Reynolds 1988). To prevent the attack of animals, repulsives with chemical effects (such as certain plant parts, ashes, liquids) or dissuading (dung) can be placed within the pit or used to line it.

Storage pits might be lined or capped or neither (Cunningham 2011). When preserved, the content of storage pits is relatively homogeneous: this is a concentration of one or a few species mixed (Dunham 2000; Marinval 1988; Vencl 1996) or separated with layers of straw, in bags or baskets (Buxó & Piqué 2008; Cunningham 2010) but usually in the same stage of processing (Arobba, Caramiello & Lucchese 2003; Stika 1999), either for food (Buttlar 1936 apud Fenton 1983) or other purposes (medicines, dyes, etc.) (Cunningham 2011). A mixture of products of different sizes (e.g. cereals and legumes) or products mixed with other substances (sand, vegetal ashes, etc.) can be used to reduce the intergranular area and thus reduce the air content (Gast & Sigaut 1981). Plant foods can be of two types according to their storability: long storage-life plant foods such as nuts, legumes and cereals, and shorter storage-life plant foods including tubers and roots (Soffer 1989). Despite the traditional link between domesticates and high levels of food procurement, archaeological evidence shows that domesticates are not necessary for large-scale storage (Ames, Smith & Bourdeau 2008). Although the original contents and even shape of pits are rarely preserved (DeBoer 1988), their volume and position within sites might serve as an indicator of their individual-familiar or communal management (Ames, Smith & Bourdeau 2008). With
time, a reused storage pit might be abandoned and filled with debris (DeBoer 1988), the reasons for this to happen can be diverse (Collis 1999): a bad storage experience, erosion and instability or changes in the storage size required.

**Peeling (dehusking / deshelling / dehulling)**

Many seeds and fruits have to be peeled (dehusked, deshelled or dehulled, according to the particular plant) for consumption. Again, limited ways of peeling plants are thought to have existed in traditional societies, and these ways are inferred by analogy. These practices might be detected in the archaeological record through the analysis of tool trace marks in hulls and shells (*e.g.* hazelnuts, Krzywinski, Fjelldan & Solvedt 1983), the state of preservation (*e.g.* cereal caryopses char differently if they are husked or not, Boardman & Jones 1990) or the composition of the assemblages (*e.g.* the cleanliness, or absence of rachis remains, in cereal products, Hillman 1984).

**Cooking and detoxification**

Many plants can be eaten raw; however, cooking makes some foods, such as carbohydrate rich tubers, more digestible (*e.g.* Peacock 2002; Stahl 1989) and many plants or plant parts contain toxins that are obnoxious when consumed in certain quantities. These plants or plant parts can be cooked in such a way that they lose the toxins and the cooking procedure followed might be recognised in the plant remains (*e.g.* legumes, Valamoti, Moniaki & Karathanou 2011). As a consequence, many plants have higher chances of being preserved in the archaeobotanical record due to the employment of cooking techniques than plants that are not toxic or indigestible in a raw state.

Several cooking practices can be carried out in traditional societies, without any dependence on particular technological innovations: fermentation, boiling, roasting, smoking, etc. Fermentation is a form of cooking which allows for storage, and the retention of many vitamins and minerals in raw fruits (Owen 2002); moreover, sprouted grains from diverse seeds, but primarily citrics, cereals and legumes, synthesise Vitamin C and are therefore effective anti-scurvy remedies (Oliver 1973). Boiling was, for a long time, considered dependent on the existence of pottery; whilst it has been demonstrated that the introduction of heated stones in a water container can produce boiling and therefore the existence of pottery is not strictly necessary (*e.g.* Nakazawa *et al.* 2009).

Remains of cooked and plants used or discarded as fuel can, in very rare cases, appear in primary position in hearths and open combustion structures. On the one hand, direct fire exposure tends to destroy plant remains rather than preserve them by charring: they would be more likely preserved in places where reducing conditions could be ensured. Several other reasons against preservation in hearths are met:

- single-use hearths are difficult to detect archaeologically, unless in the case of complex structures, as it is repeated domestic activities that are best represented in the archaeological record (Hastorf 1998a);
there would be a notorious difference between the chance of detecting a fire that has been left to die out naturally or one that has been extinguished (Groenendijk 1987), as the amount of charcoal or ash would be entirely different;

• when hearth structures are reused, they are often periodically cleaned and swept, causing the redeposition of the charred plant remains potentially existing in a secondary location (Hubbard 1976);

• “charcoal survives only when surface hearths are covered with sediment quickly after their use” (Crombé et al. 2013);

• the preservation of charcoalified plant material is negatively affected by the deposition in alkaline environments and ash is alkaline. Therefore, only in specific soil conditions where the soil and environmental conditions allow for the ashes to be quickly leached (e.g. open air sites with permeable soils vs. caves or impermeable soils), the charred plant remains would be preserved in an identifiable state (Huisman et al. 2012).

Cooking pits are known ethnographically from several cultures around the world and several likely archaeological cases, known as cooking pits, drying ovens, earth ovens, roasting pits, etc. (vid. Fretheim 2009; Peacock 2002). Important advantages derive of using cooking pits over cooking hearths: other domestic activities might be carried out whilst cooking, without having to pay much attention to the food, and considerable amounts of fuel might be saved (Wood 2001). The shape and size of cooking pits depends on the type and quantity of foodstuffs cooked, the intensity of use (number of reuses) and the cooking technique employed (Groenendijk 1987; Peacock 2002). All these factors also influence the type of remains that can be recovered from cooking pits. Cooking pits can be easily recognised, but not exclusively, as low cones with small craters in the middle (Peacock 2002).

A so-called cooking technique, that does not require the use of fire, consists of leaving the foodstuffs in the pit to ferment and acquire flavour (Sigaut 1988). Pits might be used to reduce the bitterness of the acorns and nuts by burying them for several months (Miyaji 1999). This type of cooking leaves spoilt foodstuffs at the bottom of the pit, which can be left there if the pit is not going to be reused or can be removed by hand or by firing. This latter case might result in the charring of some elements and thus be preserved archaeologically.

Fire pits are usually characterised by thermoaltered walls or wall-linings (depending on the length of the cooking process) and a mixture of charred plant macroremains, thermoaltered bones, fire-cracked rocks, ashes and charcoal. The charred plant macroremains remaining would rarely be part of the foodstuffs processed, unless in the case of food-preparing accidents they would rather be part of the matting. However, when cooking in wall-lined pits, the carbonisation of plant foodstuffs would be easier because of the reducing atmosphere (Fortó, Martínez & Muñoz-Rufo 2008). The quantity, position and species of charcoal vary according to the type of cooking technique: e.g. Pinus is a preferred wood fuel for lengthy and slow fires; embers can be left to run out or be extinguished (Groenendijk 1987) and charcoal fragments can appear above or under stones (Peacock 2002). Thermoaltered walls or wall linings and bottoms would only be present in the case of lengthy fires (Roudil 1989 apud Salavert 2010).

The use of fire pits for plant cooking is usually intended for complex carbohydrate foods that require prolonged cooking, such as some roots and bulbs; whilst easily cooked food might be placed directly in an open fire over the coals without the need for a special preparation (Thoms 2003). Depending on the
type of plant, foodstuffs might be left cooking and cooling within the pit from half a day up to two days (Peacock 2002). 5 types of pit-cooking techniques exist (Gascó 2003), depending on the desired form, length and temperature of the cooking and the cultural traditions (in some cases, the use of a pit might be dispensable). Sand, stones and vegetable mattings and wrappings (bark, broad leaves, ferns, etc.) are frequent elements in pit cooking:

- **Smoking:** the bottom of the pit is full of smoky embers and foodstuffs are placed over a piece of wickerwork, made of plants such as willow or hazel (Groenendijk 1987).

- **Steaming:** stones are placed at the bottom of a pit and branches are lit under or above them to heat them, then a stick is placed in the middle of the pit and the foodstuffs are placed over the stones and covered with a matting material, the stick is removed afterwards and water is poured through the aperture left by the stick, reaching the heated stones and producing steam (Peacock 2002; Reinhard & Bryant 1992).

- **Roasting:**
  - the foodstuffs are placed within the pit and are covered by a layer of *e.g.* sand and a fire is lit on top (Mithen & Score 2000);
  - embers are made at the bottom of the pit and are covered by a heat conductor, such as sand or stones (alternatively, the pit can be filled with branches and covered by stones and then the branches can be lit), then foodstuffs are placed on top and covered by a plant matting (*e.g.* Groenendijk 1987; Holst 2010; Senna-Martínez & Quinta-Ventura 2000; Peacock 2002);
  - stones are placed at the bottom, a fire is lit above the stones, the unburnt wood is removed, then the foodstuffs are placed on top of the stones and ashes, covered by some plant matting layer, and are left there to cook (*e.g.* Hildebrand 2003; Moore *et al.* 2010; Peacock 2002);
  - ceramic cooking (*e.g.* Thoms 2003; Vaquer *et al.* 2003).

- **Frying** (Gascó 2003) with animal or plant oils.

**Dyeing**

Dyes from plants can be produced by simple fermentation in water, mixing with acidic substances (*e.g.* alum) or decocting (Rivera Nuñez & Obón de Castro 1991a). The colouring substances (leaves, flowers, stems, nuts, etc.) are normally gathered, left to dry, pounded and introduced into water.
Fibre extraction

Stems for fibre extraction are best harvested in late summer when they have reached their maximum height, but before the leaves have dried out (Hurcombe 2008), they then have to be retted, in periods ranging from weeks to months, and broken to free the fibres (Zohary, Hopf & Weiss 2012).

The production of string along with simple knowledge of knotting, weaving, and looping, make possible a wide range of products including “nets, containers, packaging, baskets, carrying devices, ties, straps, harness, clothes, shoes, beds, bedding, mats, flooring, roofing and walling” (Hurcombe 1994).

Oil extraction

Oil from seeds could be obtained by decantation, i.e. crushing the seed, pouring hot water and scooping the oil after setting (Zohary, Hopf & Weiss 2012). For example, oil-flax extraction might involve the roasting of the seeds, which are then ground on a millstone until a flour-like product is produced, and finally the dough is mixed with water, put in baskets and pressed with a wooden beam for a day to extract the oil (Larsson 2013).

4.3.3 Preservational issues: differential preservation

The differential preservation of different plants and plant parts, according to the way in which they are treated and their own characteristics, influence the quality and quantity in which plant macroremains are recovered in archaeological sites.

No age preservation limit exists for plant macroremains in the archaeological record, providing the different conditions for allowing the several preservation forms are met: from fossilised plant remains (e.g. Olduvai Gorge, 1.7-1.8 Ma, Bamford 2012); Pakfield, 700 ky, Parfitt et al. 2005), waterlogged (e.g. Gesher Benot Ya’aqov ca. 780 ky, Goren-Inbar et al. 2002), to carbonised (e.g. Douara cave, 55-67 ky, Matsutani 1987; Kebara, 45-60 ky, Lev, Kislev & Bar-Yosef 2005). In the Iberian Peninsula, Pleistocene plant macroremains are scarce in archaeological sites, but this is probably due to an anthropic recovery bias, rather than preservational: Gorham and Vanguard (Gale & Carruthers 2000), Nerja (Badal-García 1998; Badal García 2001) and El Niño (García Moreno et al. 2014).

4.3.3.1 Depositional issues

Different depositional related events might help or hamper the preservation of different plants or plant parts.
Part I: Framework

4.3.3.1.1 Digestion and dispersion

Many seeds are able to survive animal digestion, depending on the animal (type, age, type of digestion) and seed characteristics (size, shape and hard-seededness). Moreover, plant material included in dung, a reduced and more protected context, may be more likely to survive fire exposure than loose remains (Wright 2003); coprolites often contain fragile plant remains that otherwise would not be recovered, such as fragments of acorn shells (Wakefield & Dellinger 1936 *apud* Reinhard & Bryant 1992). The recognition of plant parts that have been digested is relevant for the interpretation of plant assemblages in archaeological sites. This might be possible when the plant part has been somehow affected by digestion or if it is recovered within coprolites. Identifying the animal originating the coprolites is also relevant, as the diet and feeding strategies of domesticated animals might be partially reconstructed. This identification can be sometimes done based on pellet shape, size and composition; and colour and smell (after rehydratation) in the case of desiccated specimens (Reinhard & Bryant 1992).

Certain animal coprolites are mistakenly determined as seeds at first sight because of their cylindrical shape and small apex in one of the ends (Scott *et al.* 2010). Seeds and plant parts from animal dung are often recovered in a mineralised state as calcium phosphate, as the phosphate content in faecal pellets is high and promotes mineralisation (Hansen 2001).

Human

In certain cases, it is difficult to distinguish human from non-human coprolites, especially with crushed or fragmented samples, and because of the great variety of shapes and sizes of human faeces, partly depending upon the diet: they can appear as large segmented pellets, cylindrical masses, or as amorphous pads (Reinhard & Bryant 1992). In general, the only coprolites that are certainly of human origin are those extracted from human mummies or burials. Different plant tissues show heterogeneous survival capacities (Holden 2001):

- Plant tissues usually surviving digestion: lignified, suberised or strongly cutinised cell walls (*e.g.* seed coats, fibrous tissues, stone cells, fruit epicarps, cork layers, etc.).
- Plant tissues that may or may not survive digestion depending on conditions: thickened cellulose walls with only slight lignification or a loose association with a cuticle (leaf or stem epidermal tissue) and dense storage parenchyma rich in oil and protein (the embryos of some seeds, nut kernels, etc.)
- Tissues that will not survive digestion under normal circumstances: ground tissue of most plant organs (roots, stems and storage parenchyma).

Some seeds, those that have a hard outer coat, survive human digestion (Calder 1977) and are defecated almost unchanged, with other food remains and indigestible elements (Carrión *et al.* 2004). Sometimes, empty seed coats are recovered. Even after grinding and mastication, many types of testa are identifiable (*e.g.* the case of cereals, Körber-Grohne 1964). However, in cases where the seed coats are ground or heavily masticated, evidence is lost. Moreover, the seeds of fruits containing large pits are not usually swallowed with the fruit. Legume seeds present special problems of interpretation: they are...
usually completely or near completely digested. Leaves, roots, tubers, and bark are not commonly found
in human coprolites. Food preparation techniques can sometimes be inferred from seed remains in
human coprolites. (Reinhard & Bryant 1992)

**Animal (non-human)**

Animals acting as seed dispersers might account for the appearance of seeds of diverse plants at
considerable depths in soils, of seeds of past vegetation to the soil surface and of seeds of ecologically
constraint plants outside their natural distribution area. Worms are important vertical underground
dispersers (Forey et al. 2011); whilst above-ground, ants and beetles are short-distance dispersers (de
Vega et al. 2011; Wolff & Debussche 1999) and mammals, reptiles and birds medium to long-distance
dispersers, from some hundred metres to several kilometres, even thousands of kilometres in particular
cases (Proctor 1968), depending on the intestinal transit time and home range size (Debussche &
Isenmann 1989).

To facilitate conclusions about dung as a source of archaeological seeds, it is advisable to collect data
from a specific study region and its associated environmental zones: seed taxa in dung differ depending
on the animal species (both because of the survival to digestion and because certain plant taxa may be
preferred by certain animals), the season of the year, and the region (Hastorf & Wright 1998).

Coprolites might be used as a general dietary proxy, but not for the immediate diet before death, as
differences exist in the time that takes each product to pass the digestive tract, depending on the animal
and foodstuff (Badal & Atienza 2008): the majority are excreted on the second and third day after
consumption, with small numbers still found on the eighth day (Akeret et al. 1999).

Some arthropods produce oblong faecal pellets (Scott et al. 2010) in which plant tissues are not
recognisable: the taxonomical distinction of the producers after the morphology of the pellets needs
further studying, as it might prove an interesting taphonomical proxy in co-occurrence with other
charred plant macroremains from the same archaeological contexts.

**Frugivores**

It is often proposed that carnivore coprolites, which can be identified by their hard outer coating of
dried intestinal lubricant secreted as protection for the intestinal wall, are scarcely interesting for
archaeobotany as they rarely contain plant macroremains (Reinhard & Bryant 1992). However, most
(at least current) carnivores eat fruits with certain assiduity, and act as frugivores, dispersing their
undigested stones and seeds. Some herbivores are frugivores as well (Fedriani & Delibes 2009a).
Frugivorous animals should not be considered in a strict sense, as different animals can act differently
towards different plan taxa (Torroba Valmori 2013).

Birds, lizards and other frugivorous animals (specialised or non-specialised) eat whole fruits (Torroba
Valmori 2013), of which the meat is digested and the seeds and stones are usually excreted, either
within droppings (in mammals such as foxes, badgers, boars, martens, deer or rabbits), or regurgitated
pellets (some birds, such as corvids and gulls) (Debussche & Isenmann 1989). These seeds might be
found in archaeological sites, either in dung used as fuel, in droppings of visiting animals or within stomach contents of consumed animals. Even the human consumption of chyme, stomach contents, intentionally or not, or even fresh dung, are possibilities backed by ethnographic, and possibly archaeological evidence, that must be taken into account (vid. Buck & Stringer 2014). Depending on the environment (Perea et al. 2013), the seeds of fleshy fruits can be present in more than 50 % of faecal pellets. These seeds are mostly undamaged despite great differences in gut-passage time (Calviño-Cancela 2004), although slight differences in coat thickness and permeability might occur (Torroba Valmori 2013). However, preservation greatly varies with the animal and seed: deer destroy about half of ingested seeds; rabbits act mostly as seed disperser for some fruit-bearing plants and mostly as seed predator for some others (Perea et al. 2013). Lizards feed primarily on insects and small vertebrates, but also act as seed dispersers of several fleshy-fruited plant species (Piazzon et al. 2012; Torroba Valmori 2013). Rosaceae and Caprifoliaceae are the fleshy-fruited species that are preferred (Debussche & Isenmann 1989) but a wide repertory of dispersed seeds are known (Torroba Valmori 2013). Seeds coming from pigeon digestion are easy to detect when accompanied by crop stones (Ramsay & Tepper 2010), otherwise their appearance is not particularly determinant.

In addition, the existence of frugivore insects, such as beetles, capable of dispersing undamaged small seeds from fleshy fruits, has been recently discovered (de Vega et al. 2011).

Granivores

Granivores (insects, particularly ants; birds, mainly Turdidae and Corvidae; and other small mammals, mainly Mustelidae) might be responsible for the presence of seeds in archaeological sites, either by creating stores of seeds that are eventually uneaten, by creating middens of excreted undigested parts of seeds (Aronne & Wilcock 1994; Wolff & Debussche 1999), by carrying the seeds within them when hunted and eaten by humans (e.g. pigeons store in their craws diverse types of seeds for delayed consumption, Vaquer & Ruas 2009), or by transporting and burying the seeds in mammal faeces (de Vega et al. 2011).

Worms are important vectors for the spread of seeds all along the soil profile and seed germination as well, but some seeds which have passed through earthworm guts might show physical damage due to the chemical damage associated to digestion (Forey et al. 2011), the proportion surviving digestion might vary between 30 and 100 % of the seeds ingested, depending among other factors in their reingestion (Tryon 2006). Seeds selected by earthworms are usually <2-3 mm, depending on worm size and species-specific dietary habits; shape, surface structure and smell/taste might also be important selective factors; seed of annual herbaceous plants are generally preferred to grasses (Hansen 2001). In fact, earthworms might also be responsible for the selective removal of carbonised small seeds (<2 mm) from soil layers (Tryon 2006). Depending on the worm species, the ingestion of organic detritus can occur near the surface or at considerable depths, and the excretion above or below ground (Tryon 2006).
Herbivores

The faeces of herbivores are often easily recognised by their shape, size and the predominance of grass and other plant remains, from soft tissues, such as leaves and stems, to hard tissues such as wood, bark and seeds. Low-growing plant species are adapted to herbivore ingestion for their reproduction; whilst seeds of high-growing species are hardly ever able to survive digestion (Gardener, McIvor & Jansen 1993). Grazers select the most palatable species: heavy grazing favours the least palatable populations (Butler 1995). Seeds might be transported whole (Bottema 1984) but generally are extremely fragmented, particularly during chewing by ruminants (Poppi, Hendriksen & Minson 1985).

Horse and cow coprolites are grass rich, loose and rarely preserved as pellets. Cattle faeces should not contain fragments much larger than 2 mm (Poppi, Hendriksen & Minson 1985). In general, legume seeds pass better than grasses. Factors influencing how (in quantity and quality) are: weight, size (positive, and relative, depending on the orientation) and proportion of hard seeds (causing them to be retained longer) (Gardener, McIvor & Jansen 1993). When cattle is fed branches for fodder, even though they only eat the leaves and the smaller branches, the wood of bigger branches might be added to dung by trampling and admixing (Robinson & Rasmussen 1989).

Sheep and goat faeces are the richest in seeds, compact and in pellet-shape. Although sheep and goat faeces are sometimes separated by their shape (Rasmussen 1993), the variability of sheep, and especially of goat, droppings is great and the overlap in size and weight can be complete: this is probably connected to the variability of environments and diets to which they are exposed, it is therefore probably better to limit comparisons to specimens from similar environments (Linseele et al. 2010). Between 0.8 and 55.5 % of seeds/fruits fed to small ruminants can be recovered in faeces (Akeret et al. 1999). Sheep and goat produce on average about 30–40 droppings at a time (Linseele et al. 2010). Goats graze less discriminately, and a greater range of plant taxa appeared in their dung (Hastorf & Wright 1998), as well as wood (Robinson & Rasmussen 1989). Both of them are able to chew and digest whole wheat grains and the size of items passing the rumen undigested is smaller than that of cows (Robinson & Rasmussen 1989). Cereal chaff is fragile and hardly ever survives after sheep and goat digestion (Valamoti & Charles 2005).

4.3.3.1.2 Carbonisation and distortion

Fire-carbonised carpological remains are subfossil, the real fossils are those that have experienced a geological carbonisation (Zohary, Hopf & Weiss 2012), the term subfossil is sometimes used to refer to recent intrusions, usually uncharred, in archaeobotanical samples.

Plant remains exposed to a heat source can be transformed into charcoal (quasi-inert and black charcoalfied material), carbonised (in the absence of air, i.e. oxygen) or incompletely charred (in the presence of a restricted supply of air, i.e. oxygen) (Braadbaart, Poole & van Brussel 2009). Charcoalfied plant material is not pure graphite-like carbon but aromatic compounds or polycyclic hydrocarbons: this has important bearings on preservation, as it is almost inert but not completely (Huisman et al. 2012). Charcoal formation is related to temperature, length of exposure to the heat source and heating rate (Braadbaart, Poole & van Brussel 2009). Carbonisation might be achieved either at high and low temperatures: a long exposure time (50 minutes) and a limited supply of oxygen
are crucial at low temperatures (around 300 °C), at high temperatures (above 500 or 700 °C) carbonisation is very rapid (Bowman 1966 *apud* Boardman & Jones 1990; Wilson 1984).

Carbonisation can occur in relation to both human burning activities and wildfires, as flame temperatures of natural fires range from less than 300 to more than 1000 °C, but are typically 400 °C (Yang *et al.* 2011). Although it has been considered that seeds will rarely come from natural fires (Miksicek 1987), all plant parts might be charred and preserved in such events (Scott *et al.* 2000).

Capacity for surviving fire-exposure and achieving carbonisation, in a sufficiently good state of preservation as to allow the researcher to identify the remain (Wright 2003), vary between plants and plant parts and depend greatly upon moisture content. Some charred plant remains can even contain ancient DNA and other biomolecules (Jones & Colledge 2001). Wood is the only plant macroremain that can stand a temperature of 900 °C for an hour; nutshells are near in resistance (Lopinot 1984 *apud* Wright 2003). Alternating periods of heating and cooling and progressive heating are more conductive to preservation than prolonged periods of sustained heat (Goette *et al.* 1994). Plant parts should not have direct contact with the flames, an abrupt temperature rise leads to the appearance of bubbles within seeds, especially in oleaginous ones, and they can explode in order to free the gases (Téllez & Ciferri 1954), become reduced to ashes (van Zeist 1987), or secrete the liquid contained within the endosperm (Renfrew 1973), forming a crusty band, highly vulnerable to erosion, around the perimeter (Wright 2003). Other key elements that are also detrimental in the preservation by charring of plant remains are size and density (Jones 1991) and amount, *e.g.* isolated vs. assemblages (Antolín i Tutusaus 2012).

Consequently, an important representation bias exists towards plants more easily carbonised (siliceous, dense and hard, such as hard coated seeds, cereal grains and fruits), over those rich in water or oils (such as leaves, roots, sprouts or cereal chaff) (*e.g.* Bakels 1995; Boardman & Jones 1990; Hillman 1981; Kubiak-Martens 2002; Zapata Peña 2000; *vid.* Figure 37). Furthermore, those taxa that yield by-products that can be used as fuel in hearth-fires (Scarry 1986 *apud* VanDerwarker & Peres 2010) and those that are prepared (peeled, cooked, dried, etc.) with the use of fire (Dennell 1976) are over-represented.

### 4.3.3.2 Postdepositional issues

Postdepositional factors have additive, mixing and destructive consequences (Miksicek 1987).

As charcoalfied plant material is not elemental carbon nor inert, as has long been believed (*e.g.* Miksicek 1987), charred plant remains are susceptible to postdepositional preservation issues. If completely charred, *i.e.*, if all the chemical elements in the plant part have been transformed into

THE APPARENT ABSENCE OF CHARCOALIFIED PLANT MATERIAL FROM AN ARCHAEOLOGICAL SITE DOES NOT NECESSARILY IMPLY THAT CHARCOALIFIED MATERIAL WAS NOT PRESENT AT SOME STAGE IN THE PAST: THE SO-CALLED LAYERS OF BLACK CARBON, IN WHICH A NOTORIOUS DEFICIT OF IDENTIFIABLE CHARCOALIFIED MATERIAL IS FREQUENT, IS USUALLY A RESULT OF THE ACCUMULATION OF CHARCOALIFIED FRAGMENTS RESULTING FROM LONG-TERM DEPOSITION IN AN ALKALINE ENVIRONMENT (BRAADBAART, POOLE & VAN BRUSSEL 2009).


4.3.3 Recovery

Finally, the process of excavation in itself might affect the preservation of plant remains: in excavations where the recovery of small archaeological items is intended to be carried out in situ (not in sieves), scraping the soil with steel and wooden tools is a common practice, and this is very aggressive for fragile carbonised plant material (ANTOLÍN & BUXÓ 2011; FAIRBAIRN 2013).
5 Complementary sources for archaeobotany

The interpretation of the carpological assemblage from a particular context requires the employment of several sources of interpretation, from the purely archaeological geologically-based (taphonomy) to analogy (ethnography, experimentation and ecology).

5.1 Ethnographical and experimental analogy

Archaeological methodology in general, and particularly archaeobotany, is closely related to two disciplines: experimental archaeology and ethnoarchaeology. The role of these two disciplines is important in all stages of archaeobotanical research, in some cases being even indispensable. Therefore, an important part of this thesis relies on both experimental and ethnoarchaeological studies, carried out by the author for the specific purpose of this work or published by other researchers.

Both ethnographical observation and experimentations are the main source of inspiration for the comprehension of the potential role played by plants in human societies and for the interpretation of archaeological contexts and remains. Experimental archaeology has an advantage over ethnoarchaeology: the direct control of the intervening variables by the archaeologist. They both contribute to the improvement of the analytical techniques, either as a source and a method for testing interpretative hypotheses (taphonomical, socioeconomic, etc.). Their usefulness resides purely in our confidence in analogy, a two-fold assumption. The role of analogy in archaeological interpretation has been long and extensively debated (Ascher 1961).

The first assumption is that prehistorical formation processes can be understood from the present day, the way in which things get deposited and buried and the natural processes of decay or preservation of matter not having changed. For the improvement of the analytical techniques, modern plant assemblages are deposited, following controlled experiments mimicking potential archaeological cases, or during real practices ethnographically studied. Because the processes of decay and preservation of matter have not changed over time, comparing what was deposited and how, to what is recovered and in which particular form in the modern example, is able to determine how much information, in terms of quantity and quality, might get lost in archaeological sites from deposition to recovery and what proportion of this loss is related to the employment of certain analytical techniques. This allows an evaluation of how reliable are each recovery, identification or quantification techniques that can be employed, in order to determine the best set of practices for each specific type of context, form of preservation, abundance and state of preservation of the remains, etc.

Secondly, a limited repertoire of ways of doing things in non-mechanised societies exists and the ways in which things were done in the prehistorical past can be suggested with certain confidence when similarities occur between different elements of the partially-known archaeological record and the well-known directly observed ethnographical or experimental record. This reliance on analogy has, unfortunately, one main methodological objection: the fact that some types of archaeological remains might closely resemble those obtained through an experiment or ethnoarchaeological study does not exclude the possibility of other now unfathomed actions producing similar remains (equifinality or
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presentism). Particularly, the ways in which plant types and species might be used and transformed (from acquisition to processing according to the final function) are studied, according to the information provided by modern or submodern societies ethnographically studied or through controlled experiments, usually inspired by other ethnographical observations.

5.1.1 Ethnoarchaeology

Ethnoarchaeology is the study of ethnographical evidence, particularly material, for a better comprehension of the archaeological one. “Ethnographic data have a strong role to play in opening up multiple possibilities for processes and the other world views which they may incorporate” (Hurcombe 2008). Ethnoarchaeology provides references of how traditional activities can be carried out with the limitations imposed by a particular degree of technological knowledge. “Skills are constantly being re-invented throughout the ages, and then forgotten again when no longer required” (Wood 2001). Several referential works gather ethnographic evidence about agricultural processes in non-mechanised societies, in order to achieve a deeper understanding of the archaeological record, and have been used in this thesis (e.g. Hillman 1984-1986; Peña-Chocarro 1999; Peña-Chocarro & Zapata Peña 1999; Valamoti, Moniaki & Karathanou 2011). Additionally, informal non-structured interviews have been carried out to complement some of the existing information regarding the traditional ways in which certain plant resources might have been exploited by past societies (e.g. - Corylus avellana L., p. 224).

5.1.2 Experimental archaeology

Experimental archaeology, in the concept of archaeology by experiment, can be a highly controlled research activity, with specific measurements and systematical recording of observations providing quantifiable data (vid. Outram 2008). The measurements do not necessarily need to be continuous and of great precision: an order of magnitude might suffice for a qualitative assessment (Hurcombe 2008). “The information produced by practical experiments is by no means devoid of personal perception and social content. Experiments can elucidate the possibilities of the acts of making material culture as the highly social concepts of technological choices, chaînes opératoires and taskscapes” (Hurcombe 2008). In this thesis, experimental work by other authors has proved essential for obtaining clues on the significance of plant remains and their charred preservation in archaeological deposits (e.g. Alonso et al. 2013; Boardman & Jones 1990; Braadbaart 2008; Cunningham 2010; Valamoti 2002). Additionally, some experimentations have been carried out with the purpose of obtaining criteria which might allow a functional interpretation of certain plant remains (e.g. - Chamaerops humilis L., p. 219; López-Dóriga 2015).

5.2 Ecology

The information provided by two aspects of purely-biological botany, autoecology and syneocology/phytosociology (e.g. Bouby 2000), is sometimes useful for the understanding particular exploitation patterns. Because both of the disciplines have their limitations when applied to
archaeological cases, a combination of the two seems more reliable (Jones 2002a). In this thesis, plant ecological affiliations have been assigned to very general categories (vid. Table 76) following the main work of Iberian flora (Flora iberica 1986+).

5.2.1 Synecology/phytosociology

Phytosociology is a discipline that studies plant communities or associations (phytocenoses) and their environments, i.e., the characteristic plant groups in each type of biotope (with its specific soil type, climate and topography). The identification of the different landscapes (vegetation mosaic), including cropfields, exploited by past human groups is its main interest for archaeobotany (e.g. Bouby 2000). However, certain methodological problems exist: firstly, some plant species can grow in secondary habitats and appear in different plant communities, only a few diagnostic species are appropriate proxies; secondly, it is possible that the ecological requirements of plant species and groupings have changed over time, particularly because of human impact; and thirdly, the main problem, the thanatocenosis (the charred archaeological assemblage) is not an exact representation of the palaeophytocenosis (the past community of plants of a biotope), but an artificial association of plants from different habitats related to different activities, as a result of human intervention (Hillman 1991), very difficult to individualise (vid. p. 132).

5.2.2 Autoecology

Autoecology studies the environmental demands and preferences of each plant species (climate, luminosity, soil, water, etc.). Many archaeobotanists rely on data from Central Europe (Ellenberg et al. 1992) which is not necessarily generalisable to the Mediterranean of the Atlantic regions. The main unsettling problem in autoecology is that many plants have unknown natural requirements (particularly those weeds that have lost their original habitats because of the anthropisation of the environment, obligatory weeds Zohary 1950), requirements that vary greatly according to the degree of competition from other plants or requirements that are unspecific (e.g. Bouby 2000).

5.2.3 FIBS

FIBS (functional interpretation of biological surveys) studies easy-to-measure plant attributes related to plant ecology (such as maximum canopy height, maximum canopy spread and maximum dry leaf weight per node) to establish functional groups sharing a suite of characteristics which can be recognised in different plant associations and are functionally related to habitat productivity, allowing for the recognition of anthropic variations which might point to the existence of agricultural practices such as irrigation, fallowing, crop rotation, manuring, etc. (e.g. Bogaard, Jones & Charles 2005; Charles, Jones & Hodgson 1997; Jones et al. 2005). The potential existence of functional types related to several ecological characteristics limits its usefulness in characterising agrarian systems.
6 Other archaeobotanical sources

The various kinds of subdisciplines that study archaeobotanical remains (anthracology, carpology, phytolithology, palynology, etc.) are usually grouped according to the methods of observation, recovery, and analyses employed, thus leading to the separation of micro and macroremains and chemical and molecular evidence (Pearsall 2000; Wright 2010). However, other and more ample classifications, including not strictly botanical evidence, are interesting as well (Rivera Núñez & Obón de Castro 1991a based on Dimbleby 1967(1978), Evans 1978, Ford 1978b). In this work, a modified melange of both ways of classifying is suggested.

6.1 Direct sources

These are strictly plant remains, including micro and macroremains.

6.1.1 Micoremains

Tiny plant parts (smaller than 5 µm, according to Rivera Núñez & Obón de Castro 1991a) that are visible only under high-power magnification (Wright 2010).

6.1.1.1 Starch granules

Starches are sub-cellular food storage units, composed of two organic polymers, amylose and amylopectin, which form a series of laminated layers around a central hilum (Coil et al. 2003). All plant organs contain starch, but the richest are storage organs such as seeds and underground organs (tubers and bulbs). Starch grain morphology is genetically determined and varies at family, genus or species level: for that reason, the establishment of criteria for the specific determination of starch grains is still in development for certain groups (e.g. Aceituno Bocanegra & Sáez 2012).

Starch granules remain in situ when plants, decompose, but are vulnerable to heating at high temperatures. Activities that can produce starch grain deposition are food plant processing, cooking, consumption and discard. Alteration patterns might be discerned in starch grains, possibly in relation with plant processing (e.g. Mercader 2009; Henry, Brooks & Piperno 2011). Starch grains might be preserved when other plant remains are not, the limit of preservation has been up to 20 ky, although some recent older discoveries launch the date considerably backwards: a 105 ky site in Mozambique (Mercader 2009), Middle Palaeolithic Shanidar cave (Henry, Brooks & Piperno 2011) or several Upper Palaeolithic European sites from 30 ky (Bilancino II, Kostenki 16–Uglyanka and Pavlov VI, Revedin et al. 2010) and Ohalo II, 23 ky (Piperno et al. 2004; Nadel et al. 2012).
6.1.1.2 Palynology: Pollen and NPPs

Palynology studies pollen grains and non-pollen palynomorphs such as spores, cellular tissues, chrysophytes and diatoms (unicellular freshwater and marine algae). It is a palaeoenvironmental proxy useful for the detection of very general processes in landscapes (such as anthropisation: creation of forest clearances, introduction of exotic flora, existence of crop fields, etc.) and the environments of archaeological sites (vid. López Sáez & Peña Chocarro 2008). Pollen grains are the reproductive male gametes of flowering plants; spores are produced from fungi and non-flowering plants, such as mosses, ferns and algae. The decay-resistant portion of both pollen and spores is composed of sporopollenin, an organic compound (Coil et al. 2003). Cellular tissues are different undecomposed plant cells within the non-mineral fraction of soils, such as cellulose rings, stomata cells or trichomes (Coil et al. 2003). Diatoms are single-celled algae that exist in nearly any condition where moisture is present, (including fresh and salt water, soils, tree trunks, brick walls, and clay deposits) and produce opal silica frustules, or ‘shells’, with taxonomically distinctive morphologies (Coil et al. 2003). Chrysophytes are an order of algae which produce two types of durable silica ‘shells’ known as scales and cysts, which are starting to be studied (Coil et al. 2003).

Because of their distinctive morphologies and surfaces, fossil pollen and spores can often be taxonomically determined with a high degree of precision, although this might vary from taxa to taxa: whilst in some cases species level determinations are straightforward, in others it reaches generally unspecific terms [e.g. Cerealia, vid. Behre 2007]. The preservation of pollen and spores over time is affected by the depositional environment: important interspecific differential preservation phenomena might occur, particularly in dry sedimentary contexts (Coil et al. 2003). Moreover, pollination rain is very heterogeneous, according to different taxa, landscapes and seasonality, under certain conditions different types of pollen grains might be destroyed and contamination is difficult to detect (Rivera Núñez & Obón de Castro 1991a. However, in some specific cases it is more archaeologically meaningful [economical pollen, (Rivera Núñez & Obón de Castro 1991a], as when it is recovered from the inside of vessels, scrapped from tools, in mud bricks, tombs (Leroi-Gourhan 1975), mummy wrappings, the guts of preserved bodies, fossil faeces, etc. The oldest pollen recovered from a closed archaeological context is from a burial at Shanidar IV cave, Iraq (Leroi-Gourhan 1975, contested by Gargett 1989 and Sommer 1999).

6.1.1.3 Phytolithology: phytoliths

Two types of phytoliths might be recognised in archaeological deposits: siliceous ones, which are casts of individual or aggregated cells or intercellular spaces, or calcium phytoliths, made of calcium carbonate or calcium oxylate (Coil et al. 2003). Phytoliths are produced by the above-ground parts of silica-accumulating plants (some ferns, as well as gymnosperms and angiosperms) and are released when the plant tissues break down following decomposition. Silica phytoliths are considered the most durable of all plant remains: as they are inorganic, they are resistant to decay, and to mechanical breakage and only a high pH (> 9) is detrimental to survival. Calcium phytoliths are less likely recovered and identified, as they particularly fragile in acidic soils and laboratory manipulation (Coil et al. 2003).
The ability to correlate individual phytolith forms with taxonomical groups is highly variable. They can sometimes be identified to family or species level, but more often just to assemblages, families or tribes and plant parts, as different plants produce similar and heterogeneous phytoliths in their different plant parts. Phytoliths can be common in hearths, silos, threshing floors and ash layers (Huisman et al. 2012), but they can also be found inside pottery, plaster, and even on stone tools and animal teeth. The form of preservation can give hints about specific practices: clear cut phytoliths can point to the uses of threshing sledges in threshing floors (Anderson 2006).

As with starch granules, the preservation time limit for phytoliths has been put at 20 ky, but recent older discoveries would make a reconsideration necessary: El Abric Romani (Allué et al. 2012), Hayonim (Madella et al. 2002). Moreover, methods for dating phytoliths are being developed (Boaretto 2009; Rapp & Mulholland 1992).

6.1.2 Macroremains

Complete or fragmented plant parts that are either visible to the naked eye or with a low-power microscope (Wright 2010; bigger than 500 µm, according to (Rivera Núñez & Obón de Castro 1991a). Their recovery from archaeological contexts may involve hand collecting, screening, or flotation.

6.1.2.1 Silica skeletons

Sometimes, charring destroys the cellulose material within a plant part but the siliceous content from the cell walls survives if no mechanical postdepositional forces intervene. Thus, sieving or flotation is detrimental to the survival of these plant remains (Rivera Núñez & Obón de Castro 1991a).

6.1.2.2 Imprints

Plant imprints may appear in pottery, clay linings and floors and pisé/adobe. This can be either superficial or structural (Rivera Núñez & Obón de Castro 1991a). Three general categories are distinguished among the former (Hurcombe 2008): chance impressions, impressions which occur as a consequence of the production process and are allowed to remain, and impressions which have been deliberately added as decoration.

Imprints located in the walls of pits lined with clay inform about the food-plants contained within.

Imprints in vessels bases or pisé/adobe inform about the plants involved in the manufacturing process. Pisé and adobe bricks are usually left to dry in the open-air on plant beds, which sometimes, but not necessarily, are composed of food by-products (e.g. cereal chaff). Chance impressions in sherds can be mat impressions on pot bases, basketry and cordage supports during pot construction, wrappings of string or cloth.

Imprints in rough ceramics of early periods or in materials poor in clay are often rather blurred and difficult to identify. However, the impressions can sometimes be preserved distinctly so that a
taxonomically precise identification is possible. The problem then is establishing the provenance of the vessel for documenting the introduction of exotic flora.

### 6.1.2.3 Anthracology

It studies wood charcoal, and can be useful for studying different subjects (Scott & Damblon 2010), among which identifying functional areas, such as hearths, and specific activities, such as fuel selection and forest management (Out, Vermeer & Hänninen 2013), building and tool use (accidentally charred or as a result of fire moulding, Tegel et al. 2012) and tar production. A detailed study of the preservation conditions of the wood charcoal fragments allows the inference of certain practical issues, such as fire temperature in hearths, whether the wood was fresh or dry, etc. Anthracology is also limitedly useful for dendrochronology and C\textsuperscript{14} dating (avoiding the old-wood effect if possible) and a palaeoenvironmental proxy. However, cultural choices (vid. Théry-Pariset, Chabal & Chravzez 2010) and differential preservation (vid. Chrzazvez et al. 2014; Théry-Pariset et al. 2010) might bias the representativeness of wood charcoal analyses. Microcharcoal analyses (Coil et al. 2003; Marquer 2010) try to avoid the bias of differential preservation issues affecting different taxa and depositional environments; however, it might be transported over long distances (Scott & Damblon 2010). Charcoal is as old as human sites, and charcoal from human-made fires is abundant from 600 ky; however, natural charcoal formation is a concern for the distinction of human practices (Scott & Damblon 2010).

### 6.1.2.4 Vegetative remains

Flowers, leaves, stems, etc. These are occasionally preserved in archaeological sites, where special conditions for the preservation for organic matter exist (such as waterlogging, mineralisation or desiccation).

### 6.1.2.5 Parenchymae

Macroremains from nut kernels and vegetative underground storage organs, such as tubers, roots and rhizomes (Hather 1994), composed largely of parenchymatic cells are preserved either by carbonisation or other methods (desiccation, etc.). It is possible to recognise characteristic features under both low and high power microscopy: under low-power microscopy, vegetative tissues are generally amorphous and featureless; the arrangement and form of vascular tissues in parenchymae cells, seen at higher levels of magnification, are the most important characteristics in identifying tissues to family, genus or species level (Perry & Jones 2002). Parenchymae are of problematical preservation and very difficult to identify to species level: due to the eroded surface of most tissue fragments, external morphology is usually not diagnostic and fresh surfaces must be obtained for examination under SEM, ideally oriented along a transverse plane of the tissue (Perry & Jones 2002). Parenchymatic tissue might be preserved in coprolites, but because of the alterations occurred during digestion, they are usually very difficult to identify (Bryant 1974).
6.1.3 Transformed plants

These are plant remains that have been physically changed as to be only identifiable because of certain specific characteristics (Rivera Núñez & Obón de Castro 1991a)

6.1.3.1 Foods, beverages and condiment preparations

Flours (Siret & Siret 1888) made of varieties of plants (cereals, legumes, fruits, etc.) and other seeds or fruits with a taphonomical history (pressed vines, broken grains for bulgur, etc.), sometimes forming crusts within pottery vessels or sticking to lithic mortars. These might be preserved carbonised, desiccated, etc.

6.1.3.2 Plant-technologies

In particular preservation conditions (waterlogging, desiccation, etc.), but usually not by charring, plant-technologies are preserved.

6.1.3.2.1 Plant-fibres

Stems and bark are used with a small transformation, consisting only in torsion or pressing, for basketry and matting. In addition, plant fibres might be extracted from stems and barks in order to produce plant-fibre technologies, such as in woven textiles (Adovasio, Soffer & Klima 1996), cordages (Glory 1959), bedding (Nadel et al. 1994), etc. Plant-fibres are destroyed more easily than animal fibres because of the attack of phytophagous insects (Appleyard & Wildman 1980) but they are often preserved near metallic instruments that have suffered oxidation or in anaerobic sites.

Some very old special cases of plant-fibre preservation are known: in Middle Palaeolithic lithic tools covered with a siliceous microfilm from Abri du Maras (Hardy et al. 2013), the 30 ky-old calcified cordage fragment from Ardales (Ramos & Weniger 2014) and fragmentary fibres from the waterlogged site of Ohalo II (ca. 21 ky, Nadel et al. 1994). Other indirect evidence comes from the imprints of cordage, knots and woven material on clay at several Gravettian sites (Pavlov, Dolni Vestonice, Mezhirich and Kosoutsy) (30 ky, Adovasio, Soffer & Klima 1996; Soffer et al. 2000) and natural casts of rope at Lascaux (ca. 20-18 ky, Leroi Gourhan 1982).

Plant fibres can be identified by examination under high augmentation and chemical methods: white light compound microscopy might be useful for distinguishing between broad categories of fibres (animal fibres, bast plant fibres and non-bast plant fibres). Bast fibres can be extracted from plant stalks or tree bark: flax, hemp, nettle, ramie (an Asian nettle variety), jute, and more rarely, wood (but not cotton) and identified via DNA analyses, the presence of crystals in the associated tissue, polarisation microscopy and x-ray microdiffraction (Bergfjord et al. 2010) and in particular cases, with light microscopy (Kvavadze et al. 2010).
6.1.3.2 Wooden tools

Wooden objects are not preserved in archaeological sites, except when special preservation conditions are involved; some of the most remarkable finds are at the sites of Schöningen (Thieme 1997), l’Aric Romani (Carbonell & Castro-Curel 1992), La Draga (Bosch-Lloret 2005), the Ertebolle culture (Price et al. 2001; Gron & Skaarup 1993), and several sites in Central Europe (Tegel et al. 2012). It seems that some tools exteriorly carbonised might be preserved intact interiorly (Rivera Núñez & Obón de Castro 1991a).

6.1.3.3 Coprolites

Many types of indigestible individualised plant remains might be preserved in coprolites, particularly in latrines, where mineralisation conditions occur or when dung has been used as fuel and has carbonised.

6.2 Chemical and molecular evidence

In between direct and indirect sources, several types of evidence are still involved in deep methodological developments. Chemical and molecular evidence are residuals that can require very different and complex means of extraction and analyses (Wright 2010).

6.2.1 Molecular biomarkers

Molecular markers (residual lipids, proteins and alcaloids), commonly obtained by gas chromatography or mass spectrometry (GC/MS), may be found in different places and their origin identified, and as each plant species has a particular pyrolysis product (Schellekens, Barberá & Buurman 2013):

- derivatives of vegetal origin (dyes, wines, oils, honeys, sugars, resins, tars, pitches, bitumens, etc.) are obtained by physical and chemical processes in such a way that the original structure is unrecognisable (e.g. Burger et al. 2011; Rivera Núñez & Obón de Castro 1991a); residues are the result of the combined action of decomposition and preservation of these derivatives.
- any inorganic porous material that has been in contact with one of these compounds: e.g. pottery vessels of both adsorbed (onto the vessel surface) and absorbed (into the vessel wall) residues can lead to the detection of the processing of plant products (Evershed 2007); smoking pipes (Bruhn et al. 1978; Raffauf & Morris 1960);
- soils and sediments and may serve as proxies for past vegetation composition and crop field use (e.g. Motuzaitė-Matuzevičiūte et al. 2013).

The best preservation conditions are stable, cool, dry and pH-neutral environments. Lipids are considerably more resistant to decay than DNA, proteins, carbohydrates, etc. (Evershed et al. 2001).
6.2.2 Biosignatures

6.2.2.1 DNA

Genomic analyses in relation to plant exploitation can be oriented towards two objects: human remains and plants. In humans, the identification of certain genes has been tentatively associated to the adaptation to particular diets, e.g. amylase and starch rich diets of tubers and cereals (Walker 2007). DNA can also be found in some archaeological plant remains (to trace phylogeny or distinguish between morphologically undistinguishable forms, vid. Schlumbaum, Tensen & Jaenicke-Després 2008) or plant-based compounds (to aid in identification); however, such DNA evidence is often so fragmentary and degraded that it is difficult to amplify. The best conditions for DNA preservation is when plant remains are desiccated; in waterlogged remains DNA rarely survives long and in charred remains, only when temperatures have not reached 250 °C; moreover, samples for DNA analysis are very susceptible to recent pollution (Fernández et al. 2013).

6.2.2.2 Trace elements

Dietary minerals, or mineral nutrients, are the chemical elements required by living organisms; trace elements are dietary minerals needed in very minute quantities. The proportion of certain trace elements in relation with calcium within the mineral part of bones (subjected to age and age-at-death variations), is a palaeounitrional proxy for the identification of herbivorism (mainly strontium and barium) or legume consumption (zinc).

6.2.2.3 Stable isotopes

Isotopic analyses study the distribution of stable isotopes and chemical elements within the chemical compounds present in bioarchaeological remains (bones, seeds, wood, etc). Isotopic signatures and ratios are measured using mass spectrometry: $\delta^{13}C$ is the proportion between $^{13}C$ and $^{12}C$ of the sample in relation to that of the fossil C, whilst $\delta^{15}N$ between $^{15}N$ and $^{14}N$ of the sample in relation to that of the atmospherical N; $\delta^{34}S$ to that of ocean water sulphate ($SO_4^{2-}$). These analyses can be applied to infer several social aspects related to trophic levels and environments, such as palaeodiets, population movements and trade, agricultural practices, etc.

6.2.2.3.1 Palaeodiet

Stable isotopes analyses can be applied to the reconstruction of organisms’ diet and, indirectly, to palaeoenvironmental living conditions. Body tissues and faeces are the target for stable isotope analyses, whose proportions vary with food and the water source. In animals, comparisons might be established between the isotopic values in bones (representing the last years of life of the individuals) and teeth (representing the enamel-development period). Stable isotope analyses have serious limiting
methodological objections: several possible feeding patterns and environmental conditions can produce the same values and values vary with environmental change and the base of the food in each ecosystem, thus it is necessary to check the isotopic baseline for each (Post 2002). A comprehensive intertaxonomical analysis of isotope composition in modern ecosystems is lacking, therefore enough reference data for the comparison with fossil material (for which it would be necessary to remove 1.5 ‰ in δ13C values to adjust the fossil fuel effect of the industrial era) are yet to be obtained and the potential amount of variation and variables intervening in isotope composition are yet to be discovered (Sponheimer, Lee-Thorp & de Ruiter 2007).

δ13C and δ15N values might be measured in bulk collagen and in compound-specific biochemical components.

δ13C and δ15N analyses in bulk bone collagen can help reconstruct the average of an individual’s diet or major dietary trend over the whole life (Pollard et al. 2011) or of that between 10-30 years prior to death (Ascough et al. 2012). δ13C values predominantly reflect the δ13C of dietary protein, with some local variations26; δ15N values of consumer bone collagen also reflects that of dietary protein, with an offset of up to +3.4 ‰ per trophic level (Post 2002), this is known as fractionation (Mestres Torres 2007). δ13C in tooth enamel is thought to reflect dietary carbohydrate composition rather than protein from animals fed on plants (Pollard et al. 2011). Protein sources or diets, are as well influenced by the compartment effect (Mestres Torres 2007), and can be classified as: terrestrial C3 (most ecosystems, typically evidenced in low δ13C and low δ15N), terrestrial C4 (usually seen as an adaptation to hot dry conditions, typically high δ13C and low δ15N), CAM (Crassulacean acid metabolism: succulent plants, with a mixture of C3 and C4 photosynthesis, O’Leary 1988), freshwater (a ± 20 ‰ variation can be expected in δ13C values and the variation of δ15N is not well known yet (Ascough et al. 2012)27, and marine (typically high in δ15N and δ13C, in the Northern Atlantic28). Usually, a large number of trophic levels are frequent in marine ecosystems whilst terrestrial are relatively simpler; moreover, long-lived animals have isotopic signatures spanning long periods (Post 2002). High δ13C values with no elevation of δ15N are usually considered the result of a mixed C3–C4 diet. Isotopic signatures point to the source of long-term, heavy consumption; this should not imply that other resources were not consumed, but rather that they were not consumed in sufficient quantities to significantly affect their bulk isotope values (Honch, McCullagh & Hedges 2012). However, small dietary differences might be detected in some cases, in addition to the difference between C3 and C4 plants, due the offset in isotope values between different plant types and plant parts:

26 Terrestrial plant δ13C values, and hence herbivore tissue δ13C values, show wide geographical variation, as well as freshwater organisms from different freshwater systems and marine biota from different regions with local upwelling phenomena (Ascough et al. 2012). Trophic fractionation of δ13C is assumed to be 0 ‰ in some ecosystems (Post 2002) whilst it is between 10 and 14 ‰ in others, at least in tooth enamel, varying among different types of animals (Sponheimer, Lee-Thorp & de Ruiter 2007), and the portion of the enamel sampled (interior vs. exterior) (Schoeninger 2007).

27 Plants in flowing streams usually have δ13C values around -28 ‰ whilst those in stagnant water around -14 ‰ (O’Leary 1988) but a difference between littoral and pelagic organisms and large and small lakes also exist (Keaveney & Reimer 2012; Post 2002).

28 This might vary accordingly to differences in length in trophic chains, multiplicity of freshwater effects input, etc. (e.g. Petchey et al. 2013)
– the offset between both δ\textsuperscript{15}N and δ\textsuperscript{13}C values in grain and other plant parts might allow to distinguish between animal foddering with chaff and with grain (Fraser et al. 2011; Wallace et al. 2013),

– as fruits tend to be slightly enriched in δ\textsuperscript{13}C (about 1.5 ‰) compared to leaves, it might be possible to distinguish between folivory and frugivory (Sponheimer, Lee-Thorp & de Ruiter 2007).

– Signatures of δ\textsuperscript{15}N can differentiate between legumes (averaging a δ\textsuperscript{15}N of 1‰) and non-nitrogen fixing plants (an average of 3‰) (Schoeninger & DeNiro 1984).

The limitation is that particular patterns can produce unexpected results far from typical [e.g. intensive crop manuring (Honch, McCullagh & Hedges 2012), high consumption of seaweed]. However, “the quality control criterion applied to assess the purity of isolated collagen, i.e. the widely used C/N ratios [1, leaves considerable room for exogenous (contaminating) organic matter affecting bulk carbon and nitrogen isotope values” (Evershed 2007).

δ\textsuperscript{13}C measurements in single biochemical components (aminoacids in collagen) is an underdeveloped but promising analysis that can serve to make important contributions to dietary discriminations, as different aminoacids preserve very different palaeodietary signals, incorporating non-protein dietary carbon (e.g. Evershed 2007; Honch, McCullagh & Hedges 2012). Moreover, it minimises possibilities of pollution (Evershed 2007). δ\textsuperscript{13}C measurements can also be undertaken in lipids and bioapatite. Cholesterol (a lipid widely preserved) is a proxy for short-term diet (Evershed 2007).

The values in sulphur (δ\textsuperscript{34}S) can be combined with those of carbon and nitrogen in order to distinguish between marine and terrestrial dietary sources. Terrestrial plants have reported values averaging around -7 ‰ to +8 ‰ except those in coastal areas, which can exhibit values close to that of seawater (+17 to 21 ‰), due to the effect of sea spray or precipitation. Sulphur isotope values for freshwater sulphate can range widely in different freshwater systems, allowing a differentiation between dietary contributions from terrestrial and freshwater sources in geographical situations where the ranges of δ\textsuperscript{34}S values are distinct and when high human non-marine δ\textsuperscript{15}N values are also present (Privat, O’Connell & Hedges 2007).

The values of δ\textsuperscript{18}O in dental enamel carbonate are measured to track population movements and find the location in which the individual was living at the enamel-development stage. This is so, as the values of δ\textsuperscript{18}O are thought to be related to the oxygen isotope values in the local drinking water; however, distant regions might have very similar values due to similar underlying geology and local biosphere (Pollard et al. 2011) and differences in δ\textsuperscript{18}O values are also related to the drinking water source within the same local environment: if it is consumed with plants, through evapotranspiration in leaves, δ\textsuperscript{18}O values are enriched in comparison to those of meteoric water, whilst if it is consumed through roots and meat, δ\textsuperscript{18}O values are depleted (Sponheimer, Lee-Thorp & de Ruiter 2007).

The potential of Calcium stable isotope values (δ\textsuperscript{44}Ca) for dietary reconstructions is being explored and has promising perspectives: it might be able to overcome the limitations of δ\textsuperscript{13}C values in regards to different plant parts and the distinction between C\textsubscript{3} and C\textsubscript{4} plant consumption, in addition to surpassing the preservation life of other elements, such as Nitrogen and Carbon (Melin et al. 2014).
6.2.2.3.2 Paleoenvironments

Carbon and Nitrogen stable isotope values (δ\(^{13}\)C and δ\(^{15}\)N) can be applied to reconstruct past agricultural environments: if researched in soils, a distinction on the type of plants (C\(_3\) vs. C\(_4\)) that were grown and the development agricultural practices (such as manuring or irrigation) might be inferred (e.g. Wallace et al. 2013), with adequate allowance for natural variability and charring effects. Archaeological data of δ\(^{13}\)C values should be compared to ecological studies of δ\(^{13}\)C values in contemporary organisms from the same ecosystem and the atmosphere, taking into account that charring temperature affects δ\(^{13}\)C, increasing (Poole et al. 2002) or depleting it (Yang et al. 2011), but more significantly in δ\(^{15}\)N values (Fraser et al. 2013a contra Kanstrup et al. 2012).

The δ\(^{13}\)C values of plants depend primarily on the plants’ photosynthetic pathways and physiognomic characteristics, thus varying from species to species and plant parts of the same plant (Fraser et al. 2013a; Yang et al. 2011), and on environmental conditions: in C\(_3\) plants, δ\(^{13}\)C values have been linked to changes in water use efficiency as a response to water stress or abundance. Plant δ\(^{15}\)N values vary considerably, according to the availability of nutrients: manuring cereal crops raises the δ\(^{15}\)N values from below 2.6 ‰ to 6-8 ‰. In domesticated cereal crops, isotope measurements can serve to infer the conditions of growing, such as the use of irrigation or manuring (in legumes only in intensive cases) (Fiorentino et al. 2015; Fraser et al. 2011). Medium δ\(^{15}\)N values between 2.5 and 6 ‰ could reflect several scenarios which would be tested on the weed assemblages: lower levels of manure application over the long-term, the residual effects after a period of intensive manuring, or the early years of a new cultivation regime (Fraser et al. 2011; Fraser et al. 2013b).

The values of δ\(^{18}\)O might be also measured on remains of C\(_4\) plants to infer environmental parameters in agricultural crops (Fiorentino et al. 2015).

Strontium isotopes in bioarchaeological remains are measured to provide geolocation information of different organisms, as Sr is accumulated in plants according to its presence in the local environment. Thus, strontium isotope values (\(^{87}\)Sr/\(^{86}\)Sr) have been successfully measured to track the provenance of foodstuffs and plant remains (Fiorentino et al. 2015; Heier, Evans & Montgomery 2009). However, this method has been criticised as is subjected to a priori preconceptions: “similar data can produce opposite population conclusions” (Bocquet-Appel et al. 2012). The ratio \(^{87}\)Sr/\(^{86}\)Sr can also help recognising the use of fertilisation with seaweed (Frei & Frei 2013).

Equally, the comparison of sulphur values (δ\(^{34}\)S) among the biological community of an archaeological site can help determine the import of beings that were grown elsewhere (e.g. Privat, O’Connell & Hedges 2007).

6.3 Indirect sources

6.3.1 Cultural traces

Cultural traces related in some way to plants (Rivera Núñez & Obón de Castro 1991a) can provide limited but diverse information regarding past human exploitation of plants. In historical times, various
types of literature can also contribute to the knowledge about past plant exploitation, although in a restricted way (vid. López Sáez & Peña Chocarro 2008).

6.3.1.1 **Graphical representations**

Graphical representations, both rock and mobile (in megaliths, pottery, figurines, coins, etc.), are a very particular type of evidence, because it is voluntary and thus selective and subjective, and the reasons for choosing to make them are impossible to know. In historical times, documents containing descriptions and references to plants are added to this type of evidence. So except in the case of extremely realistic and detailed representations, the activity related to plant use and the plants themselves are very difficult to ascertain with precision and its interpretation might always be subjected to divergent views.

6.3.1.1.1 Parietal

In rock art, various types of representations are determined as plants or related to plants: scenes of agricultural activities, such as gathering (Cueva de L’Or, Valencia) or ploughing (Valcamonica and Mont Begó, Switzerland; Bohuslän, Tengeby, Backa and Litsleby in Sweden); crop fields and cereal crops (Ertebolle art, Anderson, 1980); mushrooms (Akers et al. 2011); transformed plants (textiles, ropes and cloths) (Adovasio, Soffer & Klima 1996; Bahn 2010; Castro Curel 1990; Soffer, Adovasio & Hyland 2000); and other related motifs (e.g. Le Roux 1992).

6.3.1.1.2 Mobile

Plants might be inspirational motives for pieces of art, such as acorn ornaments (Rivera Núñez & Obón de Castro 1991a), or form part of the accompaniment of others: human statuettes holding plants (Merlin 2003).

6.3.1.2 **Paraphernalia**

Tools, instruments and other artefacts related to the care, cultivation and use of plants, which can be categorised as specific (for management, cultivation, gathering, transformation, storing or use) or generic (Rivera Núñez & Obón de Castro 1991a).

6.3.1.2.1 **Spatial elements**

Spatial evidence is difficult to ascribe to specific chronologies and its identification is sometimes debatable: field boundaries between different crop fields or animal fields; plough and ard marks (e.g.
Aqdus, Hanson & Drummond 2012; Fowler & Evans 1967); irrigation ditches, *tamuli* from field clearing activities (Bradley 1978), etc.

6.3.1.2.2 Non-vegetal technologies

**Functional typology**

The recovery of certain type of artefacts from specific contexts have traditionally been employed as evidence for the use or certain plants in a particular way; this type or argumentation has been, however, progressively abandoned due to its problems. “Ethnographic data make it difficult to assume that specific [ground-stone] tool types correlate with specific foods” (Wright 1994). A wide range of morphologies may serve the same purpose even within the same human population; others may be used for different specific functions despite being formally identical; others are multi-purpose tools; then there are *ideal* (for the archaeologists) cases where a certain morphology is closely tied to a single function (Stone 2009).

Stone pounding and milling stones have traditionally been associated with domesticated cereal processing, but can be used in many other activities, from other plant product processing to completely different things, such as ochre preparation (*e.g.* Nadel & Lengyel 2009). Moreover, stone technologies cannot be used as the sole proxies for the existence of plant processing activities, as wooden instruments or pits in the ground serve equally well for the same purpose (*e.g.* Fullagar, Meehan & Jones 1992; González-Urquijo *et al.* 2000a). It has recently been hypothesised that stones used for plant processing are imbued with sexual symbolism (Mithen 2007).

*Asturian picks* have been conceived in different literatures as used for limpet gathering, nut cracking, root and tuber digging (Clemente *et al.* in press) or plant smashing and processing (Straus 1979). Experimental programmes have shown that use-wear traces produced by the use of picks for limpet gathering and nut cracking over a stone hammer are identical, but the picks seem to be more efficient for limpet gathering than nut cracking; it is thus considered that nut cracking is less effective when carried out with picks in comparison to unshaped pebbles, and picks have proven to be inadequate for tuber and root digging (Clemente *et al.*, in press).

Pottery has been considered indispensable for the consumption of certain carbohydrate-rich plants that required prolonged cooking (boiling) times, however, other cooking methods that do not require the use of pottery (such as roasting or baking) or boiling with other implements (such as introducing heated stones in wooden, bark or stone containers) are equally effective (Stahl 1989).

**Use-wear**

Use-wear analyses might be able to determine the activity for which artefacts (stone, bone or shell) were used, at least in general terms (osseous, ligneous, or soft material). However, many processes require no tools or the necessary tools could be made of wood or bone and have long use-lives as personal
tools or multi-purpose tools. Use-wear analysis in relation to plant use has traditionally focused on two main aspects: milling and cutting technologies.

Many osseous artefacts interpreted morphologically as hunting implements seem to have been actually used in the production of textiles (Kehoe 1999; Soffer 2004).

Shell tools with use-wear traces similar to those produced in plant processing (Cuenca-Solana, Gutiérrez-Zugasti & Clemente-Conte 2011) have been recognised in several contexts (Cuenca, Gutiérrez-Zugasti & Clemente 2014).

Unfortunately, not all plant or plant parts processed with mortars leave perceptible marks on them (e.g. Roda Gilabert, Martínez-Moreno & Torcal 2012; Goren-Inbar et al. 2002). Still, stones with a characteristic central depression surrounded by abrasions are often interpreted as typical massive nut cracking anvils (Holst 2010), commonly known as pitted-stones, but this premise arises from ethnographical evidence in other world regions with hard-shelled nuts and seems not to be applicable for the Holocene European nuts (Roda Gilabert, Martínez-Moreno & Torcal 2012). Furthermore, this nut assumption can sometimes be contradicted by residue (Breschini & Haversat 1993) or use-wear analyses (Roda Gilabert, Martínez-Moreno & Torcal 2012) or in many other cases remains untested. Stone hammers for cracking nuts occasionally produce fractured and battered stones similar to some Early Palaeolithic industries (Shea 2007). The micropitted surfaces on grinding stones used for cereal processing seem to be clearly distinguishable from those for processing more greasy products, such as nuts, legumes or animal hides (Bofill et al. 2013).

The discovery of sickle elements with a micro-polish attributed to processing cereal straw, cereal polish, has been an important argument in discussions about the origin of agriculture (e.g. Unger-Hamilton 1992), but this has been attenuated with ethnographical (Bohrer 1972; Peña-Chocarro 1996), experimental (González-Urquijo et al. 2000b) and archaeological evidence (Anderson 2013) of other methods of gathering cereal ears, either wild or domesticated. Moreover, ethnographical evidence shows that farmers occasionally use their sickles in other less systematical tasks, such as the removal of weeds from cultivated plots (Carvalho, Gibaja & Cardoso 2013). It is agreed that the appearance of characteristic striations in sickle elements depend on a long list of variables such as the type of plant, its maturity and humidity, cutting-height and duration of use, the type of sickle and the position of the reaper (Anderson 1992). However, the disagreement comes on how to differentiate between domesticated cereals and other non-ligneous plants: it was soon seen that other plants than cereals, such as reeds or sedges, produce sickle gloss (Anderson 1992). These might be differentiable, at least experimentally (Van Gijn 1989). “Experiments with wild (reed, fern, cane) and domestic (wheat, barley) show that undifferentiated use-wear is formed if lithic implements are submitted to a short period of use. […] However, when a higher degree of wear is reached after more intensive use of the implement, the harvesting of cereals creates a completely original series of use-wear, clearly distinguishable from the harvesting of other non-ligneous plants” (Yamada 2000 apud Carvalho, Gibaja & Cardoso 2013). However, the traditional wear trace interpretation categories, such as cereals and reeds, are criticised because of being insufficiently varied, masking a more varied set of patterns, since different but repeated patterns of wear are recorded within such groupings (Hurcombe 2008).

In some cases, the particular nature of certain use-wear marks might be difficult to precise to specific levels (Annelou van Gijn, Annemieke Verbaas, Aimee Little): a Late Mesolithic (it disappears in the Early Neolithic but reappears later) mysterious transversal polish (known as polish #23) results from
processing a non-siliceous plant, but the identification of this plant processing activity remains elusive,
despite a number of experiments (peeling tubers such as *Ranunculus ficaria*; peeling *Trapa natans*;
scrapping nettle, willow, rushes and sedges, such as *Scirpus*, *Juncus* or *Phragmites*, to extract the
fibres; cracking nuts, such as *Corylus avellana*).

Other experiments have been able to find similarities between some archaeological and experimental
marks, but the identification is not fully confident, given the large number of wild edible plants in
Europe and the limitation of experimentations to a few of them (Hardy *et al.* 2013).

### 6.3.2 Zooarchaeological traces

#### 6.3.2.1 Osteology

Through the study of particular features in osteological elements certain information about past diets
can be inferred. Functional tooth morphology, tooth and enamel structure and the biomechanics of
mastication have been used to discuss hominin diets in general ecological terms (hard seeds, fruits, or
soft leaves), despite some methodological problems in the distinction of adaptative and inherited traits
(Walker 2007) and the lack of equivalence between what is possible to eat and what is eaten (Teaford
2007). For the study of a single species, osteological evidence is restricted to metabolic diseases
evidenced in bones: *e.g.* malnutrition or hypervitaminosis, and dental pathologies, which provide more
specific information about the role of plants in palaeodietics, as they might be associated with the
consumption of certain plant foods (Fernández Crespo 2007). Comparisons between different individuals
or populations might be able to establish social or cultural dietary traditions: in individuals, differences
might be according to gender, status, etc.; in populations, care should be taken to compare individuals of
the same age, gender, and status, as longevity and infancy-care might be influenced. Samples from
cemeteries do not necessarily randomly represent the entire population: they belong to people who were
interred, and we lack the criteria according to which someone could or could not be subject to this ritual
(Cruz Berrocal 2012). For accuracy, it is necessary to compare samples coming from a similar
taphonomical history. In addition to general malnutrition signs, such as enamel hypoplasia or porotic
hyperostosis, other pathologies inform more specifically about diet:

- Caries, the position of the caries and type are important, as well as the tooth type and age of the
  individual (Jackes 2009):
  - caries on the occlusal side might be the evidence of a diet with a high consumption of sugar and
    carbohydrate rich food, like wild vegetables, nuts or honey,
  - polycaries could be related to an intensive consumption of cariogenic carbohydrates, typical of
    wild fruits,
  - root caries suggests a dependence on starched products,
  - interproximal caries on the crown, in young individuals, and approximal caries are related to the
    frequent ingestion of sweet foods, containing either fructose and sucrose (Lubell *et al.* 1994).
• Periodontal disease: plaque on teeth is a mineralisation caused by proteins and starch, which is evidence of a common consumption of pulses and animal proteins.

• Wear or attrition: Extremes of diet can be easily distinguished once pre-mortem microwear has been determined (Walker 2007), such as grazing vs. browsing or hard seed and fruit vs. soft leaf eating. Unfortunately, many foods are not hard enough to scratch teeth (Lucas 1991) and diverse foods might produce the same type of wear. Moreover, in some cases it is not the food, but its associated grit that produces the wear (Sponheimer, Lee-Thorp & de Ruiter 2007). Consistently oriented criss-crossing striations are related to technological activities rather than eating, such as the use of anterior teeth in leather or fibre-work (Jackes 2009).

• Dental calculus (enamel): some plant residues (starch, phytoliths, etc.) are accumulated in dental calculus in very variable lapses of time depending on the individual and his or her habits (Buck & Stringer 2014); they might represent a period between the whole life-span and a few months prior to death (Lieverse 1999).

6.3.2.2 Parasites and pests

The appearance of certain undesired companion animals (insects, rodents, etc.) in particular contexts can inform about changes in vegetation and plant use by past human groups: e.g. human-companion rodent species, such as the house mouse (Mus musculus) (Povoas 1998 apud Carvalho, Gibaja & Cardoso  2013); crop weevils and pests (Panagiotakopulu 2001), manure-thriving insect species (Kenward 2009), tapeworms from particular diets (Walker 2007), attached feeding molluses from algae gathering (Lubell et al. 2006), etc.
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Part III A: Results: the identified taxa

The description of the identified taxa has been organised by taxonomical groups (major clades and families), as a way to avoid biased categorisations based on potential uses or modern values. Families are very important botanical units: the taxa described have been nested into families, in which smaller groups (tribes, subtribes, genus...) are described when relevant. All plant remains identified in this work belong to spermatophytes or phanerogams, i.e. plants that produce seeds, and they are a subgroup of the embryophytes, i.e. land plants. The particularities of each plant macroremain and the plant to which it belonged have been compiled following an outline described next.

First, the scientific nomenclature according to Flora iberica (Flora iberica 1986+) or Flora Europaea (Tutin et al. 1964-2001) (in parenthesis other common family nomenclatures). The “-” preceding the family scientific name indicates that some plant remains have been determined at that level, if the “-” is absent, then the family name is given only for purposes of categorisation. Domesticated species have two nomenclatural traditions, both are going to be used:

- a conventional binomial nomenclature, established from the morphological point of view, and in which domesticated species are considered different species from their wild ancestors,

- a specific for domestication events in which, according to genetics, once the wild ancestor is recognised, it comes to share with its crop the second part of the binomium and the wilderness/domesticity appears as subspecies (Zohary, Hopf & Weiss 2012).

Some of the more important vernacular names in British English (taken from ITIS Catalogue of Life, Roskov et al. 2015, or Plants For A Future, Fern 1992-2010), Spanish (from Anthos, Aedo & Castroviejo 2012) and Portuguese (from Flora Digital de Portugal, Crespi 2015) are listed next.

A general description of the macroremains and their characteristic features follows, especially of those which are relevant to the taxonomical and taphonomical identification and quantification. The dispersal mode, which might have important bearings over the presence of the taxa in an archaeological site, is noted. Next, the contexts studied in this work in which they appear and the known occurrences in other archaeological contexts are noted. The environmental requisites of the genera or species and characteristics which might be relevant for the interpretation (morphology, reproduction, blooming, nutritional properties, etc.) are summarised accordingly with Flora iberica (Flora iberica 1986+), unless otherwise stated.

Next, known uses, mainly through ethnobotanical compilations but also historical texts, are noted for each of the usable plant parts, following the order presented in Plant use (p. 139). This does not necessarily imply that specific plant uses have remained unmodified over the ages, but rather that when very particular properties are commonly appreciated, it is unlikely that these properties would pass unnoticed by prehistorical peoples.

Finally, specific experimental taphonomical approaches carried out in the framework of this work or by others are described, with particular attention to specific observations which would contribute to the improvement of the understanding of archaeobotanical formation processes in three basic aspects: how fragmentation of plant remains might take place; how carbonisation affects the preservation and representativeness of the assemblages of charred plant macroremains; and how non-anthropic marks can be distinguished from those of human-use origin, which can help to infer past plant usages.
At the end of each taxon description, a table summarises its potential of appearance in the charred archaeological record. Two types of proxies have been considered for establishing the probability of plant taxa to be preserved in the archaeobotanical record: ethnobotanical and preservational ones. When considering the likelihood of seeds and fruits becoming carbonised from the ethnobotanical point of view, the following criteria have been followed: chances are rated as high when the seed or fruit itself might be processed with fire (e.g. for storage); chances are rated as medium when another part of the plant than the seed or fruit is processed with fire (e.g. plants with medicinal uses in which the vegetative plant parts might be decocted to make infusions); and chances are rated as low when no part of the plant is known to be possibly processed with fire (consumption is in a raw state and no medicinal uses are known for the plant). Taphonomical criteria regarding carbonisation and fragmentation originating from controlled experiments (for general plant types, described in 11.3.3.1.2 Carbonisation and distortion, when specific data are not available about the taxon or closely related ones) have been considered for deciding upon the chances of plant remains to be archaeologically preserved in a charred state: the plant remain is rated as having high preservational chances if it is highly resistant to fire exposure (for long intervals or relatively high temperatures; e.g. nutshell or dense seeds) and fragmentation does not easily occur, or if occurring, does not prevent identification; it is rated as medium if only one of the previous premises is met (e.g. dry seeds); and it is rated as low if none of the premises are met (e.g. fruits, cereal glumes or oily seeds).

At the end of the chapter, a summarising table is given (vid. Table 76).

**Gymnosperms**

Seed-producing, non flowering plants, with C₃ and CAM photosynthesis (Sage & Monson 1999).

**Pinaceae**

- *Pinus pinea* L.

**Vernacular names:** (plant) stone or umbrella pine; (fruit) pine cone, pine nut

**Nombres vernáculos:** (planta) pino piñonero, pino doncel, pino real, pino albar, pino manso; (fruto) piña, piñón

**Nomes vernáculos:** (planta) pinheiro manso; (fruto) pinha, pinhão
Part III A: Results: the identified taxa

Description of the macroremains

The remains determined are pine cone bract scale apophysis fragments and nutshell fragments (Figure 38). It is the fragment of scales from the central part of the apophysis, with the terminal or dorsal umbo, and the pericarp fragments, that have allowed the specific taxonomical determination. Convex bract-scale apophysis (Flora iberica 1986+) with ridges departing from the slightly depressed dorsal umbo towards the edges of the apophysis (IIIPC reference collection) are typical of *P. pinea*. Stone pine is the only peninsular species of pine with thick (>1mm), dense woody nutshells. In cross section, the nutshell has small, rounded, thick-walled cells (Gale & Carruthers 2000).

Quantification of *P. pinea* remains is problematical because of the different types of remains recovered. The number of complete pine cones cannot be obtained from this type of fragmentary preservation, although if the number of bract-scales were high, it could point to the existence of several cones. To obtain the number of nuts, in this work, nutshell fragment counts have been divided by 8 because of their small size and bract-scale fragment counts have been divided by 6, which is the number of ridges per apophysis, and then multiplied by 2 which is the number of nuts per bract scale.

Presence in the archaeological record

In this work, *P. pinea* plant macroremains have been recovered from Poças de São Bento. *Pinus* spp. macroremains (other than wood) are relatively scarce in archaeobotanical literature of the Old World until the Iron Age (Queiroz et al. 2006) or Roman times (e.g. Bakels & Jacomet 2003; Kislev 1988; Sadori, Giardini & Susanna 2010; Sostarić & Küster 2001). Pine cones, scales and nutshell fragments from *P. pinea* are known from Middle Palaeolithic Gorham’s and Vanguard caves in Gibraltar (Gale & Carruthers 2000) and during the whole sequence in Nerja Cave in Málaga (Badal et al. 2012; Badal-García 1998; Badal García 2001) and from various Portuguese sites from the Neolithic onwards (Queiroz et al. 2006) such as Vale Pincel I (Carrión Marco, García & Figueiral 2012) or Zambujal (Stika et al. 2013). Other Early Holocene references are for *Pinus* sp. bract scales at La Falguera (Bernabeu Aubán 2006) and Can Sadurní (Antolín et al. 2012), cone and needle fragments at La Peña de la Abuela (Stika 2005), El Mirador (Rodríguez 2004; Rodríguez & Buxó 2008) and *P. halepensis* in North Africa (Fahmy *et al.* 2008; Kislev, Hartmann & Galili 2004; Morales 2010).

Figure 38: Left: Dorsal and frontal view of a modern *Pinus pinea* cone bract scale (Photograph by Eduardo Palacio). Right: Charred fragments from pine cone bract scales from Poças de São Bento determined as *P. pinea*. Scale bar = 1 cm.
Ecological characteristics

*Pinus pinea* is a large evergreen tree of up to 30 m by 10 m., with a ramified trunk in its upper part, with thick branches forming an umbrella-like dense canopy. It rarely survives for much more than 100 years (Fern 1992-2010). It is a tree native to the western Mediterranean that grows in mild, humid, coastal areas, forming part of three types of woodland: grass-rich, maquis-type and woods on damper soils (Gale & Carruthers 2000). It might appear in mono-specific forests or mixed with *P. pinaster* or *Quercus suber*, in sandy or clayey light soils, in plains or hills up to 1000 m a.s.l. in temperate climates; fruiting begins in spring but the pine nuts do not open naturally until the heat of summer; the fruits are globose-ovoid deciduous cones of about 8-15 by 7-10 cm, and the seeds 15-20 by 7-11 mm (Flora ibérica 1986+).

Dispersal strategy

The prevalent dispersal mode is autochory (Paula & Pausas 2009), although endozoochory might be also relevant.

Ethnographical information

Bromatological use

*Pinus pinea* nuts are rich in oils and protein and edible raw or cooked. They have been highly appreciated and the most valued of the pine nuts in Europe as a food source from Roman times, simply as nuts (Palladius and Pliny *apud* Girard & Tchernia 1978), even traded outside their natural range distribution (Willcox 1977; Maurizio 1932), for sauce (Apicius *apud* Girard & Tchernia 1978) and pastry-making (Flora ibérica 1986+). The seed has a soft texture and a slightly resinous flavour (Fern 1992-2010). *P. pinea* seed oils can be used as flavouring additives for food and beverages (Sünitar *et al.* 2012); powdered young *P. pinea* cones can be added to soups and a vanilla flavouring is obtained as a by-product of resins released from *P. pinea* pulpwood (Fern 1992-2010).

Cosmetic use

Oils from *P. pinea* have been used as fragrances in cosmetic and household products, particularly for the face (Pardo de Santayana *et al.* 2011), or boiled extracts for bathing (Sünitar *et al.* 2012). A tan or green dye is obtained from *P. pinea* needles (Fern 1992-2010).

Pharmaceutical use

Essential oils obtained from the cones of *P. pinea* collected just at the time of maturity have wound healing properties, which have been recognised in folk medicine at least from Antiquity (Celsus *apud* Girard & Tchernia 1978). In Roman times, stone pine nuts were considered as aphrodisiac (Apicius *apud* Gale & Carruthers 2000).
Part III A: Results; the identified taxa

Different *Pinus* spp. plant parts, but mainly the oils, have bactericidal, fungicidal, insecticidal, anticarcinogenic, pesticidal, antioxidant, anti-inflammatory, analgesic and sedative effects (Süntar *et al.* 2012); the turpentine is antiseptic, diuretic, rubefacient and vermifuge (Fern 1992-2010). Although *Pinus* spp. wood, sawdust and resins can cause dermatitis in sensitive people, externally they can be a very beneficial treatment for a variety of skin complaints, wounds, sores, burns, boils and rheumatic affections, used in the form of liniment plasters, poultices, herbal steam baths and inhalers (Fern 1992-2010).

The needles contain a substance called terpene, released with the rain, that has a negative effect on the germination of some plants (Fern 1992-2010), but at the same time acts as slug barrier.

**Symbolical use**

*Pinus* spp. cones are nowadays an appreciated ornamental motive and *P. pinea* cones seem to have been associated with Mithra’s cult during Roman times (Willcox 1977).

**Technological use**

*Pinus* spp. cones are appreciated as fuel sources due to their high calorific power. *Pinus* spp. resin, transformed into turpentine by vapour distillation, has traditionally been used for making impermeable containers and glueing (Juan Tresserras & Matamala 2004). Turpentine has a wide range of uses such as solvent for waxes and varnish; rosin is the substance left after turpentine is removed, which is used by violinists on their bows; pitch can also be obtained from the resin and is used for waterproofing and as a wood preservative (Fern 1992-2010).

**On processing**

**Procurement: cultivation and gathering**

*Pinus* spp. and particularly *P. pinea* have been widely cultivated in the Iberian Peninsula (Flora iberica 1986+). *P. pinea* cones can be gathered from the ground when they have matured, opened their bracts and fallen from the tree or can be gathered immature, if the nuts are to be consumed, by knocking down the cones from the tree in winter (to avoid predation from animals) and storing them until the heat arrives in summer, when the taste of the nuts improves by the loss of bitterness (Badal García 2001).

**Storing**

*Pinus pinea* seeds have a long storage life but roasting prolongs the storage life even more, even in an unshelled form (Gale & Carruthers 2000).

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Peeling (dehusking / deshelling / dehulling)

*Pinus* spp. cones gathered unopened might be exposed to a source of heat, such as a fire (on the branches over a fire or placing the cones on the ashes) or the sun, in order to make the bract-scales open and allow the nuts to fall (Badal-García 1998; Badal García 2001). *P. pinea* nutshells can be hard to crack because of the thickness of the shell: this might be carried out with a hammerstone. Roasting the cones for at least an hour in an earth oven facilitates the removal and deshelling of the nuts (Gale & Carruthers 2000).

Cooking

*Pinus pinea* seeds and young pine cones can be ground into a powder and used as a thickener and flavouring in soup (Fern 1992-2010).

Oil extraction

The essential oils from the cones of *P. pinea* can be obtained by partially grounding and distilling (Süntar et al. 2012). The resins are transformed into turpentine by tapping the trunk or by destructive distillation of the wood (Fern 1992-2010).

Taphonomical proxies

Non-anthropic marks

Owls eat whole *Pinus monophylla* nuts, digest the inner seeds and reject the shells; excreted shells are small flat fragments with rounded edges (Rhode & Madsen 1998).

★ Summary

This taxon has high probabilities of being preserved in the archaeological record (Table 36). In addition, its dispersal by endozoochory could account for the presence of nuts in the record, but the co-appearance of nut with bract scales point to human manipulation as a more likely way of introduction.

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Table 36: Recovery chances of *Pinus pinea* nuts in the charred archaeobotanical record.
Angiosperms

Flowering plants are categorised in two large groups, monocotyledons and dicotyledons, $\text{C}_3$, $\text{C}_4$ and CAM photosynthesis occurs in both groups (Sage & Monson 1999).

Monocotyledons – Liliopsidae

Monocotyledons, or monocots, are plants whose seeds typically have one cotyledon, such as grasses, rushes or sedges. Grasses and sedges concentrate the highest numbers of $\text{C}_4$ photosynthetic species.

- Gramineae (Poaceae)

  **Vernacular names:** grasses
  **Nombres vernáculos:** gramíneas
  **Nomes vernáculos:** gramíneas

  **Description of the macroremains**

  Gramineae are annual or perennial plants. Gramineae flowers are united into spikelets, the dispersal units, arranged in three types of inflorescences: spikes or racemes, panicles and spiciform panicles. The stems are rounded in cross-section and the leaves are attached to nodes. Each spikelet is attached to a continuation of the stem known as rachis. It contains one or two bracts at the base, known as glumes, and one or several flowers, each of which is a fruit, attached to a rachilla. The number or fruits per spikelet varies from species to species and within them. The fruit is enclosed by two bracts, the abaxial is the lemma and the adaxial the palea, which compose the floret. These bracts are also known as a whole as chaff. The pericarp of the fruit s fused with the seed, conforming what is known as caryopsis. The dorsal face of the grain is covered by the lemma and shows the scutellum where the embryo is; the ventral face is covered by the palea and shows the hilum. The size of the caryopses, and partially the shape also, is generally determined by the number of fruits per spike. (Cappers & Bekker 2013).

  “Archaeobotanists use the term “straw” to refer to the culm (stem) of the cereal plant (in archaeobotanical assemblages usually present as culm nodes) and “chaff” to refer to all the components of the cereal ear other than grain (rachis segments, glume bases, lemma and palea, etc.)” (van der Veen 1999).

  Several plant remains have been identified as grass caryopses based on their single cotyledon, embryo and hilum morphology, although the state of preservation does not allow further taxonomical determination. One of the specimens is an apical fragment with tongue-shaped scutellum which resembles *Bromus* sp.
Presence in the archaeological record

Undetermined grass macroremains have been recovered at Lapiás das Lameiras, Poças de São Bento, El Toral III and Los Gitanos. Relatively ample archaeobotanical evidence exists of a potentially intensive gathering of small-seeded wild grasses, such as *Alopecurus* spp., *Bromus* spp., *Hordeum* spp., *Koeleria* spp., *Phalaris* spp. and *Puccinellia* spp. (Harlan 1992; Weiss et al. 2004a).

Ecological characteristics

Gramineae is a very wide family of grass plants, with more than 3500 species in Flora Europaea (Tutin et al. 1964-2001), in which cereals are contained. C₄ photosynthesis is common within this family. Many wild grasses act as weeds in cereal crop fields.

Dispersal strategy

The prevalent mode of dispersal in the Gramineae is a form of autochory, anemochory, however zoochory (myrmecochory and endozoochory) also occur.

Ethnographical information

Bromatological use

Ethnographical evidence of wild grass gathering on all continents, in some cases the main foodstuff, independently of seed size and productivity, is abundant for both mobile and sedentary farmers and hunter-gatherers (Aurenche 1997; Harlan 1992; Weiss et al. 2004b). Of these exploited grasses, several genera are present in Europe in the wild: *Agropyron, Andropogon, Aristida, Brachiaria, Digitaria, Echinochloa, Elymus, Eragrostis, Glyceria, Panicum, Paspalum, Setaria, Sporobolus* and *Stipa* (Harlan 1992).

On processing

Because of the brittle rachis and hulled grains of most grasses in the wild, their processing requires more work than domesticated grasses (Harlan 1992).

Procurement: cultivation and gathering

Experimental and ethnographical work has shown that, whatever the gathering method employed, it is not possible to obtain more than 50 % of the natural seed production by a wild grass population (Harlan 1992).
Part III A: Results: the identified taxa

★ Summary

Grains from grasses have a high potential of being preserved in the archaeological record (vid. Table 37) because of their potential use which might imply dehulling by roasting (vid. p. 208) and their structural density (vid. p. 154). The grains might also be spread by ants and grazing animals (vid. p. 152).

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Table 37: Recovery chances of Gramineae grains in the charred archaeobotanical record.

- *Avena* L. sp. (*A. fatua* L. / *A. sativa* L. / *A. sterilis* L.)

Vernacular names: oats

Nombres vernáculos: avena, avena loca

Nomes vernáculos: aveia, aveia brava, aveão

Description of the macroremains

Elongated grains with a triangular embryo cavity and particular transversal view, and ribbed and spiralled awns have been identified as *Avena* sp. (Figure 40). *Avena* grains and awns cannot be
determined to species level by their external morphology, only if lemma bases were preserved with them it could be possible to tell whether it is a domesticate (*Avena sativa* L.), a wild race of *A. sativa* (*A. sterilis* types) or a wild species (*A. fatua*). *A. sativa* is a very variable group which has some interfertile domesticated varieties (mostly hulled), weedy races and wild forms (Zohary, Hopf & Weiss 2012).

**Presence in the archaeological record**

Plant macroremains determined as *Avena* sp. have been recovered from São Pedro de Canaferrim, Lapiás das Lameiras and, possibly, Los Gitanos. *A. sativa* is one of the main crops in prehistory, particularly in wet climates such as West Europe; *A. fatua* and *sterilis* are very frequently interpreted as weeds of other cereal crops in prehistoric agricultural sites (Zohary, Hopf & Weiss 2012).

**Ecological characteristics**

*Avena* spp. are annual plants, with C₃ photosynthesis (Sage & Monson 1999), which succeed well in moist climates and wet soils, stand dry summers well but are frost sensitive. *A. sterilis* types thrive in truly wild grasslands and are probably the ancestor of *A. sativa* (Nesbitt & Goddard 2006) but also colonise abandoned cultivated grounds and are a weed in wheat and barley fields (Zohary, Hopf & Weiss 2012). *A. sativa* is a domesticated species. *A. fatua* varieties are weedy (Zohary, Hopf & Weiss 2012), probably a feral derivative from *A. sativa* (Nesbitt & Goddard 2006). The grains of *A. sativa* are rich in proteins (15 %) and carbohydrates (8 %).

**Dispersal strategy**

*Avena* spp. have an anemochorous dispersal mode (Paula & Pausas 2009).

**Ethnographical information**

**Bromatological use**

*Avena sativa* serves as a staple and supplement for farm animals (Zohary, Hopf & Weiss 2012).

**On processing**

**Peeling (dehusking / deshelling / dehulling)**

*Avena sativa* requires dehulling for human consumption; dehulling of hulled grains is greatly facilitated by roasting (*vid. p. 208*).
Part III A: Results: the identified taxa

**Summary**

When intentionally exploited, *Avena* spp. grains have relatively high chances of being recovered in the archaeological record (*vid.* Table 37); however, they might merely be weeds of agricultural fields.

--- *Lolium* L. sp. (*L. perenne* L. / *L. multiflorum* Lamk. / *L. rigidum* Gaudca)

**Vernacular names:** ryegrass

**Nombres vernáculos:** ballico, raigrás

**Nomes vernáculos:** azevém

**Description of the macroremains**

These grains are small, showing the typical shape of the genus with a slightly convex ventral side, extremely slight ventral furrow, smooth dorsal side, flat in lateral view, with rounded extremes and small semicircular embryo cavity (Figure 40).

Archaeological *Lolium* grains are usually ascribed to large-sized types (such as *L. temulentum* L.) and small-sized types (of which only *L. perenne* L., *L. multiflorum* Lamk. or *L. rigidum* Gaudca might apply) (*e.g.* Nesbitt & Goddard 2006; van Zeist & de Roller 1993). Embryo ends have been used as the quantification item.

**Presence in the archaeological record**

Plant macroremains determined as *Lolium* sp. have been recovered from Lapiás das Lameiras and Poças de São Bento. *Lolium* is not an uncommon genus in the archaeobotanical record of the Iberian Peninsula (*e.g.* Antolín, Jacomet & Buxó 2015).
Inés L. López-Dóriga

**Ecological characteristics**

*Lolium* are perennial or annual herbs, native to Eurasia and North Africa, understudied (Nesbitt & Goddard 2006), with a C$_3$ photosynthesis (Sage & Monson 1999). *Lolium perenne*, *L. multiflorum* and the highly variable *L. rigidum* are closely related, and this latter has been proposed to be the ancestor of the other two. Endophytic fungi infect the grains, which produce alkaloids toxic to grazing animals and humans (Nesbitt & Goddard 2006).

*Lolium perenne* is an evergreen perennial growing in meadows at a fast rate up to 1 m.; it is not frost tender and it is suitable for all kinds of soils, adapted to mild, humid temperate climates (Fern 1992-2010). *L. multiflorum* is a perennial species believed to be native to Europe (Nesbitt & Goddard 2006) and *L. rigidum* is an annual (Nesbitt & Goddard 2006).

**Dispersal strategy**

Its dispersal strategy is anemochorous (Paula & Pausas 2009).

**Ethnographical information**

**Bromatological use**

The seeds of *Lolium* spp. are edible and might be used as a cereal, it has a nutritional value similar to oats (*A. sativa*) and contains gluten (Fern 1992-2010). *L. perenne* and *L. multiflorum* have also been used, sometimes cultivated, as fodder (San Miguel López 2004).

**Pharmaceutical use**

The whole plant of *Lolium* spp. has occasionally been used in the treatment of cancer, diarrhoea, haemorrhages and malaria (Fern 1992-2010).

**Technological use**

The plant of *Lolium* spp. has the potential to be used as a source of biomass (Fern 1992-2010). *L. perenne* and *L. multiflorum* have been also used for thatching (San Miguel López 2004).
Part III A: Results; the identified taxa

On processing

**Procurement: cultivation and gathering**

Sowing should be carried out in the spring or autumn (Fern 1992-2010), *L. perenne* and *L. multiflorum* can be cut several times during winter and be used as green fodder for domesticated animals.

**Cooking**

The seed is cooked as a cereal, but it is rather small and might result awkward to use (Fern 1992-2010).

★ Summary

*Lolium* sp. seeds used for human consumption have high chances of being preserved in the record (*vid.* Table 37).

- Triticeae

**Description of the macroremains**

This tribe category includes all caryopses which belong to large seeded cereals (wheat, barley and rye) but are not possibly further identified morphologically, because of their extreme fragmentation or erosion. They have been identified as such because of their size or have a ventral and long hilum, a short embryo, and are elongated. Given the current state of the art, it can be inferred that they probably belong to *Hordeum vulgare* (barley) or *Triticum* spp. (wheat), as *Secale* (rye) appears in South-West Europe at a much later stage. Morphologically, winter and spring varieties are indistinguishable, but arable weeds might help.

Their MNI can be most precisely quantified by ascribing fragments to anatomical categories (Antolín & Buxó 2011b): the number of whole caryopses is added to the highest number of the transversal fragments and to the highest number of the longitudinal dorsal or ventral fragments (considering that a seed cannot generate more than one of each), and to the number of longitudinal ventral-dorsal fragments divided by two (as each grain can give rise to two longitudinal ventral-dorsal fragments).

**Presence in the archaeological record**

Remains determined as Triticeae have been recovered at São Pedro de Canaferrim and Lapiás das Lameiras. Such determinations are frequent in Early Neolithic sites from all Europe, as it is relatively
usual to find some badly preserved remains impossible to determine further by exclusively morphological features.

**Ecological characteristics**

Triticeae are a tribe of cereals, annual plants with a life-cycle inferior to a year, the growth epoch depends on temperatures, which accordingly varies with the climate, latitude, altitude and topography. All Triticeae species have a C\textsubscript{3} photosynthesis (Sage & Monson 1999). High-altitude cereal growing is possible (e.g. Kirk 1974; Australian Government 2008) and germination of the grains in the spikes can occur in the field, prior to harvesting, especially during wet summers (e.g. Australian Government 2008).

**Dispersal strategy**

Cereals have anemochorous dispersal modes in the wild, although under domestication (i.e. with a though rachis that does not release the spikelet upon maturity) they generally rely on human intervention.

**Bromatological**

Triticeae grains are efficient foods due to their high energy and protein contents and their straw might be employed as fodder. They are some of the more important world food crops and were much more so in old-world agriculture. However, about 1 in 1500 people (Australian Government 2008) is currently affected by coeliac disease (gluten-sensitive enteropathy), a disorder caused by intolerance to the ingestion of gluten from Triticeae (wheat, barley and rye) and which could have been identified in the archaeological record (vid. Scorrano et al. 2014).

**On processing**

The processing techniques of the main cereal crops are well known ethnographically and experimentally, such as the case of wheat and barley (vid. Hillman 1981; Jones 1984). Cereal processing usually consists of several activities (vid. Hillman 1984-1986), which in many cases are not documented in the archaeological record as they are often developed outside domestic areas. By-products (straw, chaff and weed seeds) from the first stages of processing are only in some cases incorporated to charred deposits, as they are often employed as fodder or for technological activities (e.g. bedding, thatching or mud-brick preparation). On the contrary, the last phases of processing are much better represented as they are often carried out within domestic spaces and their by-products easily end in fires.
Part III A: Results; the identified taxa

Procurement: cultivation and gathering

Depending on the species, variety and climate, cereals might be sown in autumn (from September to November), being called winter or autumn cereals; in spring (from February to April), being called spring or summer crops; or in both of them (e.g. barley). Sowing, in the absence of ards and ploughs, can be carried out with the aid of sticks, making a hole in which the seeds are placed and then covered with soil. Cereal growing requires the continual renovation of soil nutrients, which are gradually lost. Soil nutrient renovation can be carried out through several means, each with their own advantages and disadvantages: burning (grass roots resist ordinary burning; burning releases the mineral nutrients unless it is too rapid or generates too much heat) or dispersing ashes over the field, manuring (promotes weed growing), fallowing, crop-mixing and crop-rotating (Jarman, Bailey & Jarman 1982). Crop mixing can be carried out with legumes, which fix nutrients to the soil, or with different cereal species with different requirements and maturing periods; providing other advantages in addition to nutrient renovation (Butler 1999): it ensures crops and reduces risks of failure by bad weather or pests, intensifies and diversifies production, maximises soil use and protects it from erosion, inhibits weed propagation, makes some species protect the fragile ones from the wind or act as tutors for creeping species, and reduces work seasonality by distributing it over the year.

Gathering strategies of domesticated cereals usually vary according to the use that might be intended for the straw (e.g. Peña-Chocarro et al. 2009). When it is desired to obtain long straws, gathering can be carried out by uprooting or cutting with sickles or scythes near the ground or pruning hooks (Peña-Chocarro et al. 2009). Then the ears or grains can be separated by several means (e.g. Anderson 2013). Plucking the ears by hand, stripping them with mesorias, beating them with sticks, combing them, picking the grains from the ground or cutting the stem near the ear leave most part of the straw in the field, which can eventually be eaten by domesticated animals, be burned to improve soil nutrients or be cut lower with sickles or scythes for another use. If gathering is carried out before the grain is fully mature, it has to be sun-dried or heated on the fire.

Peeling (dehusking / deshelling / dehulling)

Cereal grains need their chaff to be removed for many of their uses, such as human food preparation, but not for fodder or beer making. Threshing and dehusking cereal grains varies in complexity and length of time (vid. Hillman 1984) depending on the type of cereal (if its free-threshing, naked or hulled) and the intended use (the degree of cleanliness desired).

The process usually starts with threshing, by beating, trampling or passing a threshing sledge, to separate the ears into spikelets. Cereals in which the ear easily frees the grain are known as free-threshing (Triticum “nudum”: Triticum aestivum, T. durum and T. turgidum or Hordeum vulgare); cereals in which the ear breaks into spikelets are known as hulled (Triticum monococcum or Triticum dicoccum). This is usually followed by winnowing, to remove the light straw and chaff fragments from the spikelets, which consists in the exposure of the product from the threshing floor to the wind, to have the light straw and chaff fragments carried away from the dense grains.

The process can end here or be further continued to dehusk or extract the caryopses from the spikelets and glumes; this can be carried out with the help of wooden, stone or earthen mortars and be
facilitated by a previous roasting or soaking (e.g. Alonso et al. 2013): “the size of the mortars is
determined by the quantity of grain that is to be processed”. Naked cereals (Triticum “nudum”;
Triticum aestivum, T. durum, T. turgidum and Hordeum vulgare ssp. nudum) do not need to submit to
the dehusking procedure, as the grain and the glumes easily separate from each other upon threshing;
but hulled or glume cereals (T. monococcum and T. dicoccum), even if they are free-threshing (Hordeum
vulgare ssp. vulgare), do need it.

The crop might be also sieved to sort weeds by size, as they are usually smaller than the cereal grains
(Jones 1996).

Storing

Cereals might be stored in different structures, ranging from underground pits (silos) to above-ground
granaries. Cereal storage in underground pits, as might have been done in the case of Lapíá das
Lameiras and São Pedro de Canaferrim, has been a common practice from the Neolithic until recent
times (Sigaut 1988). Long term experiments carried out in different research projects point out that
their usefulness depends on the local climate, the topographical conditions, the way in which they are
built and the purpose of the storage (Reynolds 1988). Silos might contain grain-seed (Collis 1999),
surplus to be exchanged (Fenton 1983) or feasted (van der Veen 2007) or food-resources to be
consumed as the necessity arises or to be kept for lean periods: in good storing experiences, between 90
and 95 % of the seed-grain is fertile and the fermented crust is thin (about 2 cm thick), in bad years,
fertile seed-grain might be reduced to 5 % but grain might still be usable for other purposes, such as
fodder (Hill, Lacey & Reynolds 1983). Bread from underground-stored grains is reportedly known to
have a better taste, although moisture might affect panification properties (Burch 1999).

Storage pit functioning consists of the creation of airtight environments in equilibrium in which micro-
organisms have serious difficulties to thrive. This is achieved when bordering grains (those in the walls,
bottom and, particularly, top) in contact with moisture sprout, using the available oxygen from the
intergranular atmosphere and replacing it with carbon dioxide, forming a protecting fermented crust
(Hill, Lacey & Reynolds 1983). Because of the equilibrium being broken every time the pit is open, it is
often considered that pits are long-term storage facilities, only opened once when massive use of the
whole is going to be made; however, ethnographical examples show that pit might be opened for specific
necessities every one or two months, feeding the last crust of spoilt grain to cattle every time (Peña-
Chocarro et al. 2000).

Pits might be dug and be viably used open-air or inside houses or caves (Alcalde i Gurt & Buxó i
Capdevila 1991). Although caves are sometimes seen as inappropriate for long-term storage because of
their usually high moisture levels (Bouby, Fages & Treffort 2005), their low and stable temperatures
reduce the development of micro-organisms (Alcalde i Gurt & Buxó i Capdevila 1991) and the sheltering
from rain improves preservation irrespective of season (Hill, Lacey & Reynolds 1983). Shape is not
determinant for preservation, but bell or bee-hive shaped pits seem to be the most preferable (Collis
1999) because they are the least wasteful (Hill, Lacey & Reynolds 1983), an increase in pit size
increases the volume to wall area ratio, thus a big pit is preferable to many small pits (Hill, Lacey &
Reynolds 1983). The detrimental factor is isolation from air and water exchange to keep moisture,
temperature and CO2 at low stable levels (Reynolds 1988). Thus, the pits might be flamed to
Part III A: Results; the identified taxa

decontaminate, grain should have been dried previously and the opening should be sealed after deposition (bark, leaves, wood, clay, mud, dung, a big stone, etc.); when soils are wet, pit walls should be made impermeable (with clay, dung or leaf linings, basket work, etc.) (Fenton 1983; Owen 2002). When emptying a pit, the fermented grain-crust remains adhered to the wall and must be cleaned for the pit to be reused, this might be carried out by plucking or burning, in this latter case, often producing numerous charred grains (Jones 1984). Another source for charred grains in storage pits can be spontaneous combustion, possibly induced by high temperatures caused by the fermentation of immature grains in badly ventilated pits (Gascó 1983) or a combination of high water content (above 25 %) and a high but stable carbon dioxide concentration (up to maximum 33 %) (Hill, Lacey & Reynolds 1983).

**Detoxification**

Washing of the grains might be a method for the decontamination with toxic spores of *Tilletia caries* or *Tilletia foetida* (Hillman 1984-1986).

**Cooking**

Cereals might be cooked in different forms: as gruels, ground into flour, malted, etc. Roasting, boiling and malting (partial germinating) facilitate grinding. Moreover, malting produces a by-product, *spent grain* or *draff*, which can be used for fodder all year round, as it is easily well-preserved (Dineley 2006(2010)). Cereal flour is often sieved after grinding, producing several by-products destined for different purposes: a cracked fraction, which can be used as animal fodder, a medium fraction, which can be used for foodstuffs like *bulgur* or porridge, and the fine fraction, used as flour to make bread (Anderson 2006).

**Taphonomical proxies**

In an assemblage composed of deliberately sprouted grain for the production of malt, the percentage of germinated grain is expected to be more than 75 % (van der Veen 1989).

**Carbonisation**

Charring experiments on cereal spikelets from the Triticeae tribe (Boardman & Jones 1990): grains exhibited the widest range of survival conditions, straw nodes and rachis fragments the narrowest; glume bases occupied an intermediate position. Grains also tended to become carbonised later when enclosed in the spikelet than when loose and they tended to be better preserved and less distorted. Preservation was generally good and distortion slight whilst the grain was still surrounded by chaff. So grains could frequently be preserved under conditions which resulted in destruction of other parts of the cereal plant. A reducing atmosphere provided a broader band of survival conditions than an oxidizing atmosphere: though carbonisation was consistently delayed at low temperatures under reducing conditions, at higher temperatures destruction was delayed even more. Generally, the higher the temperature the worse the condition of the grain, though the condition of glume wheat grains was
generally better than that of free-threshing cereals. At low temperatures, free grains became more distorted in a reducing atmosphere, possibly due to the longer time it was exposed to heat without destruction. At temperatures above 350 °C, the condition of the free grain deteriorated more rapidly in an oxidizing atmosphere. The condition of grain in intact spikelets was good at low temperatures, but declined less rapidly with higher temperatures than that of free grain. This contrast was particularly marked under reducing conditions. At very high temperatures, the chaff was lost quickly and the condition of grain was again similar to that for free grain.

Carbonisation makes cereals have a globular shape and when carbonisation is produced at more than 200 °C, hemispherical cavities appear in grain surfaces (Téllez & Ciferri 1954).

The water content of uncarbonised grains may vary but will not influence the process of carbonisation: when a sample reaches a temperature of 100 °C, the free water will be converted into vapour that disappears into the external environment and the temperature of the sample will remain stable until all the water has been removed; next, when heat is still available, the temperature will rise again and the normal chemical reactions that are characteristic of the carbonisation process will occur (Braadbaart 2008).

Fragmentation

The dehusking process always produces some broken grain, whether it is carried out with a grinding stone (between 20 % and 40 % of the grain is cracked) or with a mortar (proportion of cracked grain generally less than 5 %) (Meurers-Balke & Luning 1992); higher rates might indicate a bulgur-type food preparation (Bernadová et al. 2010).

The different types of fragmentation of hulled cereals observed in carbonized, archaeological remains could be caused by the different dehusking methods to which they had been subjected (Alonso et al. 2013): “stone tools tend to break the grains more intensively than wooden tools or earthen surfaces. Grinding also fragments more than pounding, but this might be correlated with the fact that the implements used for this were made of stone.” The type of grain fragmentation (longitudinal or transversal) seems not to be correlated with the type of tool used nor with the lack or existence of a dehusking pretreatment (roasting or soaking).

When cereal caryopses are fragmented and the breakage surface is smooth and protuberant, it is likely that carbonisation is postbreakage and if it is shiny, then it has been soaked previous to carbonisation (Valamoti 2002). Precharring fragmentation can be caused accidentally during the processing of the cereal or intentionally during culinary preparation. Regular, straight and uniform caryopsis sections are normally associated with fragmentation of human origin caused during excavation and sample processing; whilst irregular, uneven and oblique, sections are possibly caused by non-human postdepositional processes (Antolín & Buxó 2011b). Postcharring fragmentation can occur at various times after charring: from trampling, sedimentary pressure, erosion, the excavation process during recovery and processing of the samples (Antolín & Buxó 2011b; Schiffer 1983).
Part III A: Results: the identified taxa

★ Summary

All species in the Triticeae tribe have high potential of being preserved in the archaeological record (vid. Table 37). Vid. infra more information on specific taxa in this tribe.

- Hordeum vulgare L.

Vernacular names: barley
Nombres vernáculos: cebada
Nomes vernáculos: cevada

Description of the macroremains

There have been identified four morphological types of grains, many conserving furrowed epidermis: hulled barley (very few angular caryopses symmetrical with straight hilum and very few angular asymmetrical caryopses with twisted hilum) and naked barley (few globular-shaped symmetrical caryopses with straight hilum and a great many globular asymmetrical caryopses with twisted hilum) (Figure 41). Accordingly, it is supposed that it is a single taxon of domesticated barley, Hordeum vulgare subsp./convar. vulgare (Zohary, Hopf & Weiss 2012), including naked and hulled forms. A problematical tendency in some references is to name Hordeum vulgare to hulled grains and Hordeum vulgare var./subsp. nudum to naked ones; whilst formal indeterminations of barley grains might be mistaken with hulled barley determinations. Here, Hordeum vulgare has been used to refer to barley grains which, because of bad preservation, cannot be assigned to one of the forms; whilst Hordeum vulgare var./subsp. vulgare and Hordeum vulgare var./subsp. nudum have been used for hulled and naked forms respectively.

Because of finding both twisted and straight-hilum grains and the high fragmentation rate and erosion, producing a relatively high number of remains indeterminable to the morphological types, it is difficult to tell whether the grains come from single or multiple-rowed spikelets, as both varieties could have been mixed (Bouby 2001). Multiple-rowed spikelets could have 6 dense rows (traditionally known...
as *H. hexastichum* or 4 lax rows (traditionally *H. tetrastichum*). In *H. hexastichum* all grains are fertile and two of each triplet is a twisted-hilum asymmetrical grain and the other a straight-hilum symmetrical one; *H. tetrastichum* has 2 fertile asymmetrical grains with twisted hilum. On the contrary, single rowed barley (traditionally *H. distichum*; *H. vulgare* subsp./convar. *distichum* in Zohary, Hopf & Weiss 2012) is a primitive form with only one fertile grain per triplet, being a straight-hilum symmetrical grain.

**Presence in the archaeological record**

In this work, naked barley has been recovered from Arangas, São Pedro de Canaferrim and Lapiás das Lameiras; and hulled barley, from São Pedro de Canaferrim and Lapiás das Lameiras. It has not been possible to determine any grain as potentially *distichum* at São Pedro de Canaferrim, but at Lapiás das Lameiras both the *distichum* and *hexastichum* varieties might be present. Barley is one of the most typical crops of the Neolithisation in the Iberian Peninsula and it appears in both naked and hulled forms. When determination has been possible, it has proved the exclusive existence of dense-eared forms (Peña-Chocarro & Zapata Peña 2012).

**Ecological characteristics**

Domesticated barley (*Hordeum vulgare* or *Hordeum vulgare* subsp./convar. *vulgare*), which was domesticated from wild barley (*Hordeum spontaneum* or *Hordeum vulgare* subsp./convar. *Spontaneum*). It is a rustic crop (Zohary, Hopf & Weiss 2012) which tolerates dry climates and poor soils with salinity or basic pH. It is the most dependable and desirable crop for highland farmers where poor soil fertility, frost, waterlogging, soil acidity and soil degradation are the major yield limiting factors, and where other cereals fail to grow (Eticha, Sinebo & Grausgruber 2010). The ideal conditions for barley-growing are deep, well-drained fertile calcareous soils (Zohary, Hopf & Weiss 2012). It has a low productivity in sand. According to some authors, *H. distichum* is a spring variety and *H. hexastichum* or *tetrastichum* a winter one (Bouby 2001); others suggest that they can be both, independently of the variety (Matterne 2001; Australian Government 2008).

The plant is annual and grows between 60 and 120 cm tall, with erect hollow stems. The inflorescence is known as ear and produces between 2 and 5 branch stems, which together with the central stem produce a spikelet at their apex. These spikelets are attached directly to the central axis, or rachis, and there are three spikelets at each node, called triplets, alternating on opposite sides of the spike. Each spikelet is made up of two sterile glumes and one floret that includes the lemma, the palea, and the grain. Therefore, each ear may carry between 25–60 kernels in six-rowed varieties or 15–30 kernels in two-rowed varieties (Australian Government 2008).

Depending on the variety, the lemmas and sterile glumes can be awned or not. In hulled or husked varieties, the palea and lemma adhere to the grain. In hull-less or naked varieties, the palea and lemma are not attached and separate from the grain on threshing. Barley grains are rich in fibres and carbohydrates, and moderate in proteins and minerals in comparison with other cereals and depending on growing conditions (Australian Government 2008).
Ethnographical information

Bromatological use

In highland areas, barley is the major source of food, home-made drinks and animal feed (Eticha, Sinebo & Grausgruber 2010). Naked forms of *H. vulgare* are usually more abundant in human food, in bread or porridge-like preparations, whilst hulled forms usually go for beer production or fodder (Zohary, Hopf & Weiss 2012). Barley has less qualities for panification that wheat, but barley malt can be used in a variety of food and beverage preparations, such as beer, milk, liquors, biscuits, cakes, etc. (Australian Government 2008). *Distichum* varieties are preferred for malt production (Australian Government 2008). Barley starch can be used as food sweetener (Australian Government 2008).

Pharmaceutical use

A wort, or juice of malted barley, has been used in modern times to fight scurvy: although very little Vitamin C is found in seeds in the dormant state, this is synthesised upon malting (Oliver 1973).

Technological use

*Hordeum vulgare* straw is not appropriate for roof thatching (van der Veen 1999) but due to its softness it is highly appreciated to fill mattresses, cushions, saddles and harnesses (Peña-Chocarro et al. 2009).

On processing

Peeling

Whilst naked barley varieties need only to be threshed for human consumption, hulled varieties would have had to be hummelled for the removal of the awns, dangerous for both humans and animals (Valamoti 2009). Dehulling, on the other hand, is probably a matter of culinary preference (Hillman 1984-1986) but it is usually carried out when hulled varieties are intended for human consumption and not when for fodder (Australian Government 2008). Grains are best dehusked by pounding, particularly with a stone mortar, 2-rowed grains are better pretreated roasted and 6-rowed soaked (Alonso et al. 2013).

Cooking

Wort, or malted grain, is prepared by letting the grain sprout in a moist environment, then the grain is dried and heated to obtain the malt, which can be ground and stored for piecemeal use in a water dissolution (Oliver 1973); it can be stored for long periods (Australian Government 2008).
Taphonomical proxies

Carbonisation

*Hordeum vulgare* grains, together with those of *Triticum*, are the first of the Triticeae to become carbonised and also the first to be destroyed. *H. vulgare* grains tend to agglomerate at temperatures above 350 °C (Boardman & Jones 1990). Whilst the whole ear survives well up to a certain point, after a long time of fire exposure only the grains are preserved (Jenkinson 1976 *apud* Boardman & Jones 1990).

Fragmentation

*H. vulgare* grains are fragmented in a small proportion upon dehusking, with primarily transversal breakage patterns in 2-rowed barley and both transversal and longitudinal 6-rowed barley (Alonso *et al.* 2013). When dehusked with a wooden mortar, roasted grains tend to fragment more than soaked grains, which do not break and are dehusked faster (Procopiou 2003).

Non-anthropic marks

Some hints suggests that barley grains might pass the digestive tract of some animals (cattle at least) undamaged (Australian Government 2008).

Additionally, great interest is placed in the detection of barley malt in the archaeological record, through the evidence provided by germinated grains (*e.g.* Dineley 2014). However, barley grains might begin to germinate in the spike in rainy conditions (Australian Government 2008).

★ Summary

*Hordeum vulgare* grains have high potential for appearing in the archaeobotanical record (*vid.* Table 37). *Vid. supra* general information for the Triticeae (p. 192).

- *Triticum* sp.

Vernacular names: wheat

*Nombres vernáculos*: trigo

*Nomes vernáculos*: trigo
Description of the macroremains

Cereal grains determined as *Triticum* sp. are large, have a deep ventral hilum and a roundish transversal section. The impossibility of observing, due to fragmentation or deterioration, other characteristic features, such as the striations in lateral view typical of *T. dicoccum* or the width of the ventral furrow inhibits the determination to species level. Moreover, the size of the grains varies too much between and within the species and often the overall shape of the grain in itself is no longer determinant after charring (Braadbaart *et al.* 2005).

In some cases where the embryonal part of the grain is not well preserved or is absent, the distinction between *Triticum* and *Secale* would be impossible; but given the current state of the art, it is inferred that the remains would belong to the genus *Triticum*, as *Secale* appears in southwestern Europe at a much later period.

Presence in the archaeological record

Several grains have been determined as *Triticum* sp. at Lapiás das Lameiras, São Pedro de Canaferrim and Los Gitanos. Such determinations are frequent in Early Neolithic sites from all Europe, as it is not unusual to find badly preserved remains impossible to determine further by exclusively morphological features.

Ecological characteristics

*Triticum* spp. are annual herbs, which grow in the wild in South-West Asia. Domesticated species are either naked or hulled. *Triticum* spp. are the cereals with the highest nutritional contents (between 60-80 % starch and 8-14 % protein). Each above-ground plant part being formed by a long straw and an ear, in which the grains are contained singly or in pairs within their spikelets. As in the case of all domesticated cereals, their rachis is tough.

Ethnographical information

Bromatological use

*Triticum* spp. grains need to be pounded or soaked if intended for cattle foddering (Robinson & Rasmussen 1989).

Technological use

*Triticum* spp. straw is highly appreciated for domestic uses (Mingote-Calderón 1987).
Taphonomical proxies

Carbonisation

_Triticum_ spp. grains have shown several changes upon experimental carbonisation in controlled reducing conditions, the main changes being increase in width, decrease in length, mass loss and the formation of external protrusions:

- morphological changes: grains become shorter and wider tending to a hemispherical shape when carbonised (Téllez & Ciferri 1954); their external shape either became rounder and more compact, but otherwise remained intact, burst open at the ventral furrow, or suffered a protrusion of the endosperm between the attachment region and the embryo or at some other weak location of the pericarp, probably resulting from damage during processing. The grains of the three species heated at 440 °C no longer show the differences in shape observed in the untreated grains: size and shape pose problems when used for taxonomical separation purposes among different wheat species without the presence of characteristic additional plant parts (Braadbaart et al. 2005); grains carbonised at a high heating rate are rather distorted, whilst at a low heating rate grains are more compact. The changes in length and width are different for dehusked and husked grains: dehusked grains of _T. dicoccum_ and _T. aestivum_ can reach an identical 100 L/W at high temperatures (from 310 °C); husked grains, after removal of the glumes, have a larger mean 100 L/W compared to dehusked grains and the degree of variation shows that a difference always remains between both species (Braadbaart 2008);

- structural changes:
  - weight loss: after 60 min. of heating at 270 °C, _Triticum_ spp. (_T. dicoccum, T. aestivum, T. durum_) grains lose between 40 and 50 % of their weight (Braadbaart et al. 2005); at an identical final temperature the mass loss of samples carbonised at a low heating rate is lower than the mass loss attained at a high heating rate (Braadbaart 2008);
  - reflectance: from 270 °C the reflectance could be measured, which rises slowly with increasing temperature up to 400 °C and thereafter rises more rapidly, with no difference observed between species and dehusked and husked grains. In the range between 270 and 370 °C, the temperature cannot be determined unless the time of exposure is known. The surface of wheat grains becomes shinier when carbonised at temperatures higher than 440 °C (Braadbaart 2008);

- anatomical changes: the formation of protrusions is strongly related with the heating rate: protrusions start to appear at temperatures above 200 °C (Téllez & Ciferri 1954) but at a low heating rate few protrusions are formed (Braadbaart 2008). Concave flanks are mainly restricted to grains carbonised at high heating rates and at temperatures higher than 300 °C (about 30-40 % of grains); however, occasionally grains become concave at low heating rates (Braadbaart 2008);

- chemical composition: Heating at temperatures higher than 250 °C results in a gradual conversion of starch into aromatic compounds and at temperatures above 440 °C, the chemical composition, which now consists of condensed aromatic compounds, does not change further (Braadbaart 2008).
Non-anthropic marks

Whole *Triticum* spp. grains appear to pass cattle digestion intact (Robinson & Rasmussen 1989).

★ Summary

*Triticum* sp. grains have high potential for being preserved in the charred archaeological record (*vid*. Table 37). *Vid. supra* general comments for the Triticeae (p. 192) and *infra* for more specific taxa in this tribe.

- *Triticum* "nudum"


Vernacular names: naked wheat (bread or common wheat / club wheat / macaroni wheat)

Nombres vernáculos: trigo desnudo (trigo común o candeal / trigo compacto / trigo duro)

Nomes vernáculos: trigo nu (trigo candial ou comum / trigo duro / trigo farro)

Figure 42: From left to right: Dorsal and ventral-lateral views of a *Triticum aestivum* modern grain; dorsal and ventral-lateral views of a *Triticum durum* modern grain; dorsal, ventral, transversal and lateral views of a charred specimen from São Pedro de Canaferrim determined as *Triticum "nudum"* (*T. aestivum/compactum/durum/turgidum*). Scale bar = 1 mm.

Description of the macroremains

The grains are clearly naked, with the typical globular appearance, with a short hilum, a flat ventral side and deep and relatively wide furrow; in side view, the maximum height is achieved in the middle and in lateral view, glume compression marks are absent (Figure 42). Naked wheat grains from the different species (*Triticum aestivum* L. / *durum* Desf. / *turgidum* L.) are morphologically indistinguishable (Zohary, Hopf & Weiss 2012) and that is the reason for referring to them as a group.
of *Triticum* “*nudum*”\(^{29}\). Some badly preserved remains have been determined as *Triticum* cf. “*nudum*” because they do not maintain all diagnostic features. Wide morphological variation within each species according to the number or grains per spikelet (from two to five) and the position of the grain within the ear, produce overlapping sizes and shapes (Maier 1996). Some grains from *Triticum* “*nudum*” found loosely in a sample, might not be definitely identified as belonging to this group of taxa (Maier 1996). The relatively wide morphological variation among the assemblage studied could be explained because of the existence of different species, different varieties or interspecific morphological variation.

**Presence in the archaeological record**

*Triticum* “*nudum*” grains have been determined at the assemblages from Lapiás das Lameiras and São Pedro de Canaferrim in Portugal, and Los Gitanos in the Cantabrian region. Grains, and less frequently rachis remains, from the different naked wheats are often recovered in European prehistorical sites from the Early Neolithic, often remaining undetermined to species level due to the absence of rachis remains or impracticality of practising DNA analyses.

**Ecological characteristics**

*Triticum* “*nudum*” refers to different *Triticum* species with very different yields and nutritional contents, but in general and in comparison to hulled wheats, they are less resistant, give better yields and have better baking properties. Each above-ground plant part being formed by a long straw and an ear, in which the grains are contained within their spikelets. As in the case of all domesticated cereals, its rachis is tough, and as all naked or free-threshing cereals, its grains free themselves easily of their glumes. *T. aestivum* thrives best in continental climates with summer precipitation. *T. durum* is the naked wheat best adapted to dry Mediterranean summers.

**Ethnographical information**

**Bromatological use**

*Triticum* “*nudum*” are often destined for human consumption, sometimes indistinctly (Percival 1921), although *T. aestivum* is the best for bread making, whilst *T. durum* is more difficult to turn into powder and is preferred for pasta preparation. The seed can also be sprouted and then added to salads or juiced to make a healthy drink (Fern 1992-2010).

**Pharmaceutical use**

The toasted bread is reported to be antihelminthic and hematocathartic and its topical application anti-haemorrhoidal; an aerosol preparation of the bran is mucolytic (Agelet & Vallès 2003). The young stems are used in the treatment of biliousness and intoxication; the ash is used to remove skin blemishes;

\(^{29}\) This is not a species name! (vid. Jacomet 2006).
the seed is antipyretic and sedative and has been used to promote female fertility; the light grain is antihydrotic: it is used in the treatment of night sweats and spontaneous sweating; the seed sprouts are antibilious, antivinous and constructive, they are used in the treatment of malaise, sore throat, thirst, abdominal coldness and spasmodic pain, constipation and cough (Fern 1992-2010).

**Technological use**

The straw of *Triticum* “nudum” has many uses: as a biomass for fuel, for thatching, as a mulch in the garden, for making paper, etc. (Fern 1992-2010).

**On processing**

**Peeling**

*Triticum* “nudum” ears break into grain and light chaff upon threshing without need of further dehusking.

**Cooking**

Different ways of preparing naked wheats are known (Hillman 1984-1986): such as ear roasting to make *frikké*, grain roasting or boiling for *bulgur* production.

**Taphonomical proxies**

*Triticum aestivum* embryos remain attached to the grains after all the experimental threshing, winnowing, sieving and charring processes (Antolín i Tutusaus 2012), thus it is not known why the archaeological specimens often lack this anatomical part. Short-term exposure of charred *T. aestivum* grains to open-air conditions can lead to the formation of soil concretions (Antolín i Tutusaus 2012).

**Carbonisation**

*Triticum aestivum* grains are, together with *Hordeum vulgare* grains, the first of the Triticeae to become carbonised and the first to be destroyed after 350 °C, they are quite drastically distorted even at very low temperatures (Boardman & Jones 1990). When charred in assemblages, in anoxic environments at 150 °C for 20 minutes, at 180 °C for 60 minutes, at 200 °C for 40 minutes and finally at 250 °C for 45 minutes, *T. aestivum* grains show a slight tendency (5 %) to form aggregates of seeds, due to the protrusion of the endosperm, but this might not survive well in the archaeological record, and about 15 % of the grains are popped or show protrusions whilst others are partially or completely uncarbonised (12 %) (Antolín i Tutusaus 2012).
Fragmentation

*T. aestivum* grains prepared for *frikke* production which end charred have their apex covered by a viscous substance (Hubbard & al Azm 1990); charred grains that had become fragmented during threshing (with a threshing board and a threshing stone) have characteristic bulging sections with smooth and shiny surfaces (Antolín i Tutusaus 2012); the type of threshing technique influences the state of preservation of rachises and grains (Alonso *et al.* 2013). Fragmentation upon recovery leaves irregular fractures on the grains (Antolín i Tutusaus 2012).

★ Summary

Grains of *Triticum* “*nudum*” have a high potential for appearing in the archaeological record (*vid.* Table 37). *Vid.* *supra* general comments for the Triticeae (p. 192) and *infra* specific information about the determined species in this category.

- *Triticum* cf. *durum* Desf. / *turgidum* L.


Vernacular names: macaroni wheat / rivet wheat

Nombres vernáculos: trigo duro / trigo farro

Nomes vernáculos: trigo farro

Description of the macroremain

A single rachis segment (Figure 43) with one lateral side straight, another slightly curved, and parallel with one another, with a slightly bulgy glume insertion point and a very small portion of the glumes remaining, probably corresponds to a tetraploid rachis segment (*T. durum* / *T. turgidum*) (Maier 1996). However, the shape and size of naked wheat rachis segments vary according to the position in the spikelet, thus ideally more than one rachis segment would be necessary to identify an assemblage with certainty, as some rachis segments of *Triticum compactum* might be similar.
Part III A: Results: the identified taxa

Presence in the archaeological record

A remain determined as tetraploid wheat has been recovered at Lapiás das Lameiras, where abundant grains of *T. "nudum"* grains have been also found. Naked tetraploid wheats appear in the archaeological record before hexaploid ones. Naked wheats appear in the Iberian Peninsula from the Early Neolithic, however, only at two sites (La Draga and La Marmotta) has tetraploid wheat been positively identified (Antolín & Buxó 2012).

Ecological characteristics

Each above-ground plant part being formed by a long straw and an ear, in which the grains are contained within their spikelets. As in the case of all domesticated cereals, its rachis is tough, and as all naked or free-threshing cereals, its grains free themselves easily of their glumes.

Ethnographical information

Bromatological use

*Triticum durum* grains are mainly used for the elaboration of pasta.
Pharmaceutical use

A decoction or syrup of the shoots of *T. durum* has traditionally been used as laxative, antipyretic and cough sedative (Maxia et al. 2008).

Taphonomical proxies

Carbonisation

Free-threshing rachis fragments took a little longer to become carbonised than did glume wheat glumes, but only at 250 °C, they also tended to disintegrate more quickly and at lower temperatures; even at 300 °C they were beginning to disintegrate after 5 h; reducing conditions delayed both carbonisation and, particularly, destruction of rachis (Boardman & Jones 1990).

★ Summary

In comparison to grains, *Triticum durum* rachis segments have less chances of being preserved in the charred archaeological record (*vid.* Table 38). *Vid. supra* general comments for the Triticeae (p. 192) and naked wheats which might be of relevance for this taxon (p. 203).

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<th>Preservation Ethnobotanical</th>
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Table 38: Recovery chances of *Triticum durum* rachis segments in the charred archaeobotanical record.

- *Triticum “vestitum”*


Vernacular names: hulled or glume wheats (emmer / einkorn / new glume wheat)

Nombres vernáculos: trigos vestidos (escanda, escaña menor / escaña mayor)

Nomes vernáculos: trigos vestidos
Part III A: Results; the identified taxa

Description of the macroremains

Two glume wheat spikelet forks, one with a glume base attached (Figure 44), have been recovered in a very poor state of preservation. The primary keels of the glumes are missing and the length of the scar cannot be clearly observed, thus inhibiting the distinction among the different hulled wheats.

Several grains of Triticum, with clear deep and narrow ventral furrow and dorsal hump, have been also impossible to determine to species level. The distinction is often difficult between two-grained T. monococcum grains and T. dicoccum ones.

Until the discovery of new glume wheat, hulled wheat remains of unknown species were often determined as Triticum monococcum/dicoccum. Because the Neolithic distribution of the new glume wheat species is still unknown, the possibility of its existence in assemblages where hulled wheat has been determined cannot be excluded.

Presence in the archaeological record

Both chaff and grains from Triticum “vestitum” have been determined at Lapiás das Lameiras. This type of determinations are usual in archaeological reports from many European sites from the Early Neolithic onwards, because preservation factors often inhibit the observation of crucial identification features.

Ecological characteristics

Triticum dicoccum and T. monococcum are hulled wheats, resistant and adapted to mountainous climates and poor soils, but give a relatively low yield in comparison to naked wheats. The above-ground part of the plants is formed by a long straw and an ear, in which the grains are contained singly or in pairs within their spikelets. As in the case of all domesticated cereals, their rachis is tough, and as all hulled cereals, its glumes remain naturally attached to the grain.
Ethnographical information

On processing

Peeling

*Triticum dicoccum* and *T. monococcum* cereal ears break up into separate spikelets and awn fragments upon threshing. To remove the grains from the glumes, a dehusking process is needed, which produces the breakage of the spikelet into free grains, light chaff (glumes and awns), rachis segments, spikelet forks and glume bases. Glume wheats are better dehusked with different tools either without any pretreatment or roasted, than soaked; predehusking roasting (but not soaking) destroys the glumes of hulled wheats (Alonso et al. 2013).

Taphonomical proxies

Carbonisation

Free glumes (of the glume wheats) show the next widest survival conditions after grains. The rate of carbonisation for glumes was only slower at the lowest temperature (250 °C) but glumes were destroyed more readily than grains. Einkorn was generally the first to turn to ash. The band of survival was greater under reducing than under oxidizing conditions (Boardman & Jones 1990):

- Under oxidizing conditions, the rates at which glumes became carbonised were very similar to those for grain (being slightly delayed only at 250 °C). The upper limit of survival was lower than grains, generally around 400 to 450 °C. Even at 350 °C after 3h it is doubtful whether they would survive deposition and retrieval and after 5h they had become twisted, reduced in size and finally little more than black and grey dust.

- Under reducing conditions, the glumes took longer to become carbonised at low temperatures (250 °C) and survived to higher temperatures (500-550°C) particularly over short periods of time. At low temperatures, the glumes of whole spikelets appear to take longer to become carbonised than free glumes, both under reducing and oxidizing conditions, and resist longer. The differences between the whole spikelets and free glumes became much less marked as temperatures increased until, at 500 °C the loss of the glumes was delayed by only 15 min. in the whole spikelets. At high temperatures, both loose glumes and those in spikelets behaved very similarly.

- Under oxidizing conditions at 300 °C, the whole spikelets were the only components remaining uncarbonised after half an hour, but at 350 °C the light chaff burnt away and the rest of the spikelet was totally carbonised. The grain and glumes tended to be fairly fragile and to disintegrate easily. This fragility was most marked at very low temperatures, especially after long periods of time.

- Under reducing conditions, the delay in carbonisation was even more marked, particularly at low temperatures, and the rate at which the glumes were lost was also considerably slower. After 3 h at
Part III A: Results: the identified taxa

250 °C the whole spikelets were outwardly little changed, though the grains had become partially carbonised. After 5 h at 250 to 350 °C the whole spikelets were complete, carbonised and quite intact. There was some evidence of fusion of grains to glumes at 300 to 350 °C. At 400 to 450 °C the chaff of the whole spikelets survived much longer than the free chaff and the difference was even more marked than under oxidizing conditions.

**Fragmentation**

*T. monococcum* spikelet forks tend to get fragmented more easily than those of *T. dicoccum* upon dehusking (Alonso *et al.* 2013).

**Summary**

*Triticum “vestitum”* spikelet forks have fewer chances than grains to be preserved in the charred archaeological record (*vid.* Table 39). *Vid. supra* general comments for the Triticeae (p. 192) and *infra* for species belonging to this category.

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Table 39: Recovery chances of *Triticum “vestitum”* spikelet forks in the charred archaeobotanical record.

- *Triticum “dioecenum”* (*Triticum dioecoen* Schlûb.)

(*T. turqidum* ssp. *dioecoen* Schrank ex Schlûb.)

**Vernacular names:** emmer

**Nombres vernáculos:** escanda, escaña menor

**Description of the macroremains**

Grains determined as *T. dicoccum* have an elongated appearance, with a narrow and deep ventral hilum, a short and slightly pointed embryo, lateral compression marks and its maximum height just right after the embryo in lateral view, sometimes humpy (Figure 45). Some badly preserved remains have been determined as *Triticum cf. dioecenum* because they do not maintain all diagnostic features.
Presence in the archaeological record

Remains determined as *T. dicoccum* have been recovered at Lapiás das Lameiras and São Pedro de Canaferrim. Despite being now underutilised crops, hulled wheats had been very important crops from the beginnings of the agriculture of domesticated species. In some cases, such as the Mediterranean region, hulled wheats were soon widely substituted by naked wheats, whilst in other regions, such as Central Europe, they continued to have importance for a long period.

![Figure 45: Left: modern specimen of *Triticum dicoccum* in dorsal and lateral-ventral views; right: charred specimen from Lapiás das Lameiras in dorsal, ventral, lateral and transversal views determined as *Triticum dicoccum*. Scale bar = 1 mm.](image)

Ecological characteristics

*Triticum dicoccum* is a resistant crop that has relatively low yields, and that can be sown in autumn or spring (Kreuz 2007). The above-ground plant part is formed by a long straw and an ear, in which the grains are contained in pairs within their spikelets.

Ethnographical information

Bromatological use

*Triticum dicoccum* has historically been an important crop, both for human food, animal fodder and high-quality beer production. Vread might be obtained from it (Peña-Chocarro & Zapata Peña 1997).
Technological use

The straw from *T. dicoccum* is very appreciated in basketry and animal bedding (Peña-Chocarro & Zapata Peña 1997).

On processing

Dehusking

Whilst *T. dicoccum* used for human consumption needs to be dehusked, if it is used for animal fodder or for seed it is not dehusked but only threshed, as dehusking often damages the embryo and inhibits germination (Peña-Chocarro & Zapata Peña 1997).

Taphonomical proxies

Carbonisation

“The presence of chaff has no effect on the size and a minimal effect on the shape of the heated grains at 290 and 340 °C. At 440 °C the grains heated with chaff have about 10 % smaller shape, but the size remains unaffected.” (Braadbaart et al. 2005). Dehusked grains were charred under experimental conditions at different temperatures, in the range of 130 to 700 °C (Braadbaart et al. 2004a; Braadbaart & van Bergen 2005):

- morphological changes: Grains become swollen up to 250-270 °C. Subsequently, the size decreases, as the total weight decreases with increasing temperature, and the grains get rounder;
- anatomical changes: Protrusions and vesicles: Up to 250 °C, no protrusions appear on grains, above this temperature, protrusions appear proportionally as the temperature increases. Between 340 and 400 °C, the pericarp shows vesicles;
- structural changes: starch granules in the endosperm cells do not change in size.

- mass loss: for each temperature, the mass loss reaches a constant level after a certain time (the higher the temperature, the shorter the time) although the total mass loss does not become constant. A heating time of 120 min. is sufficient for the total mass loss to become constant at all temperatures. A strong rate of mass loss was observed in the range of 220 to 250 °C.
- Reflectance: vitrinite reflectance rises slowly from 270 to 400 °C, thereafter it rises more rapidly.
- chemical changes: from 310 °C starch is no longer present, thus the grains have a better chance to survive the microbial degradation processes. at temperatures above 440 °C, the chemical composition, which now consists of condensed aromatic compounds, does not change further
Fragmentation

*Triticum dicoccum* grains present high indices of fragmentation after dehusking but experimental results are contradictory: the fragmentation rate is independent of the pretreatment used, and predominates in the transversal axis, although in the longitudinal one it is also frequent (Alonso et al. 2013); when dehusked with a wooden mortar, roasted grains tend to fragment more than soaked grains, which do not break and are dehusked faster (Procopiou 2003); soaking increases fragmentation when dehusking with saddle querns (Meurers-Balke & Luning 1992).

★ Summary

Grains of *Triticum dicoccum* have high chances of being preserved in the archaeological record (vid. Table 37). *Vid. supra* general comments for the Triticeae (p. 192) and hulled wheats (p. 208).

- *Triticum monococcum* L.

(*T. monococcum* L. ssp. *monococcum*)

Vernacular names: einkorn

*Nombres vernáculos*: escaña mayor

Figure 46: Left: Modern specimen of a *Triticum monococcum* grain from a single-grained spikelet in lateral-ventral view; right: charred specimen from Lapíás das Lameiras determined as a *Triticum monococcum* grain from a single-grained spikelet in dorsal, ventral, lateral and transversal views. Scale bar = 1 mm.
Part III A: Results: the identified taxa

Description of the macroremains

Grains identified as *T. monococcum* are elongated, with a deep and narrow ventral hilum, a short and obtuse embryo, lateral compression marks, a marked dorsal ridge, and pointy apex (Figure 46). Some badly preserved remains have been determined as *Triticum* cf. *monococcum* because they do not maintain all diagnostic features. Most grains identified as such came from single-grained spikelets, which have a convex ventral side, instead of the flattish seeds from double-grained spikelets. Although both can co-occur on the same ears, ears with two-grained spikelets latter are rarer cultivars (Weiss & Zohary 2011).

Presence in the archaeological record

Plant macroremains determined in this work as *T. monococcum* have been recovered from São Pedro de Canaferrim and Lapiás das Lameiras. Despite being an important crop in the Neolithic of other parts of Europe, the presence of *T. monococcum* in the archaeobotanical record of the Iberian Peninsula is rare and in low quantities, never appearing to have constituted a major crop in the area, but rather an obnoxious weed of naked wheat crops (Zohary, Hopf & Weiss 2012).

Ecological characteristics

*T. monococcum* is a herbaceous plant that reaches about 70 cm, each above-ground plant part being formed by a long straw and an ear, in which the grains are contained singly or in pairs within their spikelets. It has a relatively low production but is resistant to poor soils and prefers fresh climates rather than warm (Zohary, Hopf & Weiss 2012). It can be sown in winter or spring (Kreuz 2007). The grains are nutritive.

Ethnographical information

Bromatological use

*Triticum monococcum* grains are not the best suited cereals for baking as breads, but have been used as such as well as a porridge ingredient, in bulgur-type preparations, soups, couscous, wafer or consumed whole. Different food preparations are obtained with a mixture of einkorn flour alone or in combination with different cereals and water, milk or olive oil, butter or grape juice (Peña-Chocarro et al. 2009). It has also been used as fodder for domesticated animals, both alone or mixed with other products, such as barley or vetches. A mixture with olive oil was particularly recommended for cows and goats after giving birth and einkorn-fed hens were said to lay bigger and whiter eggs (Peña-Chocarro et al. 2009).
Technological use

*Triticum monococcum* straw is the most appreciated for thatching roofs because of its length, hardness and resistance to rain, lasting several years with a little maintenance every year (Peña-Chocarro *et al.* 2009). Accompanying softer materials, it is also a good filling for mattresses and cushions.

On processing

Procurement: cultivation and gathering

Because its resistance to rain, *T. monococcum* can be left as the last cereal crop to be gathered. Usually, the choice of harvesting technique depends on the suitability of the technique to obtain long straw for thatching (Peña-Chocarro *et al.* 2009).

Grinding

Although boiled and dried *T. monococcum* grains require more strength than unprocessed grains to fragment in the first movements with a grinding stone equipment, the processed grains turn into bulgur-type remains in about half the time than unprocessed ones (Valamoti, Chondrou & Papadopoulou 2013). Cracked grains are used for different types of food preparations (Peña-Chocarro *et al.* 2009).

Taphonomical proxies

Carbonisation

*Triticum monococcum* grains were the last of the Triticeae to become carbonised and also the most resilient at high temperatures, even up to 550 °C (Boardman & Jones 1990). At 250 °C, the glumes require more time to be carbonised than the grains (Bowman 1966 *apud* Boardman & Jones 1990).

Fragmentation

*Triticum monococcum* grains fragment intensively upon dehusking, presenting a high tendency towards longitudinal fragmentation (Alonso *et al.* 2013).

★ Summary

Grains of *Triticum dicoccum* have high chances of being preserved in the archaeological record (*vid.* Table 37). *Vid. supra* general comments for the Triticeae (p. 192) and hulled wheats (p. 208).
Palmae (Arecaceae)

- Chamaerops humilis L.

Vernacular names: (plant) dwarf-palm; (fruit) date  
Nombres vernáculos: (planta) palmito, palma enana; (fruto) dátil, palmiche  
Nomes vernáculos: (planta) palmeira-anã, palmeira-das-vassouras

Description of the macroremains

An endocarp half fragment (the stone of the fruit), woody, with oval shape and surface sculpture consistent of divergent lines emerging from the apex (Figure 47). The part with the embryo is missing. The breakage is transversal and its surface is clean, allowing the internal anatomy of the remain to be distinguished, composed of an external layer of homogeneous scalariform cells and an internal layer with longitudinal vases.

Presence in the archaeological record

São Pedro de Canaferim is the site studied in this work which has provided Ch. humilis plant macroremains. The other known finds of Ch. humilis in the archaeobotanical record are only from Ifri Oudadane, an Early Neolithic site in Northern Africa, in which abundant stone remains have been recovered (Morales et al. 2013).

Ecological characteristics

Ch. humilis is generally a dwarf-palm, up to 2 m high by 1.5 m wide (an arboreous variety, Ch. humilis var. lusitanica, exists), present in shrub xeric and sun-exposed ecosystems, indifferent to soils and up to 1100-1200 m a.s.l. (Flora iberica 1986+). The plant is rustic and drought resistant, and thrives in environments with intermediate grazing pressure but tends to disappear in over-grazed...
environments (Navarro, Alados & Cabezudo 2006). Its current distribution does not reach the area in which it has been recovered (Flora iberica 1986+; Pinto da Silva 1989). The fruit ripens between summer and autumn, the fruits are dates, fibrous ellipsoidal drupes, of about 1.2-4 by 0.7-1.6 cm (Flora iberica 1986+).

**Dispersal strategy**

Its reproduction is based on endozoochory (Paula & Pausas 2009), i.e., seed dispersal by ingestion of the fruit and defecation of the seed by animals, particularly by foxes, badgers, rabbits, boars and deer (Fedriani & Delibes 2009a; Fedriani & Delibes 2010; Perea et al. 2013).

**Ethnographical information**

**Bromatological use**

The date from *Ch. humilis* is palatable but astringent, as it has a high tannin content, it is eaten dried (Fern 1992-2010); young shoots and bracts are very appreciated foodstuffs (Flora iberica 1986+).

**Pharmaceutical use**

Several *Ch. humilis* plant parts have medicinal properties, which affect the way in which they are prepared (Hasnaoui et al. 2011): leaves are macerated for antidiabetic use, bracts and shoots are eaten raw as a tonic for stomach-ache.

**Symbolical use**

Plants are used in celebrations (San Miguel López 2004) and to form hedges (Fern 1992-2010).

**Technological use**

Fibres from *Ch. humilis* leaves are used in basketry, brooms and hats (Flora iberica 1986+), cordages (Fern 1992-2010) and finger guards for threshing cereal (Peña-Chocarro et al. 2009). Leaves are used to make baskets where cereals can be dehusked by rubbing (Peña-Chocarro et al. 2009).

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30 It is possible that this reference might provide uncontrasted information (vid. Beall 2012).
Part III A: Results: the identified taxa

**Taphonomical proxies**

**Fragmentation**

Experimentation has been carried out in the framework of this thesis to obtain modern fracture references for the specimen recovered. *Ch. humilis* dates were gathered in early autumn from naturalised cultivated plants in the Cantabrian region. The fruit flesh, proved to be best extracted by smashing the fruit between two stones, resulting in the easy obtention of the whole of it in one piece (whilst it is difficult to extract it by hand, as it often breaks in very small fragments). Smashing the fruit does not break the stone (0 breakages in 25 smashings), allowing the inference that the fracture in the archaeological specimen is probably an unintentional and post depositional (at least postcharring) phenomenon.

**Summary**

Due to the woody character of the endocarp and the type of use for the plant, *Chamaerops humilis* endocarps are highly likely to be preserved in the charred archaeobotanical record (*vid. Table 40*).

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Table 40: Recovery chances of *Chamaerops humilis* endocarps in the charred archaeobotanical record.

**Dicotyledons – Magnoliopsidae**

Dicots are plants with two cotyledon; the number of species in which C₄ occur is not yet well-known (Sage & Monson 1999).

**Anacardiaceae**

- *cf. Pistacia lentiscus* L.

Vernacular names: mastic tree

Nombres vernáculos: lentisco, cornicabra

Nomes vernáculos: aroeira
Description of the macroremains

Thin (0.5mm) and slightly curved woody coat fragments with smooth surfaces and transversal section (Figure 48) have been determined as cf. *Pistacia lentiscus* endocarp fragments, after checking seed and fruit coats from all possible taxa according to ecological proxies. For quantification, the number of nutshell fragments has been divided by 8.

Presence in the archaeological record

Plant macroremains potentially belonging to *Pistacia lentiscus* have been tentatively determined at Poças de São Bento; this taxon is relatively frequent in Mediterranean sites (*e.g.*, Antolín *et al.* 2012; Aura *et al.* 2005; Morales 2010; Pérez Jordà, Peña Chocarro & Morales Mateos 2011).

Ecological characteristics

*Pistacia lentiscus* is an evergreen shrub growing up to 8 m in shrublands, it stands all soils and tolerates droughs but needs sun exposure; the leaves contain up to 19 % tannin and the fruit is between 3.5 and 5 mm wide, scarcely fleshy, and ripens in autumn (Flora iberica 1986+; Fern 1992-2010).

Dispersal strategy

Its dispersal mode is endozoochory (Paula & Pausas 2009), by corvids (Vaquer & Ruas 2009) among other frugivorous animals.
Part III A: Results: the identified taxa

Ethnographical information

Bromatological use

\[ \textit{Pistacia lentiscus} \text{ seeds provide an edible oil (lentisquina) which might be used in human and animal subsistence (Flora iberica 1986+). Moreover, the resin from the bark has a sweet liquorice-flavour, with agreeable odour and mild resinous taste which is used to make liquor and as a flavouring in puddings and sweets (Fern 1992-2010).} \]

Pharmaceutical use

The resin from the bark of \( \textit{P. lentiscus} \) is is analgesic, antitussive, carminative, diuretic, expectorant, odontalgic, sedative and stimulant; it is chewed to strengthen the gums and as a breath sweetener, applied to boils, ulcers, ringworm and muscular stiffness, used as an expectorant for bronchial troubles and coughs and as a treatment for diarrhoea, mixed with other substances is also used as a temporary filling for carious teeth (Fern 1992-2010). The leaves and branches are rich in tannin and are thus used as astringent (Flora iberica 1986+).

Technological use

\[ \textit{Pistacia lentiscus} \text{ has been cultivated for the extraction of the resin, mastic, from its trunk bark, and the current disappearance of the tree might be related to its intensive exploitation for charcoal, as its wood provides a high quality charcoal (Flora iberica 1986+). Mastic resin is used in varnishes, as a fixative in perfumes, glue, embalming; an oil obtained from the seed is used for lighting and soap making (Fern 1992-2010). The ashes from burning the branches and leaves have been used to produce soap (Zamora Zamora 2004).} \]

On processing

Oil extraction

The resin of \( \textit{P. lentiscus} \) is obtained by making incisions in the bark of the trunk (avoiding the wood) of the tree between mid-summer and autumn, then it can be dried and used as a powder, or distilled for oil and essence (Fern 1992-2010). The oil from the seeds is obtained by pounding in mortars (Zamora Zamora 2004).

Summary

This taxon has a medium to high probability of being recovered in the charred archaeological record (\textit{vid}, Table 41).
Betulaceae (Corylaceae)

- Corylus avellana L.

Vernacular names: (plant) hazel; (fruit) hazelnut

Nombres vernáculos: (planta) avellano; (fruto) avellana

Nomes vernáculos: (planta) aveleira, avelaneira; (fruto) avelã

Description of the macroremains

Fragments of heterogeneous sizes from the pericarp or achene of fruits have been determined as belonging to Corylus avellana. The surfaces are smooth, planar, and slightly curved; longitudinal vessels seen in transversal section easily allow for the determination to species (Figure 49). A distinctive cross-sectional anatomy, consisting of four layers of cells (Fairbairn, Kulakoğlu & Atici 2014), is visible in the transversal section of the fragments. Some fragments have lost the outer epidermis, showing the underlying channels.

Important hazelnut shell quantification problems exist: many diverse procedures for quantifying hazelnuts from their charred shell fragments have been used and consensus has not yet been reached (vid. Berihuete Azorín & Antolín 2012; López-Dóriga in press).

Quantification methods based on the number of fragments:

- obtaining a reference standard number of charred fragments per hazelnut from an old counterpart (Scaife 1992);
Part III A: Results: the identified taxa

- dividing by two (Buxó 1997) or four (Ruas, Laurent & Bénédicte 2005-2006) the total number of fragments;
- counting the number of fragments above 2 mm in size (Hosch & Jacomet 2001; Martin 2010);
- counting the number of bases (Tolar et al. 2011);
- establishing size categories for the fragments (1=up to 15 mm\(^2\), 2=16-60 mm\(^2\), 3=over 60 mm\(^2\)), then dividing the number of remains classified as 1 by 2, adding the result to the other remains and dividing the total by 8 (Berihuete Azorín & Antolín 2012, modified as in STAPLE website forum; Antolín & Jacomet 2015). This is the method employed in this work whenever it has been possible.

Quantification methods based on weight:
- multiplying the weight of the charred shells by two, to obtain the whole fruit weight (Lopinot 1984);
- weighing the shell fragments that are charred when hazelnuts are smashed and their shells are discarded over the fire (Perry 1999a apud Mason 1996a);
- obtaining a standard reference weight of charred shell per hazelnut from whole or half hazelnuts in the same deposit (McComb 1996 apud McComb & Simpson 1999; López-Dórigha in press);
- obtaining a standard reference weight of charred shell per hazelnut from modern counterparts (Bouby & Surmely 2004; Carruthers 2000; Perry 2005).

Quantifications methods based on volume:
- obtaining a standard reference volume of shell per hazelnut from modern counterparts (Testart 1982);
- obtaining a standard reference volume of shell per hazelnut from whole or half hazelnuts in the same deposit (Holst 2010).

Presence in the archaeological record

*Corylus avellana* macroremains have been recovered from all studied layers at all sites in the Cantabrian region: El Carabión, Arangas, Los Gitanos, Mazaculos II, El Toral and El Mazo. *C. avellana* shell fragments are one of the most frequent botanical remains found in archaeological sites in temperate Europe (e.g. Clarke 1976; Zvelebil 1994), particularly Mesolithic (Crombé et al. 2013; McComb 2009), and particularly Atlantic sites in the Iberian Peninsula (Zapata Peña 2000). They are frequently recovered in concentrations of considerable quantities, often within pits (Cunningham 2011; McComb 2009). In other parts of Europe where waterlogged preservation exists, hazelnuts are also found uncharred and sometimes whole (Bunce 2010). When recovered from hearths, they are considered excellent samples for radiocarbon dating Mesolithic contexts (Crombé et al. 2013). Its presence in starch analyses is more limited (Saul et al. 2012).

The importance of *C. avellana* as a food resource is highly debated, partly due to serious quantification disagreements. Its high relevance is often suggested for the Mesolithic (e.g. Clarke 1976; Holst 2010; Jarman, Bailey & Jarman 1982; Mithen & Score 2000) and Neolithic (e.g. Gregg 1988; McComb & Simpson 1999; Moffett, Robinson & Straker 1989; Stevens & Fuller 2012), and calculations of demographical sustainability based on hazelnut diets have been made (Jacobi 1978).
Inés L. López-Dóriga

times, hazelnuts are considered more likely as snacks (Scaife 1992) or seasonal foodstuffs (Perry 1999a *apud* Mason 1996a). In any case, its regular consumption, not necessarily in abundance, is considered demonstrated (Dietsch 2007). Other uses of the fruits, such as funerary goods, are considered as well: the nuts dispersed in and around the pottery vessels at the Neolithic necropolis of Parma via Guidorossi (Rottoli, pers. comm.) and a single nutshell fragment at Cumbria (Campbell 2004).

**Ecological characteristics**

The hazel is a small deciduous tree or shrub of up to 8 m by 3 m; it generally grows in shady and damp areas, particularly in valleys and hill slopes, in hedgerows, forest borders of small and sparse forests, in small groups or isolated, up to 1900 m a.s.l.; it tolerates strong winds but not maritime exposure (Flora iberica 1986+; Fern 1992-2010). The hazelnuts (achenes) are subglobose or ovoid, with a woody pericarp, of highly variable size, between 1.2 and 2 cm (Flora iberica 1986+), they are highly nutritional fruits, rich in lipids, proteins and carbohydrates, with a very low content in water (Loewenfeld 1947) which can make them indigestible if eaten in large quantities (Howes 1948); they ripen in autumn. It is cultivated for its fruit and was possibly taken into cultivation in classical times. Factors such as the age of the plant, soil and light conditions, and pollination changes affect fruit development; which added to the factors affecting developed fruits, such as illnesses and predators, make their final yield quite unpredictable (McComb & Simpson 1999).

**Dispersal strategy**

The dispersal is based in zoochory (hoarding) (Laborde & Thompson 2009).

**Ethnographical information**

*Corylus avellana* is nowadays one of the most important plant species in the Cantabrian region (San Miguel López 2004).

**Bromatological use**

*Corylus avellana* leaves, preferentially those of grown trees, are used as green fodder for domesticated animals (McComb & Simpson 1999); the fruits are edible raw and cooked in several different ways (Fern 1992-2010; *cf.* Jones 2000; Kubiak-Martens 1999; Mason 1995; McComb & Simpson 1999; Zapata Peña 2000): in salad dressings, breads, cakes, biscuits, sweets, etc; they can also be liquidized and used as a plant milk (Fern 1992-2010). It has been an important starter and snack for travellers and farmers (Concepción-Suárez 2004). As it can be stored for a long time, it has been a staple foodstuff for the preharvest scarcity in some regions (Gómez Pellón, pers. comm.), although its taste is a little bitter and dry by that time (Concepción-Suárez 2004); a differentiation was made between *ablanas* (soft, early and large hazelnuts) and *ablanos* (hard, late and small).
Cosmetic use

*Corylus avellana* nuts were used in historical times for perfume making (Montaner & Simón 1887-1898) and their non-drying oil in cosmetics (Fern 1992-2010); the shells, roasted or burnt, reduced to powder and mixed with oil, were reportedly used in the past to change the colour of children's eyes, from light to dark (Peña-Chocarro, Archaeobotany mailing list at Jiscmail); the nuts were heavily exported to England during the 17th to 19th centuries from Asturias, where their shells and rinds were used for dyeing fine clothes (de Pumareda 1711); the bark and leaves are a source of tannin and the seed contains a non-drying oil used in paints, the whole seed can be used to polish and oil wood (Fern 1992-2010).

Pharmaceutical use

The bark, leaves, catkins and fruits from *C. avellana* are used medicinally: they are reported to be astringent, diaphoretic, febrifuge and odontalgic (Fern 1992-2010). Roasted hazelnuts, or a beverage of them, were used in classical times to treat coughing (Pliny *apud* Mata Parreño *et al.* 2010). The inner skin that surrounds the kernel has astringent properties, the masculine flowers sudorific and leaves and small branches vasoconstrictor (*Flora iberica* 1986+). The seed is stomachic and tonic and its oil is effective in infections with worms in babies (Fern 1992-2010). It has also been used as an animal repellent, used to keep away scorpions and other venomous animals (Agustí 1717). Leaves are sometimes smoked although apparently no specific effect is sought (San Miguel López 2004). Trunks are used to put broken extremities in a splint (San Miguel López 2004).

Symbolical use

Natural water springs have been traditionally decorated with branches from different trees, including *C. avellana* (San Miguel López 2004).

Technological use

*Corylus avellana* kernels are rich in oils, which might be used for technological activities, such as bone and antler tool maintenance (Spangenberg *et al.* 2014); the shells are highly appreciated for lighting or rekindling fires (personal observation) and by-products of other species of hazelnut, such as the shells of *Corylus colurna*, have given positive results for their employment in dyeing activities (Tutak & Benli 2012).

The wood is also a popular fuel which can be made into charcoal fuel; the charcoal is of good quality for artists (Fern 1992-2010). The lower gallery in La Garma cave, a site in the Cantabrian region with evidence of human use from the Palaeolithic to the Middle Ages, has abundant charcoal fragments from hazel which would presumably have been employed as torches (Arias, pers. comm). *C. avellana* wood is very flexible, soft and easy to split, which makes it highly appreciated for its use in huts, fences and home gardens, for basketry and tool making, fishing rods (cf. Mason 2005, San Miguel López 2004), small items of furniture (Fern 1992-2010) and twisted rope production from twigs (San Miguel López 2004;
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Stone 2009). The twigs are reportedly used as dowsing rods by water diviners (Fern 1992-2010). Long branches from hazel are also used as poles for gathering fruits from trees by beating (San Miguel López 2004). Young leaves from C. avellana have been used to make practical jokes consisting of making them sound like explosions (San Miguel López 2004).

On processing

Procurement: cultivation and gathering

According to popular belief, the procurement of branches for technological activities must be carried out within specific moon phases (San Miguel López 2004). The Thompson Indians of southern British Columbia, practised controlled burning of Corylus bushes to enhance their nut production (Turner et al. 1990). Corylus spp. can be easily cultivated: it bears transplanting at any age, it succeeds in most soils, is fairly tolerant to wind but not to heavy frosts, plants are self-fertile but a more certain crop is obtained if more than one cultivar is grown. Often grown as a coppiced shrub in woodlands. (Fern 1992-2010)

According to some recent ethnographical and experimental observations, there might be only a small period of opportunity for the successful human harvesting of hazelnuts in areas where competition is high (McComb 2009). In these cases, C. avellana nuts would have to be gathered when the kernel is fully grown in the shell and the nut still green, before ripening and falling to the floor, to avoid predation by squirrels and other animals and to maximise the gathering product per area (Gunther 1973; Kuhnlein & Turner 1991). This reduces their long term preservation qualities and involves more postgathering processing activities: it is necessary to sun dry them and thresh them to free them of the “hat”. When competition is low (pers. obs.), C. avellana nuts are gathered from the soil, checking they are not infested and that the cupule falls easily (otherwise, they are blind nuts). Sprouted hazelnuts are explicitly preferred in some cases (Krzywinski, Fjeldan & Solvedt 1983). At least 1.400 nuts can be harvested per hour (Holst 2010; Talalay, Keller & Munson 1984).

Sorting

Corylus avellana nuts have to be sorted for long term storage: infested nuts weigh less than healthy nuts and can be left spread over a cold place in order to provoke the exit of the larvae.

Drying

Corylus avellana nuts are best dried, either in the sun, by the fire (more effective) or smoked over a hazel wickerwork (Fernández, pers. comm.), with several objectives (Mason 1996b):

• to kill insects (but most of the kernel would have already been eaten at gathering time);
• to improve and lengthen their life (green or unshelled nuts are very susceptible to carcinogenic mould fungi. Holst 2010);
Part III A: Results: the identified taxa

- to deshell them more easily (Mithen & Score 2000; Talalay, Keller & Munson 1984), although it is already easy without any treatment (Mason 1996a);
- to improve their oil content, reducing the content of indigestible fats, or extract it;
- to improve their taste; as it induces the “typical nutty flavour” (Holst 2010);
- to facilitate grounding to make a paste (Mithen & Score 2000).

Storing

Corylus avellana nuts are not seasonal proxies for site occupation, as they might be successfully stored for several months with very little effort (McComb 2009): up to 6 months, just placed in a dry, dark and cool deposit; up to 12 months, stored in a dry, dark and cool deposit after having been dried (cf. Mason 1996a). Above ground storage within rush bags in wooden sheds is ineffective, as a small portion of the hazelnuts is edible and the taste is unpleasant (McComb 2009). In underground storage experiments (Cunningham 2005; Cunningham 2010; McComb & Simpson 1999; McComb 2009) the shape and size of pits have not proved to be important for the preservation of nuts (hazelnuts and acorns) but isolation from moisture is (Cunningham 2010). Medium-term preservation (about 18 weeks) is good (between 60 % and 90 % are suitable, even in unideal conditions with leakage) (Cunningham 2005). Storage in containers within pits, helps the retrieval of the store and ensures cleanliness (Cunningham 2010), in some cases, storage in baskets within pits might be more successful than direct burial (McComb & Simpson 1999; McComb 2009) perhaps because of the isolation from moisture.

Peeling (dehusking / deshelling / dehulling)

Corylus avellana nut deshelling does not require the employment of specific tools, as any stone with a flat surface might serve the purpose, therefore it is unlikely that hazelnut cracking stones can be recognised in the archaeological record. However, chimpanzees are known to transport and reuse appropriate stones for nut-cracking (Carvalho et al. 2009). It is estimated that between 500 and 950 nuts can be individually cracked per hour by an experienced person (Barlow & Mithen 2000; Howes 1948, Mithen & Score 2000).

Ethnographical records regarding the consumption of other hard-shelled fruits mention an advantageous opening technique for processing large quantities of fruits, in contrast with having to crack them open individually: it consists of submitting them to a quick change of temperature, achieved by heating them with burning straw placed around and pouring cold water over them (Howes 1948). This did not work when roasting hazelnuts at 300 °C (own experiment). Roasting at higher temperatures might provide a successful result, but great care is needed to avoid charring if the hazelnuts are going to be eaten.

Cooking

Corylus avellana nuts might be prepared in different ways for human consumption (cf. Jones 2000; Kubiak-Martens 1999; Mason 1996a; McComb & Simpson 1999; Zapata Peña 2000): smashed with
meat or animal fat; dried in cakes with other plants; boiled, etc. The oil from the nuts can be extracted by boiling to use it for other foodstuffs (Turner & Szewinski 1988 and Kuhnlein & Turner 1991 *apud* Mason 1996a). Hazelnuts can be left a month in a haystack for the improvement of their flavour (McComb, comment to Hazelnut news 3).

**Discarding**

Nutshells are often considered domestic waste and thus are likely to be thrown to fires, as fuel or as a way of disposing them (*vid.* Jones 2000; Scaife 1992).

**Taphonomical proxies**

**Carbonisation**

Warped and flattened nut fragments might be the result of their being cracked before carbonisation or exposure to violent heat (Helbaek 1952a). Experimental charring has shown that, as charring temperatures move from 300 to 350 °C, the epidermis of the nutshell began to collapse and show the longitudinal parallel channels on the nut surface, and the shells fracture across the cell lumen instead at along the cell walls (Fairbairn, Kulakoğlu & Atici 2014). It is likely that a charred hazelnut assemblage from a single charring event (*vid.* p. 132) has different epidermic preservations, as not all individuals might have come into contact with fire at the same time and fire temperatures in open hearths are variable (Berihuete, pers. comm.).

Experimental work carried out in the course of this thesis (López-Dóriga in press; López-Dóriga 2015) has been able to establish criteria for distinguishing between charred nutshells fragmented postdepositionally (as in the case of stored deposits accidentally burnt or hearth accidents whilst roasting food-resources), and charred nutshells fragmented predepositionally (as a result of discarding food by-products into fires). This can help to understand the formation of deposits of primary or secondary type (*vid.* p. 132), *i.e.*, produced from a single event of charring but not necessarily being *in situ*. This is also useful for identifying tertiary deposits (*vid.* p. 132) in which the charred items come from multiple charring events of different condition. The criteria are mainly fire alteration traces:

- 95 % nutshell fragments which were exposed to fire once broken show at least one of the following fire alteration marks:
  - the outer skin of the pericarp is deformed and curled in itself, outlying the inner woody part of the pericarp,
  - transversal fissures appear on the edge surfaces of the pericarp fragments, more abundantly in the transversal edge surfaces (in 45 % of cases in fresh hazelnuts and in 55 % in dry ones) but in the longitudinal edges as well (40 % in both),
  - the edge surfaces of the pericarp fragments are in general rough and discontinuous, sometimes with vesicles (30 % in longitudinal edges of fresh nutshell fragments and 20 % in dry ones; whilst only 5 % in both fresh and dry transversal edges),

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• 100% nutshell fragments broken after charring present a smooth and continuous edge surface, sometimes presenting negatives, showing that the breakage has occurred after the material has achieved a certain vitrified constitution. However, 7% of the fragments have fissures caused by trampling which, in isolation, could be mistaken with heat fissures.

It has been tested if hazelnuts could be massively cracked open as was recorded ethnographically for other hard-shelled fruits: these were opened by a quick change of temperature, achieved by heating them with burning straw placed around and pouring cold water over them (Howes 1948). This could be very advantageous for processing high quantities of nuts, in contrast with having to crack them open individually. However, this did not work when roasting hazelnuts at around 300 °C between 5 and 15 minutes. Roasting at higher temperatures might produce a successful result, but much care is needed to avoid charring if the hazelnuts are going to be eaten in a tasty condition afterwards. Hazelnuts open naturally when exposed to an intense heat, but when this happens they are so charred as to be inedible (López-Dóriga in press).

If the carbonisation of hazelnuts is produced accidentally whilst roasting, then:

• if hazelnuts come into direct contact with fire whilst being roasted, their shells become readily charred and the kernel becomes unpalatable (Carruthers 2000; Kubiak-Martens 1999; Mithen & Score 2000);
• hazelnuts might have been roasted in different types of pits, which influence the amount of hazelnuts which end up charred:
  • pits filled with hazelnuts and a fire on top, separated by sand, produce only a small percentage of charred inedible hazelnuts (López-Dóriga in press; Mithen & Score 2000), varying according to fire length and pit size (Mithen & Score 2000);
  • pits with embers at the bottom are useful for roasting or smoking hazelnuts placed above a piece of wickerwork (Groenendijk 1987), only hazelnuts sliding through the wickerwork will be charred;

Regarding the preservation of hazelnut shells, certain observations have been shown:

• hazelnuts must have been burnt already mature, otherwise their pericarp is too thin and easily destroyed (Mason & Hather 2000);
• nutshell fragments between ash layers near a high-temperature fire carbonise very quickly (McComb & Simpson 1999; McComb 2009);
• no macroscopical differences in charred hazelnut shells exist between those carbonised in oxidising or anoxic atmospheric conditions (Berihuete Azorín & Antolín 2012);
• uncharred hazelnuts break into halves and smaller fragments, whilst charred ones break into much smaller fragments and dust (López-Dóriga in press; Mithen & Score 2000).

**Fragmentation**

Deshelling *C. avellana* nuts by percussion with stones does not leave macroscopical evidence on the stones (Carruthers 2000; Roda Gilabert, Martínez-Moreno & Torcal 2012; Roda Gilabert, Martínez-Moreno & Torcal 2013), It would be necessary to use the same stone over a very long time (for hours) in
the same operation to leave traces (Goren-Inbar et al. 2002). Despite that, it is often considered, according to ethnographical evidence in other world regions with hard-shelled nuts, that typical massive nut cracking anvil stones possess a characteristic central depression surrounded by abrasions (Holst 2010). However, roasted hazelnut crushing and grinding did generate diagnostic wear traces (Roda Gilabert, Martínez-Moreno & Torcal 2012; Roda Gilabert, Martínez-Moreno & Torcal 2013).

Impact marks upon charred shells left by stone cracking are difficult to identify (López-Dóriga in press), as they are small and superficial scratches, and almost disappear upon charring. The absence of other known opening marks suggests the likely opening by this technique (Scaife 1992).

A particular way of opening hazelnut shells that is still used has been recognised in medieval remains from Bryggen, Bergen, in which a sharp knife had been used to remove the tip of the nut and then split the shell by inserting the point of the knife in the whole and turning it. Unfortunately, the shells opened in this way are undistinguishable from those opened by squirrels, as they employ the same technique with their teeth (Krzywinski, Fjelldan & Solvedt 1983).

Non-anthropic marks

Predator marks, such as those of red squirrels, foxes, badgers, dormice, wood mice, Eurasian nuthatch (Sitta europaea), are potentially recognisable in archaeological specimens (Collinson & Hooker 2000; Vaquer & Ruas 2009), as was confirmed in experimental specimens charred in this work. Red squirrels open hazelnuts with their teeth, leaving a distinct mark in the perigonal scar; great tits (Parus major) crack open hazelnuts in clean halves by hitting the perigonal scar with their beaks whilst holding the nut with a claw (McComb & Simpson 1999); rodent incisor marks have been successfully identified at Star Carr (Clark 1954), Møllegabet II and Hallskov (Gron & Skaarup 1993; Robinson & Harild 2002). Consistent for all the rodent gnawings is the sharpness of the grooves on the inner edge of the hole, with different patterns according to the type and size of the rodents, which have different gnawing techniques (Collinson & Hooker 2000). The experimentation carried out during this work suggests that outer marks on the surface of the pericarp might be easily eroded in archaeological specimens, but other experiments suggest that “an abraded modern hazelnut still retains faint upper incisor marks [of the mice] on its outer surface” (Collinson & Hooker 2000).

Several animals (from small rodents to birds) create fruit stores for the winter in underground holes, which could be mistaken with human stores, as these stores would have rodent teeth or bird claws marks only if the animals eventually ate them. Badger (Meles meles) and wood mouse (Apodemus sylvaticus) hoards are not of comparable size to what are considered normal human stores; red squirrel (Sciurus vulgaris) hoards are scattered in many small caches (McComb & Simpson 1999).

Insect holes (probably from the hazelnut weevil, Curculio nucum/Balaninus nucum) have been identified on whole hazelnuts at Møllegabet II and Hallskov (Gron & Skaarup 1993; Robinson & Harild 2002) as well as in some of the experimental and archaeological fragment samples studied in this work. These phytophagous insects lay their eggs inside hazelnuts making a small perforation in the shell; when the insect develops into a grub, it exits the hazelnut by eating the shell and leaving a 2-3 mm round hole.
Part III A: Results; the identified taxa

★ Summary

Due to their high resistance and the way in which they might be processed, hazelnut shells have a high potential for being recovered in the archaeological record in a charred state (*vid.* Table 42).

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Table 42: Recovery chances of *Corylus avellana* nutshell in the charred archaeobotanical record.

**Boraginaceae**

- *tp. Echium sp. L.*

**Vernacular names:** viper’s bugloss  
**Nombres vernáculos:** viborera, lenguaza  
**Nomes vernáculos:** viperina, soagem

**Description of the macroremain**

Mericarp (with a seed within) fragments, showing a large hilum at the base and two planes at right angles in interior view (Figure 50), have been determined as *tp. Echium sp.* *Echium* ssp. mericarps are usually irregularly tuberculated, have one dorsal, one ventral and two lateral keels and a crown-shaped triangular base (*Flora iberica* 1986+).

**Presence in the archaeological record**

A specimen potentially belonging to *Echium* sp. has been determined at Poças de São Bento.
Ecological characteristics

_Echium_ spp. are annual, biennial or perennial herbs or sub-shrubs, which grow in roadsides, slopes, meadows and particular lithologies; the fruit is stony, composed of four mericarps (Flora iberica 1986+) and ripens from summer to autumn (Fern 1992-2010).

Dispersal strategy

They depend on autochory (barochory, they simply fall to the ground) for their dispersal (Paula & Pausas 2009).

Ethnographical information

Bromatological use

The leaves from _Echium vulgare_ are edible raw, as a salad, or cooked (Fern 1992-2010), the seeds of many species in the Boraginaceae family are rich in oils with a high Omega 3 content which might be used in culinary preparations (Chilton et al. 2008).

Pharmaceutical use

_Echium_ spp. plants had been used from classical times against snake bites, particularly from vipers (Flora iberica 1986+). The leaves and flowering stems of _Echium vulgare_ are reported to be aphrodisiac, sweat-inducing, diuretic, antitussive, emollient, demulcent, diaphoretic, pectoral and vulnerary, but its alkaloids might be toxic (Fern 1992-2010).

Technological use

A red dye is obtained from the root of _Echium vulgare_ (Fern 1992-2010).

On processing

Procurement: cultivation and gathering

Leaves for medicinal use are gathered in summer and can be preserved for the whole year (Fern 1992-2010).
Part III A: Results: the identified taxa

★ Summary

Despite having very resistant stony mericarps, the way in which *Echium* sp. seeds might be used reduce their recovery potential (*vid*. Table 43).

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Table 43: Recovery chances of *Echium vulgare* mericarps in the charred archaeobotanical record.

**Chenopodiaceae (Amaranthaceae)**

Heterocarpy (heterogeneity in fruit morphology) is common in this family, therefore determinations to species level are not always secure (Cappers & Bekker 2013). C\textsubscript{4} photosynthesis is common within this family (Akhani 1997).

- *Chenopodium* sp. L.

Vernacular names: chenopods, goosefoots

*Nombres vernáculos*: quenopodios

*Nomes vernáculos*: quenopodios

**Description of the macroremain**

A lenticular seed with flattened sides, of about 2 mm length by 1.25 mm width, the radicle short but broken has been determined as *Chenopodium* sp. (Figure 51). The rugose surface sculpture exclusively matches that of *Ch. polyspermum* but the shape is not strictly coincident. Chenopods expand in thickness upon carbonisation: this is problematical for the distinction among the various species of *Chenopodium* based on measurements (Wright 2003).

![Figure 51](image-url)

Figure 51: Left: modern achene of *Chenopodium polyspermum* in ventral view. Right: dorsal view of charred achene from São Pedro de Canaferrim determined as *Chenopodium* sp. Scale bar = 1 mm.
Presence in the archaeological record

Plant macroremains determined as Chenopodium sp. have been recovered from São Pedro de Canaferrim. Chenopodium spp. finds are very frequent in archaeological sites, but determination to species level is not as usual. Ch. polyspermum seeds in huge numbers have been found in a late prehistorical site in Central Europe (Behre 2008).

Ecological characteristics

The genus Chenopodium is composed of highly morphologically variable species, annual or perennial herbs, straight or prostrated, with small flowers and seeds often surrounded by a hard shiny membranous pericarp, sometimes succulent, lenticular in shape and the perisperm is farinaceous and abundant (Flora iberica 1986+), ripen from summer to autumn (Fern 1992-2010). This genus follows a C₃ photosynthetic pathway (Akhani 1997).

Dispersal strategy

The dispersal strategy in this genus is autochory (Paula & Pausas 2009).

Ethnographical information

Bromatological use

The flowers, leaves and seeds of all members of the Chenopodium genus are edible to different degrees and very nutritious vegetables; however, many of the species in this genus contain toxic substances (saponins, oxalic acid, nitrates and hydrogen cyanide), though usually in quantities too small to do any harm if reasonable cooked quantities are consumed (Fern 1992-2010).

On processing

Cooking

Most toxic substances are broken down to a large extent in the cooking process (Fern 1992-2010). The seed should be soaked in water and thoroughly rinsed before being used; cooking can consist of parching for popping as maize corn (Miksicek 1987), grounding and baking into a bread or sprouting and adding to salads (Fern 1992-2010).
Taphonomical proxies

Carbonisation

The preservation of *Chenopodium* spp. grains in an identifiable state after charring requires both short exposure intervals and low temperatures: carbonisation is only achieved at temperatures ranges between 300 °C / 50 minutes and 400 °C / 5 minutes (Aguirre *et al.* 2013-2015; Wright 2003). Upon carbonisation at low temperatures, chenopods diminish in size and weight but expand in thickness (Wright 2003), whilst at higher temperatures or higher exposure intervals (at 350 °C for 60 minutes or between 400 and 700 °C for 5 minutes) the perisperm starts to protrude, forming a crust around the pericarp and becoming highly friable (Aguirre *et al.* 2013-2015; López & Heumann 2013-2015; Wright 2003). Most often, only one of the cotyledons explodes, whilst the other remains within the pericarp (López & Heumann 2013-2015); the complete disappearance of the seed occurs at 700 °C, being the embryo the last surviving element (Aguirre *et al.* 2013-2015).

Use-wear

Soaked *Chenopodium* seeds have a translucent appearance when charred. Boiling separates the testa, which wrinkles, from the pericarp; the surface after charring is distinguishable (Ergun, Tengberg & Willcox 2013). Different culinary preparations affect the preservation rates and states of grains with variations among species (López & Heumann 2013-2015).

★ Summary

Despite being able to pass the digestive tract of animals undamaged and being often recovered in archaeological sites, carbonisation experiments with *Chenopodium* spp. seeds have shown their friability upon fire exposure, which reduce their chances of archaeological recovery in a charred state (*vid.* Table 44). *Vid.* *infra* detailed information about a species of this genus.

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Table 44: Recovery chances of *Chenopodium* sp. seeds in the charred archaeobotanical record.

- *Chenopodium album* L.

**Vernacular names:** fat hen, goosefoot, pigweed

**Nombres vernáculos:** berza perruna, cenizo

**Nomes vernáculos:** catassol

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Description of the macroremains

Lenticular seeds with smooth surface, short radicle, flattened sides and rounded angles (Figure 52) have been determined as *Chenopodium album*.

Presence in the archaeological record

Plant macroremains determined as *Chenopodium album* have been recovered from Poças de São Bento. *Ch. album* seeds have been often recovered in other Iberian (Antolín & Jacomet 2015) and European prehistorical sites (Fairbairn 2007). Due to its ubiquitous presence in gut contents from bog bodies and mass-stored, this taxon is considered to have been a major plant component of the diet (Helbaek 1960; Behre 2008), possibly cultivated (Bogaard 2004; Stokes & Rowley-Conwy 2002).

Ecological characteristics

*Chenopodium album* is an annual herb, growing erect between 10-150 cm but usually up to 90 cm, the seeds ripening from summer to autumn. It is not frost tender and is suitable for all type of soils, but prefers moist soil and it cannot grow in the shade; it is often one of the first weeds to appear on newly cultivated soils (Fern 1992-2010). It is a common weed of cultivated ground, especially on rich soils and old manure heaps, and a subcosmopolitan ruderal, between 0-1000 m a.s.l. (Flora iberica 1986+).

Dispersal strategy

The dispersal strategy in this genus is autochory (Paula & Pausas 2009). Each plant produces huge numbers of seeds, up to 200,000 (Behre 2008).
Ethnographical information

Bromatological use

The flowers, leaves and seeds of all members of this genus are more or less edible and very nutritious vegetables. However, many of the species in this genus contain toxic substances (saponins, oxalic acid, nitrates and hydrogen cyanide), though usually in quantities too small to do any harm if reasonable cooked quantities are consumed. Ch. album leaves have a bland taste that can be improved by adding a few stronger-flavoured leaves or the tastier young inflorescences; when eaten with beans, the leaves will act as a carminative to prevent wind and bloating (Fern 1992-2010).

Cosmetic use

A green dye is obtained from the young shoots of Ch. album and the crushed fresh roots is a mild soap (Fern 1992-2010).

Pharmaceutical use

Chenopodium album has some gentle medicinal properties. In nitrogen-rich soils, the plants can concentrate hydrogen cyanide, which in small quantities has been shown to stimulate respiration and improve digestion; internally, as an infusion, the leaves are anti-caries, anthelmintic, antiphlogistic, antirheumatic, mildly laxative, odontalgic; externally they are applied as a wash or poultice to insect bites, sunstroke, rheumatic joints and swollen feet; the seeds are chewed in the treatment of urinary problems; the juice of the stems is applied to freckles and sunburn and the juice of the root is used in the treatment of bloody dysentery (Fern 1992-2010). The saponins present in this genus of plants are much more toxic to some creatures, such as fish, and hunting tribes have traditionally put large quantities of them in streams and lakes in order to stupefy or kill the fish (Fern 1992-2010).

On processing

Procurement: cultivation and gathering

Chenopodium album might be cultivated as a food crop, in which case it must be sowed in spring in situ. Most of the seed usually germinates within a few days of sowing. However, it is usually unnecessary to sow the seed since the plant is a common weed and usually self-sows freely in most soils. The seed is seen as either very fiddly to harvest and use, due to its small size, or very easy to harvest and simple enough to utilize (Fern 1992-2010).
Cooking

Most toxic substances in *Ch. album* are broken down to a large extent in the cooking process (Fern 1992-2010). The seed should be soaked in water and thoroughly rinsed before being used; cooking can consist of parching for popping as maize corn (Miksicek 1987), grounding and baking into a bread or sprouting and adding to salads (Fern 1992-2010).

Storing

Because of their durable seed coats, *Chenopodium album* seeds are storable for long periods (Behre 2008).

Taphonomical proxies

Non-anthropic marks

*Chenopodium album* seeds survive cattle digestion (Behre 2008).

★ Summary

*Chenopodium album* seeds have medium to high probabilities of being recovered in the charred archaeological record (*vid.* Table 44). *Vid. supra* general information about the genus *Chenopodium* (p. 235).

- *Salsola* L. sp.

Vernacular names: saltwort

Nombres vernáculos: barrilla

Nomes vernácoulos: barrilha

Figure 53: Left: two views of a modern achene of *Salsola kali*. Right: two views of a charred specimen from Poças de São Bento determined as *Salsola* sp. Scale bar = 1 mm.
Part III A: Results: the identified taxa

Description of the macroremain

A flat seed with spiralling embryo (Figure 53) has been determined as *Salsola* sp.

Presence in the archaeological record

A seed of *Salsola* sp. has been recovered at Lapiás das Lameiras.

Ecological characteristics

*Salsola* spp. are annual or perennial herbaceous or shrubby plants, with a coastal habitat and which tolerate marine influence (Flora iberica 1986+). The photosynthetic pathway for those potential species from the Iberian Peninsula is C₄ (Akhani 1997).

*Salsola soda* is an annual herb, up to 80 cm, which thrives in saline soils and sands, up to 700 m a.s.l. (Flora iberica 1986+).

*Salsola kali* is an annual that grows in coastal Europe up to 60 cm, it thrives in sandy areas and fallow fields, it prefers well-drained soils, up to 8000 m a.s.l., it cannot grow in the shade but can tolerate maritime exposure and can act as a weed; the seeds ripen from summer to autumn (Flora iberica 1986+; Fern 1992-2010).

*Salsola vermiculata* is a small shrub up to 1m, which grows in subsaline areas up to 1000 m a.s.l. (Flora iberica 1986+).

Dispersal strategy

The dispersal strategy in this genus is autochory (Paula & Pausas 2009).

Ethnographical information

Bromatological use

*Salsola kali* and *S. soda* young leaves and stems can be eaten raw or cooked, they have a crunchy tender texture and acid taste, as a spinach substitute or in salads; the seeds are edible cooked, ground and used as a gruel, thickener in soups or added to cereal flours when making bread (Fern 1992-2010).

Cosmetic use

*Salsola kali* and *S. soda* ashes from the burnt plant are used for making glass and soap (Fern 1992-2010).
Pharmaceutical use

*Salsola kali* has salsolin, a substance with medicinal properties: the juice of the fresh plant is an excellent diuretic, vasoconstrictor, cathartic, emmenagogue, stimulant, and vermifuge; people with a tendency to rheumatism, arthritis, gout, kidney stones and hyperacidity should take special caution if including this plant in their diet since it can aggravate their condition (Fern 1992-2010).

On processing

Procurement: cultivation and gathering

The seed is small and hard to collect any quantity (Fern 1992-2010).

Cooking

The plant contains up to 5% oxalic acid, which, if eaten in excess, can lead to nutritional deficiencies; cooking the plant will reduce the quantity of oxalic acid (Fern 1992-2010).

★ Summary

Differing from other genera in the Chenopodiaceae family, *Salsola* sp. does not have a durable seed coat, a fact which reduces its recovery probabilities in the charred archaeological record (vid. Table 45).

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Table 45: Recovery chances of *Salsola* sp. seeds in the charred archaeobotanical record.

- Compositae (Asteraceae)

<table>
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<th>Vernacular names: daisy family</th>
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<td>Nombres vernáculos: compuestas</td>
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<td>Nomes vernáculos: compostas</td>
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Description of the macroremain

Oblong achenes with a crown-like papus at the top have been determined as Compositae. Compositae fruits show little variation in shape in many of the species, although a slight morphological difference
exists depending on their position in the receptacle or capitulum (an arrangement of many flowers in what looks like a single flower) (Cappers & Bekker 2013).

**Presence in the archaeological record**

In this work, plant macroremains from Poças de São Bento have been determined as Compositae. Finds belonging to this family are frequent in the archaeological record in prehistorical sites throughout Europe.

**Ecological characteristics**

Compositae is the largest plant family within the dicotyledons in the world, with more than 9000 taxa listed in Flora Europaea (Tutin et al. 1964-2001). Most of the Mediterranean species, one of its diversity centres (Nieto 2009), are herbaceous, annual or perennial (Cappers & Bekker 2013). C₄ and CAM photosynthesis are common within this family (Gowik & Westhoff 2011) but in few of the Mediterranean taxa (Fioretto & Alfani 1988). Many species are ruderals and thrive in disturbed habitats; the fruits are indehiscent dry single-seeded achenes with a papus which aids the dispersal and prevents herbivory (Nieto 2009).

**Dispersal strategy**

The dispersal modes vary in this wide family between epizoochory, anemochory and autochory (Paula & Pausas 2009).

**Ethnographical information**

**Bromatological use**

Several species in the family Compositae are important sources of cooking oils, sweetening agents and tea infusions (Nieto 2009).

**Cosmetic use**

Several species in Compositae have been traditionally used for cosmetic purposes (Fern 1992-2010).

**Pharmaceutical use**

Many Compositae species have been used for medicinal purposes in different folk traditions (Fern 1992-2010).
Symbolical use

Many species in Compositae are appreciated garden cultivars (Nieto 2009).

Technological use

Several species in the family have been traditionally used for technological activities (Fern 1992-2010).

★ Summary

Compositae is a very wide plant family and their seeds are very diverse. However, as a general rule, Compositae seeds have intermediate chances of being recovered in a charred state in the archaeological record (vid. Table 46). Vid. infra more information about some identified remains from taxa in this family.

Table 46: Recovery chances of Compositae seeds in the charred archaeobotanical record.

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- tp. Senecio aquaticus Hill.

Vernacular names: marsh ragwort

Nombres vernáculos: azuzón

Nomes vernáculos: tasneira

Description of the macroremains

Small seeded Compositae achene with scalariform surface sculpture and 5 edges faintly visible has been tentatively determined as Senecio aquaticus type.

Presence in the archaeological record

A seed tentatively identified as Senecio aquaticus has been found at Los Gitanos.
Part III A: Results; the identified taxa

Ecological characteristics

*Senecio aquaticus* is a annual or biennial plant, which grows in disturbed damp grasslands with acid pH and up to 1400 m a.s.l.; it performs CAM-type photosynthesis (Fioretto & Alfani 1988).

Dispersal strategy

The dispersal mode of the genus is based on anemochory or zoochory (Paula & Pausas 2009).

Ethnographical information

Bromatological use

Some species in the genus *Senecio* have traditionally been eaten (Fern 1992-2010).

Pharmaceutical use

Several *Senecio* species have a medicinal use in folk tradition (Fern 1992-2010).

★ Summary

As is generally stated for the Compositae (*vid. supra* general information about the family, p. 240), *Senecio* sp. achenes have intermediate chances for being preserved in the archaeological record in a charred state (*vid. Table 46*).

- Cardueae / Cynareae

Vernacular names: thistles

Nombres vernáculos: cardos

Nomes vernáculos: cardos

Description of the macroremains

Oblong achenes with a “robust” appearance and a characteristic crown-like papus at the top (Figure 55), have been determined as Cardueae/Cynareae.

Figure 54: Charred specimen from Los Gitanos determined as Compositae (tribe Cardueae/Cynareae). Scale bar = 1 mm.
Presence in the archaeological record

A seed from this tribe has been determined at El Toral III and Los Gitanos.

Ecological characteristics

The tribe Cardueae/Cynareae is composed of annual, biennial or perennial herbs, shrubs or trees. About 80 genera and 2500 species exist, most in Eurasia; some of the best known genera are Carduus, Centaurea, Cynara and Cirsium (Nieto 2009).

Dispersal strategy

The prevalent dispersal modes are usually anemochory and zoochory (Paula & Pausas 2009).

Ethnographical information

Bromatological use

Thistles have been traditionally eaten in soups (pers. obs.); the roots are also often eaten cooked and the seeds of all species provide a high quality oil (Fern 1992-2010).

Pharmaceutical use

Many of the taxa in the tribe have been used in folk traditions for medicinal purposes (Fern 1992-2010).

Technological use

Plants in the Cardueae/Cynareae tribe have been appreciated to create natural fences in gardens, to prevent domesticated animals predating on horticultural products (pers. obs.). Valuable fibres are also obtained from them (Fern 1992-2010).

★ Summary

As is generally stated for the Compositae (vid. supra general information about the family, p. 240), achenes of this tribe have intermediate chances for being preserved in the archaeological record in a charred state (vid. Table 46).
- Cruciferae (Brassicaceae)

Vernacular names: crucifers

Nombres vernáculos: crucíferas

Nomes vernáculos: crucíferas

Description of the macroremain

A small globular seed with a conspicuous reticulate surface structure consisting of small circular cells (Figure 55). Whilst the reticulate matches that typical of *B. rapa = campestris*, the size of the seed is too small to belong to that taxon, but rather to the genus *Erica*.

Presence in the archaeological record

A seed determined as tp. Cruciferae/Ericaceae has been recovered from sublayer A2 of Los Gitanos.

Ecological characteristics

Cruciferae are annual, biannual or perennial herbs that grow up to 50 cm and have tuberous roots, the seeds ripen from summer to autumn; *C₄* and *C₃-C₄* photosynthesis occur within this family (Sage & Monson 1999). All Cruciferae enrich the soil in which they are grown; thus, they are useful for combining with cereals to avoid soil exhaustion.

Dispersal strategy

The prevalent dispersal mode is autochory: the pods which contain the seeds release them upon maturity (Cappers & Bekker 2013).

⭐ Summary

Cruciferae are oily seeds and thus susceptible of being easily destroyed when exposed to intense direct heat (*vid.* p. 248); the way in which they are processed does not favour this exposure (*vid.* Table 47). *Vid. infra* more detailed information about other taxa in this family.
Table 47: Recovery chances of Cruciferae seeds in the charred archaeobotanical record.

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- *Brassica* L. sp. / *Sinapis* L. sp.

**Vernacular names:** crucifers or cabbages

**Nombres vernáculos:** crucíferas

**Nomes vernáculos:** crucíferas

**Description of the macroremains**

Seeds identified as such are roundish, with a very characteristic, conspicuous at low magnification, reticulate surface of small homogeneous cells. Some reports of archaeological plant remains belonging to this family in the archaeobotanical literature of the Iberian Peninsula are now being considered misdeterminations of fungi sclerotia (tp. *Cenococcum geophilum*, Alonso & López 2008). This is not the case, as anatomical features (hilum) have been recognised on the specimens.

**Presence in the archaeological record**

In this work, seeds from *Brassica* sp./*Sinapis* sp. have been recovered from Cabeço do Pez and São Pedro de Cana ferrim. Several Cruciferae species, such as white mustard (*Sinapis alba* L.), radish (*Raphanus sativus* L.), cabbage, broccoli, cauliflower, etc. (*Brassica oleraceae* L.), turnip (*B. rapa* L. = *B. campestris* L.), black mustard (*B. nigra* L.), brown mustard (*B. juncea* L.) or rape (*B. napus* L.) have not shown domestication traits until classical times although they were exploited from the Neolithic in Europe (Zohary, Hopf & Weiss 2012). Finds reported from the Iberian Peninsula are as early as the Bronze Age (Ramil Rego *et al.* 1990).

**Ecological characteristics**

All these crucifers which have undergone a domestication process, have reached a high morphological diversity (Flora iberica 1986+): there are wild and domesticated forms, including weeds and whilst wild forms are perennial, from each domesticated species an annual and biannual variety exists. In many cases the natural distribution previous to domestication is not known (Tutin *et al.* 1964-2001), but the taxa existing in the Iberian Peninsula are thought to be naturalised weedy races (Flora iberica 1986+).

The genus *Brassica* is composed of annual, biennial or perennial herbs or sub-shrubs, with up to 35 Mediterranean species. Their roots are radish-shaped and their seeds, between 1 and 3 per fruit, can be
Part III A: Results: the identified taxa

spherical, ovoid or flattened, with conduplicated cotyledons. As a ruderal weed *Brassica* is a very aggressive genus, because it stands winter frosts and is easily reproduced; it requires warm temperatures, sun exposure and nitrogen; it is found up to 2000 m a.s.l. (depending on the species) and in dry and slightly acid soils (Flora iberica 1986+).

*Sinapis* spp. are annual herbs with siliqua-type dehiscent fruits with variable numbers of globular or spherical seeds (Flora iberica 1986+).

**Ethnographical information**

**Bromatological use**

*Brassica* and *Sinapis* are considered oil plants, from whose seeds oils and flavourings of culinary use are extracted; other parts of the plants might be eaten as green vegetables or given as green fodder (leaves, stems, roots and flowers) (Flora iberica 1986+; Zohary, Hopf & Weiss 2012). The leaves and young roots can be eaten raw, as green vegetables (Flora iberica 1986+), or cooked, because they might sometimes result indigestible in a raw state (Fern 1992-2010).

**Cosmetic use**

The oil from *Brassica* and *Sinapis* seeds can be used to make soap (Fern 1992-2010).

**Pharmaceutical use**

Several species in the genera *Brassica* and *Sinapis* have different medicinal properties in folk traditions, the seeds of most *Brassica* spp. are rubefacient; a decoction of the leaves, flowers, stems or roots and the powdered seed of *B. rapa* is said to be a folk remedy for different types of cancer; root peelings and an infusion of chopped roots with flaked soap are a natural insecticide (Fern 1992-2010); *Sinapis arvensis* is used against depression (Fern 1992-2010).

**Technological use**

Crucifers have oil-rich seeds which might be used for technological activities, such as bone and antler tool maintenance (Spangenberg *et al.* 2014), for lighting (Fern 1992-2010).

**Procurement: cultivation and gathering**

*Brassica* should, under cultivation, be sown in the autumn and gathered in spring, it can take less than ten weeks from sowing to harvesting. It is possible to harvest roots all year round, they can be left in the ground during the winter, harvesting them piecemeal if no predators exist. It is often better to harvest them in late autumn or early winter and store them in a cool but frost-free place (Fern 1992-2010).
Taphonomical proxies

*Brassica oleracea* seeds are sensitive to high direct exposure to high temperatures but are rather resistant when mixed with soil upon carbonisation (Guarino & Sciarrillo 2004).

★ Summary

*Brassica*/Sinapis seeds have rather low chances of being preserved in the charred archaeological record (*vid.* Table 47 and general description of the family, p. 245).

**Empetraceae**

- *Corema album* (L.) D. Don

Vernacular names: Portuguese crowberry

Nombres vernáculos: camarina

Nomes vernáculos: camarinha

Description of the macroremains

Detached seeds (São Pedro de Canaferrim, CSP, and Lapiás das Lameiras, LL), a smashed fruit (LL) and a possible whole fruit (CSP) (Figure 56) have been found belonging to the same taxon, *Corema album*. Seeds have 6 dorsal vitae, a convex ventral side in which the hilum and an orifice are placed. The smashed fruit is a crust of 3 seeds plus a fleshy thin mesocarp that attaches them. The

Figure 56: Top, from left to right: modern seed of *Corema album* in dorsal and ventral view; charred seed from São Pedro de Canaferrim determined as *C. album*. Bottom, from left to right: modern seeds from *C. album* in lateral view; two views of a crust of charred crushed seeds from Lapiás das Lameiras determined as *C. album*. Scale bar = 1 mm.
Part III A: Results: the identified taxa

whole fruit is surrounded by a thin layer of fruit mesocarp, the epicarp is missing. The fragment of fruit consists of a portion of epicarp and endocarp in which the stalk insertion is visible, where 5 sepals are remaining.

Presence in the archaeological record

Plant macroremains determined as *Corema album* have been found at São Pedro de Canaferrim and Lapiás das Lameiras. Very few records of this species are known: a Pleistocene fossil report (seed or fruit unspecified) of 700 ky in Great Britain (Parfitt *et al.* 2005), several fruit and seeds at the Chalcolithic site of Alcalar (Stíka, pers. comm.), several waterlogged sites from the 1st millennium cal BC in Southern Spain (Peña-Chocarro, pers. comm.) and at several sites in Lisbon, from the Roman and Andalusian periods to the 16th century (Bugalhão & Queiroz 2005; van Leeuwaarden *et al.* 1999; Mateus, Queiroz & van Leeuwaarden 2003; Queiroz & Mateus 2011).

Ecological characteristics

Empetroideae is a subfamily of Ericaceae that comprises eight species belonging to three genera. *Corema* D. Don, is distributed on both sides of the Atlantic Ocean, showing a typical amphi-Atlantic distribution pattern. (León-González *et al.* 2013) *C. album* is an endemic species of the European Atlantic coast, vulnerable or in risk of disappearance because of habitat loss and competition from invasive species (Gil-López 2011). Its modern distribution is limited to the Azores archipelago and the Iberian Peninsula, from the North of Galicia to Gibraltar in the south, where several place names derive from the common name of the plant (Fernández De La Cigoña 1988)31; it is currently very frequent in the Portuguese Estremadura, with the exception of the portion of coast most proximate to the prehistorical sites, where it is scarcer (Boratyński & de la Puente 1995) or has possibly disappeared in the last few decades (Álvarez-Cansino *et al.* 2013; Marques 2007). An isolated population is also known in the Mediterranean coast of the Iberian peninsula (Aguilella & Laguna 2009).

Its habitat is coastal, from sea level to 50 m, and varying from bare stabilised sand dunes (Boratyński & de la Puente 1995) to cliff systems. It strives along a broad climatical gradient (from temperate hyperoceanic or submediterranean in the north to Mediterranean pluviseasonal in the south) (Álvarez-Cansino *et al.* 2013). It is a long-lived (Larrinaga 2010) dioecious drought-adapted evergreen understorey shrub (Máguas *et al.* 2011), that grows from 0.3 m to rarely more than 1 m in height. It is suitable for light (sandy) and medium (loamy) soils, prefers well-drained soil and acid soils and can grow in very acid soils; it can grow in semi-shade (light woodland) or no shade and prefers dry or moist soil (Fern 1992-2010).

Fruiting starts in spring and fruits ripen in summer, but remain on the plants until autumn (Álvarez-Cansino *et al.* 2013) or even winter (Marques 2007). The fruits are spherical white or pink-white berries (5–8 mm diameter) and sugary (Calviño-Cancela 2002). The shrubs show a huge variation in fruit crop (from tens, to tens of thousands of fruits) (Piazzon *et al.* 2012). Each fruit has three

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31 A Pleistocene find in the British Islands (Parfitt *et al.* 2005) suggests that either its distribution occupied in the past a much wider area than it currently does, and following this idea reintroduction efforts seem to have been recently made (Fernández De La Cigoña 1988), or events of long-term dispersal by endozoochory also occurred at that time (Proctor 1968).
(exceptionally four or two) elongated seeds (± 500 µm in length) with a thick woody endocarp (Calviño-Cancela 2002).

**Dispersal strategy**

A wide range of frugivores (lizards, deer, rabbits and hares, foxes, boars, badgers, blackbirds and seagulls) are important agents for the dispersal, either through defecation or regurgitation (Álvarez-Cansino *et al.* 2013; Calviño-Cancela 2002; Fedriani & Delibes 2009a; Larrinaga 2010; Perea *et al.* 2013; Piazzon *et al.* 2012). Rodents and passerines are important seed predators (Piazzon *et al.* 2012).

**Ethnographical information**

The genus name of Greek origin might be related to their use as brooms (de Oliveira & Dale 2012).

**Bromatological use**

*Corema album* has an edible fruit (Gil-López 2011) raw or cooked (Fern 1992-2010), which has been the object of commerce in recent times (Fernández De La Cigoña 1988). Berries have a fresh acid taste and are often used as appetisers and can be made into acid-tasting lemonades, jams and liquors (León-González *et al.* 2013).

**Pharmaceutical use**

Fruits and derived beverages are popularly used as antipyretic and to treat fevers and pinworm infections and have proved to be effective against oxidative stress-related diseases (León-González *et al.* 2012; León-González *et al.* 2013). Historical sources report its use as anti-scurvy (Hurtado de Mendoza 1840).

**Symbolical use**

Branches of *C. album* have traditionally been used in floral ritual compositions, believing them to bring good luck (Fernández De La Cigoña 1988).

**Technological use**

Dry woody branches of *C. album* have been used as fuel in kitchens and ovens due to its high calorific power and its pleasant smell thought to purify the ambient; brooms of tied branches have also been used to sweep floors (Fernández De La Cigoña 1988).
Part III A: Results: the identified taxa

On processing

Procurement: cultivation and gathering

Berries of *C. album* might be gathered from July to December (Fernández De La Cigoña 1988).

Taphonomical proxies

Non-anthropic marks

Seeds of *Corema album* might be present in animal dung. The number of seeds per pellet varies from one to several hundreds depending on the animal and the environmental diversity (Calviño-Cancela 2002; Larrinaga 2010). Rabbit excreted seeds are never broken nor show differences in traits, but can be differentiated from the natural population, as they are often smaller, likely because the lower part of the shrubs bear smaller fruits (Larrinaga 2010). Lizards’ defecated seeds are undamaged (Piazzon et al. 2012). Bird excreted seeds (from blackbird pellets and seagull egagropila) are also intact, the epicarp might be preserved but detached, in some cases the flesh is also preserved and the seeds in anatomical connection (Calviño-Cancela, pers. comm.). This good preservation does not vary despite the differences in seed gut-passage time, which is about 50 h. for lizards (Piazzon et al. 2012), for gulls 12 h., 15–74 min. for blackbirds and for rabbits and hares less than 10–12 h. (Calviño-Cancela 2004). Badgers destroy seeds (Fedriani & Delibes 2009b).

★ Summary

As *Corema album* is a fleshy fruit, it is not particularly suited for being charred, despite its frequent roasting for consumption (*vid.* Table 48). Zoochory should be taken into account as a potential way of introduction.

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Table 48: Recovery chances of *Corema album* fruits in the charred archaeobotanical record.

- *Ericaceae*

Vernacular names: heaths

*Nombres vernáculos*: brezos

*Nomes vernáculos*: urzes
Description of the macroremain

A fruit fragment consisting in a portion of the epicarp and mesocarp with the base of the 5 sepals attached has been determined as Rosaceae/Ericaceae.

A small globular seed with conspicuous reticulate surface sculpture consisting of small circular unaligned cells has been tentatively determined as Cruciferae/Ericaceae (vid. Figure 55). This determination has been done on the basis of surface sculpture matching the former and seed size matching the latter. The Ericaceae seeds in our reference collection have bigger cells.

Presence in the archaeological record

A fruit fragment has been tentatively determined as Ericaceae at Lapiás das Lameiras, a possible seed at Los Gitanos.

Ecological characteristics

Plants in the Ericaceae family are mostly shrubs, exceptionally trees, deciduous or evergreen, the fruit is an indehiscent capsule seeds, sometimes winged (Flora iberica 1986+). Ericaceae plants are often used as indicators of vegetational degradation due to human activities, such as deforestation for the creation of crop fields and intensive fuel exploitation (e.g. López Sáez, López García & López Merino 2006).

Dispersal strategy

Dependent on the genus, the dispersal strategies in this family vary between endozoochory (fleshy fruits) and autochory (fleshless fruits) (Paula & Pausas 2009).

Ethnographical information

Bromatological use

Although some species in Ericaceae, such as Arbutus, have edible fruits, in general the fruits are dry and uninteresting.

Symbolical use

Branches from different Ericaceae species have been used as decoration, particularly in special events (San Miguel López 2004).
Part III A: Results: the identified taxa

Technological use

Dry Ericaceae plants might be used for bedding for domesticated animals, leaves for practical jokes (San Miguel López 2004).

★ Summary

Ericaceae seeds have intermediate probabilities for recovery in a charred state at archaeological deposits, on account of their oily content and the way in which the plants might be processed for use (Table 49).

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Table 49: Recovery potential of Ericaceae seeds in the charred archaeobotanical record.

- **Arbutus unedo** L.

Vernacular names: strawberry tree

Nombres vernáculos: madroño (planta); madroño, madroña (fruto)

Nomes vernáculos: medronheiro

Description of the macromerains

A seed with longitudinal surface reticulate sculpture, laterally compressed and with slightly pointy base and obtuse flat apex, and a fruit half, its epidermis has flat papillae, an inner core with two smooth seed receptacles, and abundant fragments of mesocarp flesh (Figure 57) have been determined as Arbutus unedo.

Figure 57: Left: modern fruit of *Arbutus unedo* in external view and longitudinal section. Right: charred fruit in internal and external view and seed in lateral views from El Mazo determined as *Arbutus unedo*. Scale bar = 1 cm.
Presence in the archaeological record

Remains from *A. unedo* have been recovered at El Mazo. This taxon is relatively frequent in the Mediterranean Iberian Peninsula (*e.g.* Antolín *et al.* 2012; Antolín & Jacomet 2015; Buxó 2007), but scarcer in the Atlantic region, and particularly in this chronology: although wood charcoal appears with steadiness (*e.g.* Zapata Peña 1999b) only at a few sites like Prazo (Monteiro-Rodrigues 2012), Zambujal (Stika *et al.* 2013) and Anta 3 De Santa Margarida (Queiroz 2003) non-woody macroremains from this taxon have been found.

Ecological characteristics

*A. unedo* is an evergreen tree up to 8 m high and wide. It grows in *Quercus ilex* forests, mixed forests in abrupt river channels, and rocky areas, often of limestone, up to 800 m a.s.l.; it is suitable for all pH soils and can tolerate maritime exposure; the fruit ripens in autumn and it is globose, around 8 mm diameter, and deep red; the bark contains 45% tannin (Flora iberica 1986+; Fern 1992-2010). Its current distribution is very limited in the Cantabrian region, mostly to littoral areas (Flora iberica 1986+).

Dispersal strategy

Its dispersal mode is by endozoochory (Paula & Pausas 2009) and a wide range of frugivores act as dispersers (Torroba Valmori 2013).

Ethnographical information

Bromatological use

The fruit from *A. unedo* is edible raw or cooked, the Latin name *unedo* means “I eat one (only)” (Fern 1992-2010), which has been interpreted both as positively and negatively in relation to its taste. Theophrastus says the tree produces an edible fruit; Pliny that it is not worth eating (Hedrick 1919). If eaten overripe they can produce an alcoholic intoxication (Morales 1995).

The fruit contains 20% sugars and is thus very appropriate for jams and preserves and commercial experiments of sugar extraction have been carried out with them (Morales 1995). It is also used in the preparation of liquors (Morales 1995; Pinto Carvalho 2005; San Miguel López 2004). The leaves might be used as animal fodder (Pinto Carvalho 2005) and the flowers for bee-keeping and honey production (Morales 1995).
Part III A: Results: the identified taxa

**Pharmaceutical use**

All parts of the plant are effective as antibiotic; the leaves, bark and root are astringent, diuretic, renal antiseptic, and, like many other astringent plants, a gargle can be made for treating sore and irritated throats; the flowers are weakly diaphoretic (Fern 1992-2010).

**Symbolical use**

The strawberry tree was considered a sacred plant in Roman times; the branches have been used to scare witches and heal bewitched children, the tree has been planted to scare demons and branches have been used to decorate coffins and walls in Christian religious festivities (Morales 1995); more recently, A. unedo has achieved an important role in symbolical paraphernalia in relation with the city of Madrid, perhaps due to its plantation for its appreciated ornamental value (Font Quer *apud* Morales 1995).

**Technological use**

Tannin is obtained from the leaves, bark and fruit of A. unedo; which can be used in different activities such as the elaboration of dyes and mordants and tanning leather (Fern 1992-2010). The wood has been used for turning and making musical instruments like flutes (Fern 1992-2010), mortars, bowls and spoons, and thatching (Morales 1995). It also makes an acceptable fuel which produces a lot of ash and might be used in forges and bread ovens (Morales 1995). The seeds might be used as bait for hunting birds (Font Quer *apud* Morales 1995).

**On processing**

**Procurement: cultivation and gathering**

The leaves of A. unedo for herbal remedies are gathered in the summer and dried for later use (Fern 1992-2010).

**Preparation for consumption**

A decoction of the different plant parts is usually prepared for medicinal use (Morales 1995).

**★ Summary**

Fleshy fruits like Arbutus unedo have intermediate chances of being recovered in archaeological deposits in a charred state, as they have poor qualities for being preserved by carbonisation but they are likely to be exposed to the fire (*vid.* Table 50). Zoochory should be taken into account as a potential way of introduction.
Inés L. López-Dóriga

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<th>Preservational / Ethnobotanical</th>
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Table 50: Recovery chances of *Arbutus unedo* fruits in the charred archaeobotanical record.

- *Erica* L. sp.

Vernacular names: heath, heather

Nombres vernáculos: brezo

Nomes vernáculos: urze

Description of the macroremains

Roundish seeds 0.55 mm diameter, with a deep reticulate surface sculpture with unaligned more or less quadrangular cells (Figure 58), have been determined as *Erica* sp. Although their shape does, their reticulate does not match that of *E. arborea*, *E. tetralix* or *E. umbellata* nor *Calluna vulgaris* because their cells are rectangular rather than quadrangular. It is closest to *Erica terminalis*, which is not currently present in the region and has an altitude requirement (more than 100 m a.s.l.) (Flora iberica 1986+).

Figure 58: Left: Modern seed of *Erica terminalis*. Right: charred seed from El Mazo determined as *Erica* sp. Scale bar = 1 mm.

Presence in the archaeological record

Two seeds from El Mazo have been determined as *Erica* sp.

Ecological characteristics

*Erica* spp. are usually evergreen shrubs, exceptionally trees, which grow in cleared forests and shrublands, from sea level to variable altitudes; the fruit is an indehiscent capsule, usually between 2 and 2.5 cm diameter, with 4 valves and with abundant minute seeds, the seeds are globose, ovoid or ellipsoid reticulate-alveolate (Flora iberica 1986+).
Part III A: Results: the identified taxa

Dispersal strategy

The dispersal mode is autochory (Paula & Pausas 2009).

Ethnographical information

Pharmaceutical use

Leaves and flowers from different Erica species are used for medicinal purposes, such as urinary (San Miguel López 2004).

Symbolical use

Many Erica spp. are currently grown ornamentally.

Technological use

Erica spp. stems are used for making bedding, brooms and brushes, for fuel, and a yellow dye (Fern 1992-2010).

★ Summary

Erica seeds have low chances of appearance in charred archaeobotanical assemblages (*vid. Table 49 and general description of the family* (p. 251).

Fagaceae

- Quercus L. sp.

Vernacular names: (plant) oak; (fruit) acorn

Nombres vernáculos: (planta) encina, roble, alcornoque, cagiga, etc.; (fruto) bellota

Nomes vernáculos: (planta) carvalho, sobreiro, carrasco, azinheira, etc.; (fruto) bolota

Description of the macroremains

Cotyledon fragments with striated outer surface have been identified as Quercus spp. Quercus spp. cotyledons are undistinguishable to species level if the cupule is not preserved (*e.g. Deforce et al. 2009*). One of the cotyledons has a larvae hole. Some of the cotyledon or cotyledon fragments have well preserved embryo cavities, which might be relevant according to some proposals for identification based

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on the embryo axis morphology (Vázquez Pardo et al. 2004). In one of them it is short, 1 – 1.5 mm wide (broader towards the centre of the cotyledon) by 2 mm long; and the position of the embryo axis seems to be straight, perpendicular to the base of the cotyledon, but this is uncertain due to the incompleteness of the specimen. The other specimen preserves the embryo, and the cavity is short and thin (3 mm length by 1 mm width) and straight but very slightly lateral. This matches with the embryos of Quercus robur in our reference collection.

A thick and rough coat fragment has been determined as Quercus sp. pericarp basal fragment, cup or hilum (Figure 59). Quercus spp. nutshells are rarely preserved in archaeological sites, rather complete or fragmented cotyledons are found, which makes quantification easier than with other nuts (e.g. hazelnuts). Sparse cotyledon remains are often interpreted as possibly derived both from human collection for food or fuel (leaf litter or oak branches cut during summer or autumn) (Robinson & Harild 2002).

Quantification methods based on the number of fragments:

• count the number of fragments and divide by two (Buxó 1997),
• count the number of embryos or embryo cavities or the number of hilum (Deforce et al. 2009).
• count the number of different types of fragments (for cotyledons, fragments might be halves, less than halves without distal or basal end; and less than halves but with distal or basal end; whilst for pericarps, it depend on their size, in mm²; Antolín & Jacomet 2015)

Quantification methods based on weight:

• weigh complete fruits, establish a reference weight per fruit, weigh all the fragments and divide by the reference weight (Jorgensen 1977).

Quantification methods based on volume:

• count the number of acorns in a small portion of the fill and use it as a reference for all.
**Presence in the archaeological record**

*Quercus* sp. remains have been recovered from Arangas, Los Gitanos (A3, A2 y A1) and Poças de São Bento. Acorn remains, particularly cotyledons, are one of the most frequent and abundant archaeobotanical finds at sites in western Europe, often in association with pits, (*vid.* Cunningham 2011, Deforce et al. 2009, Mason 1995 and Vencl 1996) and particularly at Atlantic sites in the Iberian Peninsula (*e.g.* Tereso et al. 2013; Senna-Martínez 1995; Zapata Peña 2000).

Acorns have been considered the main staple-food of the last hunter-gatherers (*e.g.* Aurenche 1997; Bar-Yosef & Belfer-Cohen 1992; Bohrer 1972; Henry 1989; Moore 1985; Olszewski 1993; Rosenberg 1990) whilst others consider acorn consumption as a key element in Neolithic agriculture (Aurenche 1997). In other parts of the world, acorn consumption has been closely linked to the invention of pottery (Wanatabe, 1987). The term *balanocultures* is used to refer to subsistence strategies in which acorns were the central food around which lifestyles evolved (Bainbridge 1985), *balanophagy* for acorn consumption in itself (*e.g.* Aurenche 1997; Gifford 1936).

**Ecological characteristics**

*Quercus* spp. are trees, less frequently shrubs, with perennial or deciduous leaves and annual or biannual fruits (flowers from the previous year will form fruit in the year when new flowers are developing). Most species in the Cantabrian region grow between 0(300-400)-1200 m a.s.l., whilst some of those present in Portugal, up to 700 m a.s.l. Heights and preferential habitats are variable between 3 and 30 m. depending on the species. *Quercus* spp. acorns ripen in autumn and easily fall out of cupules soon after ripening. They have a high nutritional value, similar to those of cereals, both being good sources of carbohydrate, Vitamin A, trace elements, include many essential amino acids and tannins (in very variable proportions from species to species and tree to tree) (Howes 1948). The quality and flavour of the oil is comparable to olive oil. Their edibility, given by the tannin contents, vary from species to species.

Phytophagous insects might act as common plagues affecting acorns as lay their eggs in summer though a perforation in the acorn shell, from which a larva chews its way out in autumn after having eaten great part of the cotyledons. Although this pest sometimes induces the fall from the tree before full maturity of the acorn or their underdevelopment in size, eating an infested acorn with the larvae still inside might neutralise the toxicity of the tannins for some mammals (Soria, Cano & Ocete Rubio 1996; Vázquez et al. 1990), in addition to increasing the protein content of the foodstuff (Vázquez Pardo et al. 2004).

**Dispersal strategy**

The dispersal modes of plants in this genus are autochory and zoochory: hoarding (Paula & Pausas 2009). Several animals (from rodents to birds) built underground winter fruit stores, and to avoid intoxication with the tannins, they only eat the basal part of the acorn where protein-precipitable phenolics are more concentrated (Steele et al. 1993), allowing for the germination of the embryo.
Ethnographical information

Bromatological use: balanophagy

Acorns are and have traditionally been eaten by numerous societies in different periods. The oldest written sources record their consumption in the Iberian Peninsula, mentioned by Pliny the Elder, Strabo and Varro in the 1st century AD (García Gómez & Pereira Sieso 2002) but Greek and Latin references to balanophagic practices are in general very varied and ample, pointing to the customary consumption of acorns, not as an exotic practice (Aurenche 1997) as is often interpreted in the Iberian records. Using principles from optimal foraging theory, and taking into account caloric yield and processing time (850-1350 kcal/h), acorns have been considered both staples (Barlow & Heck 2002; Bohrer 1972; Dunham 2009; Tushingham & Bettinger 2013; Wright 1994), and marginal foodstuffs (Basgall 1987; McCorriston 1994). When different oak species coexist, often the different maturating periods allow for their complementary exploitation during the year (Hillman et al. 2001). Evergreen Quercus spp. raw acorns are digestible (Haws 2004); whilst deciduous ones usually need their tannins to be neutralised.

Acorns can also be used to make acorn cooking oil by boiling, crushing, or pressing (Bainbridge 1986) and beverages (García Gómez, Pereira Sieso & Ruiz Taboada 2002; Pérez Altamira 2009), or used for the distilling of schnaps and as beer malt (Howes 1948; Jorgensen 1977).

Quercus spp. acorns might be used as fodder for domesticated animals (Zohary & Hopf 1993) they are still the main ingredient used for feeding the pigs from which a culinary delicacy, the Iberian acorn ham or pata negra, is obtained. However, depending on the species, acorns might not be easily digested by domesticated animals: they may be result poisonous for cattle, horses, goats and sheep (Deforce et al. 2009).

Other plant parts are also edible: the young leaves and shoots of Quercus robur are chewed as hunger-quenchers (Menendez-Baceta et al. 2012).

Cosmetic use

Several tannin-rich parts of Quercus spp. trees (wasp galls, bark, acorns) have traditionally been used as cloth dyes (Pardo de Santayana et al. 2011), mordants (Stone 2009), writing inks and tan for animal skins (Larew 1987) and bleaching hair (Pardo de Santayana et al. 2011).

Pharmaceutical use

Several plant parts from all Quercus spp. have medicinal properties (Fern 1992-2010) and they have been used intensively from Andalusian times for their medicinal properties (Borojevic et al. 2008); for the internal treatment of various maladies, such as rheumatism (Zapata Peña 2000) and urinary incontinence, and as antidiabetic, astringent and dentifrice (García Gómez & Pereira Sieso 2002). Acorn oil has been used externally as a salve for burns and injuries (Bainbridge 1986). Other tannin-rich Quercus parts, such as wasp galls, were used in Roman times (Pliny apud Larew 1987) as infusions or
extracts to treat hangnails, toothaches, gum disease, dysentery, ear and eye sores, abscesses, and menstrual disorders.

*Quercus* spp. acorns and leaves have served as sculptural motives from the Chalcolithic times in the Iberian Peninsula for numerous ivory and bone (Cruz-Auñon & Rivero 1987; García Gómez & Pereira Sieso 2002), resin (Vázquez Pardo *et al.* 2004) and metallic ornaments (Almagro Gorbea 1999; Enríquez Navascués & Rodríguez Díaz 1985; Fernández Gómez 1985; Fernández Gómez 1999; Perea Caveda 1991), coins (Roman Ostur coinage) and Andalusian plasterwork (García Gómez & Pereira Sieso 2002). *Quercus* spp. acorns appear prominently in literature, proverbs, riddles, folk songs, etc. from the Classical times (Aurenche 1997) to recent times (García Gómez & Pereira Sieso 2002).

**Technological use**

*Quercus* spp. fibres, primarily from the bark, have been used as a basketry material (Stone 2009).

**On processing**

*Quercus* spp. acorn processing methods vary from species to species, tannin content and intended use, available time, frequency of consumption and cultural preferences (Takahashi & Hosoya 2002).

**Procurement: cultivation and gathering**

*Quercus* spp. acorns might be gathered from the ground, checking they are not infested or have not become mouldy. The most effective strategy is felling them into baskets or cloths by shaking or hitting the branches with flexible sticks (Pereira Sieso 2010). Gathering season varies from species to species, region and season (Vázquez Pardo *et al.* 2004). Collection rates vary from 3 to 960-1900 kg/hour, (Petruso & Wickens 1984; Rowley-Conwy 1984). Unprocessed acorns were usually transported to residential sites, so all waste-producing acorn processing would have occurred there (Bettinger, Malhi & McCarthy 1997).

**Sorting**

Infested and healthy *Quercus* spp. acorns can be sorted by weight (infested weight up to 50 % less) or density, as infested nuts float on cold water (Mason & Nesbitt 2009).

**Drying**

*Quercus* spp. acorns must be immediately dried after gathering, otherwise they start to sprout and become mouldy. Drying can be done under the sun or by the fire, this last one being the quickest, the most effective and the most appropriate for killing insects (Pereira Sieso 2010).
Storing

Dried *Quercus* spp. acorns might be preserved several months and even years (Testart 1981). The ability for long-term storage is one of the reasons proposed in favour of the importance of acorn consumption despite the high labour investment required in their preparation for consumption (Tushingham & Bettinger 2013). There might be preservation differences among the different species (with slightly different germinating periods) in the genus *Quercus*, but in general the longer the storage period, the sweeter the taste (Mason & Nesbitt 2009). Shape and size of pits are not important for the preservation of nuts but isolation from moisture is (Cunningham 2010). Storage in containers within pits facilitates retrieval and ensures cleanliness (Cunningham 2010). Above-ground storage is best in extension, the acorns spread over a wickerwork separated from the moisture of the ground (Pereira Sieso 2010).

Peeling (dehusking / deshelling / dehulling)

*Quercus* spp. acorn deshelling is easy in a raw state, and even easier after roasting. Removal of the astringent thin soft skin that covers the cotyledons under the shell is advisable as well (Mason & Nesbitt 2009).

Grinding

*Quercus* spp. acorns need to be roasted or baked to allow grinding, and even then, a lithic mortar is needed. Grinding 3 kg. of shelled acorns can take about 7.5 h. (Tushingham & Bettinger 2013). Depending on the size and hardness of the acorns, a coarse flour might be necessary before milling into a fine flour (García Gómez, Pereira Sieso & Ruiz Taboada 2002). Acorn grinding stones are of variable morphologies from immovable rock outcrops with cupules or pitted-stones, to metate-like, round or elongated movable mortars (Oliveira, Queiroga & Dinis 1991; García Gómez, Pereira Sieso & Ruiz Taboada 2002).

Detoxification

The toxic tannins in *Quercus* spp. acorns can be neutralised in different ways, depending on the tannin content, which varies according to the species and tree, and the desired end-product. Techniques usually include different stages, which are sometimes repeated, of boiling, leaching or roasting, and ash mixing (Bainbridge 1985).

Cooking

After detoxification, *Quercus* spp. acorns can be further transformed by roasting, baking or boiling into foodstuffs, such as soups, bread, flour or puddings, by themselves or mixed with other products, such as cereals (e.g. Aurencche 1997; Dunham 2009; García Gómez, Pereira Sieso & Ruiz Taboada 2002; McCorriston 1994; Kubiak-Martens 1999; Mason 1992; Pérez Altamira 2009; Zapata Peña 262
Part III A: Results: the identified taxa

2000). Having exposed these nuts to fire facilitates grinding into flour but an overexposure makes acorn taste too bitter (Oliveira, Queiroga & Dinis 1991). Acorn flour is not plastic and does not contain gluten, thus fermentable cereal flour is needed as a mixture to bake bread (Oliveira, Queiroga & Dinis 1991).

Acorns are thought to have been frequently roasted in pits (Senna-Martínez & Quinta-Ventura 2000) or covered by a heap of ashes and embers (Pereira Sieso 2010). Cooking with ash neutralises bitterness (de Herrera 1513) and acorn foods become a good source of calcium. Boiling Quercus spp. acorns is also a necessary procedure in dyeing, for extracting the tannins in the acorns and transferring them to the liquid which will eventually tint a textile.

Taphonomical proxies

Carbonisation

Charred Quercus spp. nutshell finds are very sparse in the archaeological record, with only exceptional cases of preservation (e.g. Zapata Peña, Baldellou Martínez & Utrilla Miranda 2008). This is possibly due to its fragility after carbonisation (Zapata Peña 2000), although the possibility of the acorns being deshelled before carbonisation cannot be excluded (McCorriston 1994). Preliminary experiments show that whole charred Quercus spp. acorns have a relatively smooth inner surface between cotyledons, whilst acorns charred after the splitting of the cotyledons has occurred, have a rough and cracked surface, sometimes with bubbles (pers. obs.).

The fire-related treatment that acorns receive greatly influences the way in which their remains are recovered, if recovered at all, after charring (Table 51; apud Vázquez Pardo et al. 2004).

<table>
<thead>
<tr>
<th>Treatment / Fruit part→</th>
<th>Cotyledon</th>
<th>Cupule</th>
<th>Pericarp</th>
<th>Embryo axis</th>
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<tr>
<td>Drying in a well ventilated atmosphere</td>
<td>Completely preserved</td>
<td>Preserved without bracts</td>
<td>Preserved fragmented</td>
<td>Completely preserved</td>
</tr>
<tr>
<td>Heating at 105 °C</td>
<td>Completely preserved</td>
<td>Preserved with bracts</td>
<td>Completely preserved</td>
<td>Completely preserved</td>
</tr>
<tr>
<td>Roasting in a wood fire</td>
<td>Preserved fragmented</td>
<td>Preserved without bracts</td>
<td>Destroyed</td>
<td>Completely preserved</td>
</tr>
<tr>
<td>Roasting in a wood fire after humidifying</td>
<td>Destroyed</td>
<td>Destroyed</td>
<td>Destroyed</td>
<td>Destroyed</td>
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Table 51: Differential preservation of Quercus rotundifolia fruit parts according to drying treatment (after Vázquez Pardo et al. 2004).

Whole Q. pubescens dry acorns, heated at 550 °C for 8 minutes in an anoxic environment, results in charring of all the elements of the nut, except the pericarp which is only partially carbonised; whilst an oxidising environment results in the charring of the pericarp and cupule, and the transformation of the cotyledons into ashes (Ruas & Bouby 2010).
Non-anthropic marks

Insect infestation is distinguishable in Quercus spp. nutshell from the holes left by the larvae on exiting: Curculio/Balaminus elephas leaves a roundish hole with straight base, whilst Cydia spp. leave a small irregular hole.

★ Summary

Quercus sp. nuts are dense but oily plant remains which have relatively high probabilities of being recovered in charred assemblages (vid. Table 52).

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Table 52: Recovery chances of Quercus sp. cotyledons in the charred archaeobotanical record.

Geraniaceae

- cf. Geranium L.

Vernacular names: cranesbill

Nombres vernáculos: geranio

Nomes vernáculos: bico-de-pomba

Description of the macroremains

A group of several plant macroremains have been tentatively identified as cf. Geranium sp. as the closest match in the absence of any other possible taxonomical determination. Geranium

Figure 60: Left: modern seeds of Geranium sanguineum, upper with coat, lower without coat, in lateral and transversal view. Right: different views of two charred specimens from Poças de São Bento, upper with coat, lower without coat, determined as cf. Geranium sp. Scale bar = 1 mm.
spp. fruits consist of 5 carpels, each containing a single seed; the seeds are surrounded at their bases by a convex portion of the sepals and carpels; the fruit can be smooth or hairy and the seed coat smooth or reticulated (Cappers & Bekker 2013).

The best preserved specimen is a broken seed (right lower corner, Figure 60), 1 mm long by 0.7 mm wide, with a portion of smooth mericarp attached and a favulariate surface underneath, possibly ovate or obovate in shape, with a small papillate apex in the middle of a round depression, of 0.25 mm, marked by two concentric circles. On regarding the broken part, the favulariate surface seems to be a covering layer of another layer with aligned cells and hollow in the inside. The favulariate layer is partly a 0.1mm thick layer with transversal circular-sectioned equidistant veins and partly a <0.05 mm thick layer with empty space between the next underlying layer.

**Presence in the archaeological record**

Plant macroremains tentatively determined as cf. Geranium sp. have been recovered from Poças de São Bento.

**Ecological characteristics**

Geranium spp. are annual, biennial or perennial herbs, sometimes shrubs, which grow in rich humid soils, near riverbeds and in disturbed areas, sometimes in slopes. The fruit is a schizocarp with a large rostrum, which in ripening divides itself in five mericarps, each with a single seed which are ejected far away, with or without mericarp (Flora iberica 1986+). Seed ripening occurs between summer and autumn.

**Dispersal strategy**

The dispersal modes are autochory and zoochory (Tofts 2004).

**Ethnographical information**

**Bromatological use**

Several taxa in the genus Geranium have been used as foods (Fern 1992-2010).

**Pharmaceutical use**

Most Geranium spp. have some sort of medicinal properties in folk traditions (Fern 1992-2010).
Summary

Geranium seeds have intermediate chances of being recovered in a charred state in the archaeological record (vid. Table 53).

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Table 53: Recovery chances of Geranium sp. seeds in the charred archaeobotanical record.

Leguminosae (Fabaceae / Papilionaceae)

Vernacular names: legumes, pulses

Nombres vernáculos: legumbres, leguminosas

Nomes vernáculos: legume

No plant remain has been determined at this taxonomical level in this thesis, but many have been at more precise (tribe, genus and species) ones (vid. infra). This chapter serves as an introduction for them.

Each fruit of a leguminosae is composed of a carpel with a variable number of seeds. These seeds are arranged in different types of fruits, the most common being the legume or pod, which burst open when ripe and free the seeds. The shape of the seeds varies according to their position within the pod. The seeds usually have thick coats and two large cotyledons, a hilum, the scar left by the funicle which attaches the seed to the pod, a radicle, a lens and a micropyle (Cappers & Bekker 2013). These features might be clearly appreciated or not depending on the species and preservation.

No reliable morphological markers are available for identifying domestication of legumes in archaeobotanical remains (Zohary, Hopf & Weiss 2012). Hence legume domestication is usually inferred based on their co-occurrence with domesticated cereals, outside the natural distribution of the components of the archaeobotanical complex (e.g. in Western Europe, Abbo et al. 2008a).

Whole seeds and irregular fragments with hilum are the quantification items which have been used; when detached cotyledons are found, their total number is divided by two.

Ecological characteristics

Leguminosae is one of the largest plant families, together with the Compositae and Gramineae, and it is composed of three subfamilies, of which only one, Papilionoidae, is present in temperate Europe. They are trees, shrubs and annual or perennial herbs. The fruit is a pod, sometimes fleshy, sometimes

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articulated, and sometimes winged, with dorsal or ventral dehiscence or indehiscence, with seeds in variable number from one to many (Flora iberica 1986+).

Most legume crops are groups in which several wild and domesticated forms or varieties or races of each species exist. Legume fruits are pods. Wild legume populations are usually small and produce a small number of seeds per plant (Bouby & Léa 2006). Contrary to most other flowering plants, legumes fix atmospheric nitrogen to soils through symbiosis with the root bacterium \textit{Rhizobium} (Zohary, Hopf & Weiss 2012), and this same characteristic allows them to thrive in poor soils (Lambein et al. 2008).

The seed coats of wild legumes are thick and impermeable and many seeds contain potent toxins to protect them from predation, most of these traits disappear in domesticates (Zohary, Hopf & Weiss 2012). Seeds of legumes are rich in high quality protein, about 25 \% of its content. Legumes are very rich in an enormous variety of non-protein amino acids that can be beneficial (\textit{Trigonella}) or toxic (\textit{Lathyrus} and \textit{Vicia}) (Lambein et al. 2008).

\textbf{Dispersal strategy}

Most wild legumes are very dehiscent (when they are fully mature, the pod opens and the seeds “jump” as far away as possible; domesticated legumes are indehiscent (the seeds remain inside the pod), gigantism is a later development (Butler 1990; Zohary, Hopf & Weiss 2012).

\textbf{Ethnographical information}

In terms of economical importance the \textit{Leguminosae} is the most important family in the Dicotyledonae.

\textbf{Bromatological use}

Legumes are the second food crops for world agriculture. They are a highly nutritional food resource and might be essential for compensating diets excessively poor in meat and too concentrated on cereals, very rich in starch. Both the immature pods and seeds of wild legumes are commonly picked and consumed as casual field snacks, despite their often being toxic when fully ripe (Fairbairn 2007). Because they thrive in conditions of drought stress when other crops fail, they are sometimes responsible for epidemical intoxications (favism, lathyrism) due to their excessive consumption (Lambein et al. 2008).

\textbf{Pharmaceutical use}

Many species in the \textit{Leguminosae} family are important medicines in folk traditions (Fern 1992-2010).
Inés L. López-Dóriga

On processing

Procurement: cultivation and gathering

Legumes are sown in spring in temperate climates because they cannot survive in winter (Bakels 2009). The most efficient way of gathering legumes is when capsules are green, hitting the plant and letting the seeds fall in a basket (indehiscent varieties) or hand-plucking or uprooting the whole plant (dehiscent varieties) (Bouby & Léa 2006; Butler 1990). When gathering seeds of Leguminosae, various taxa are usually collected together because in natural habitats these plants grow intermingled with each other (Abbo et al. 2008b). Cultivated indehiscent legumes are often gathered by uprooting, for the stems are appreciated as fodder, and are later commonly threshed by trampling to extract the seeds (Anderson 2006). Sometimes, legumes are considered weeds and are removed from crop fields and used as green manure (Enneking & Maxted 1995).

Detoxification

Many Leguminosae seeds contain toxic substances, depending on the species, pulse seeds may simply be sun-dried or washed for detoxification (Valamoti, Moniaki & Karathanou 2011). Lengthy steeping in water at room temperature effectively removes the neurotoxins from dehulled split seeds but incompletely from intact seeds (Ressler et al. 1997). However, removal of pulse seed testae is not a practice confined to toxic pulses only: testa-free cotyledons are consumed in various parts of the world, produced either on a small household scale or on a commercial basis (Valamoti, Moniaki & Karathanou 2011). Testa removal greatly improves digestibility and the nutritional quality of the pulse food (Patil & Sokhansanj 2003 apud Valamoti, Moniaki & Karathanou 2011; Singh 1995; Singh, Sehgal & Tomer 2000). Fermentation also helps detoxification (Enneking et al. 1995).

Taphonomical proxies

Carbonisation

Legumes are much sparser in the archaeobotanical record than cereals, despite their co-occurrence in Early Neolithic agriculture. This is a result of their being less able to survive carbonisation (e.g. Mikić et al. 2014) because they require higher temperatures, 500 °C, for becoming charred (Guarino & Sciarrillo 2004).

- Coronilla sp. L. / Galega L. sp.

Vernacular names: crown vetch / goat’s rue
Nombres vernáculos: alacranera / galega
Nomes vernáculos: pascoinhas /galega, ruda cabruna

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Part III A: Results: the identified taxa

Description of the macroremains

Several macroremains, some in fragmentary state, have been determined as *Coronilla/Galega* or cf. *Coronilla/Galega*. The best preserved specimens are elongated and laterally compressed seeds, with radicle and embryo at one of the sides, in the middle of the grain length (Figure 61). One of the specimens have hollows, unobserved in the modern reference collection, probably induced as a result of charring. Several species in *Coronilla* and *Galega* have been found matching the shape and size.

Presence in the archaeological record

Remains determined as *Coronilla/Galega* or cf. *Coronilla/Galega* have been found in Lapiás das Lameiras and Poças de São Bento.

Ecological characteristics

*Coronilla* spp. are shrubs or annual herbs, most of which contain a toxic glycoside called coronillin (Fern 1992-2010).

*Galega officinalis* is a perennial herb between 45 to 80 cm tall, under cultivation up to 1.2 m by 0.8. It grows in woodlands, meadows, scrub, marshy fields, roadsides and riverbanks, in all type of soils and standing shade, between 80-950 m a.s.l. It is reported to be toxic to mammals due to the fact that it contains an alkaloid called galegine. Each fruit, generally indehiscent, contains between 2 and 5 seeds, of about 4-4.5 by 2 cm, which ripen in summer (Flora iberica 1986+; Fern 1992-2010).
Dispersal strategy

A distinctive characteristic of *Coronilla* spp. from other members of the Leguminosae family is the characteristic fruit type of the genus, known as lomentum, which breaks into segments (Cappers & Bekker 2013). The dispersal mode in this genus might be anemochory and zoochory (Paula & Pausas 2009). Most *Coronilla* and *Galega* pods are indehiscent (Flora iberica 1986+).

Ethnographical information

Bromatological use

The oil from the seeds of *C. varia* is used in culinary preparations; the leaves of *G. officinalis* are edible cooked, it can be used as rennet in curdling milk, and the plant is often fed to cows and goats to increase their milk yield (Fern 1992-2010).

Cosmetic use

*Galega officinalis* is used in hand and foot baths; a blue dye is obtained from the fermented leaves of *Coronilla scorpioides* (Fern 1992-2010).

Pharmaceutical use

All species in *Coronilla* have been used as pharmaceutics, as they contain cardiotonic glycosides (Flora iberica 1986+); *C. emerus* is diuretic and cardiotonic; the whole plant of *C. varia*, used either fresh or dried is a cardiotonic; a decoction of the bark has been used as an emetic; the crushed plant has been rubbed as a salve on rheumatic joints and cramp; it can also be used as an insecticide (Fern 1992-2010).

*Galega officinalis* was once important, and to that owes the Latin adjective, in the treatment of plague, fevers and infectious diseases, and has positive effects on the digestive system and chronic constipation caused by a lack of digestive enzymes. It has been shown to increase the flow of milk in cows and goats by 35 – 50 % and reduce blood sugar levels; the leaves and flowering tops are diaphoretic, diuretic, galactogogue and hypoglycaemic (Fern 1992-2010).

On processing

Procurement: cultivation and gathering

When intended for medicinal purposes, the plant of *G. officinalis* is harvested as it is just coming into flower and is dried for later use (Fern 1992-2010).
Part III A: Results: the identified taxa

★ Summary

Coronilla/Galega seeds have intermediate probabilities of being recovered as charred plant macroremains in archaeological deposits (vid. Table 54). General characteristics of the Leguminosae family, which might be of interest for this taxon, can be seen at p. 266.

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Table 54: Recovery chances of Coronilla sp./Galega sp. seeds in the charred archaeobotanical record.

- tp. Genista sp. L. / Lotus sp. L.

Vernacular names: gorse / trefoil

Nombres vernáculos: hiniesta, retama / cuernecillo

Nomes vernáculos: tojo-gatanho / cornichão

Description of the macroremains

Small seeded (1-2 mm width) legumes with visible reticulate in the testa surface, round hilum, heteromorphic but angular shape have been tentatively determined as Genista sp./Lotus sp.

Presence in the archaeological record

Four seeds of this type have been recovered at Cabeço do Pez.

Ecological characteristics

Genista spp. are shrubs or sub-shrubs, with elliptical dehiscent fruits in autumn that can have hairs and contain up to 30 small seeds of up to 3 mm diameter; they thrive in wet grasslands and riverbanks, shrublands and rocky areas (Flora iberica 1986+).

Lotus spp. are annual or perennial herbs, with dry cylindrical or compressed dehiscent fruits, which can contain from 1 to many seeds; they thrive in meadows and rocky areas (Flora iberica 1986+).
Ethnographical information

Bromatological use

Different plant parts of *Genista tinctoria* might be employed for food, as green vegetables or condiments, or for beverages (Fern 1992-2010). Many *Lotus* spp. are edible, particularly the green pods, although some might be poisonous (Fern 1992-2010).

Pharmaceutical use

The twigs, leaves and flowering stems of *Genista tinctoria* are cathartic, diaphoretic, diuretic, emetic, stimulant and vasoconstrictor; the powdered seeds act as a mild purgative and were at one time used to make a plaster for broken limbs; a decoction of the whole plant has been used as a remedy for dropsy, rheumatism and gout; an homeopathic remedy is made from the fresh shoots in the treatment of rheumatism (Fern 1992-2010). *Genista hispanica* has also been used against dropsy (Fern 1992-2010).

*Lotus corniculatus* contains glycosides which in small quantities and dried have been used as traditional medicines, internally as carminative, febrifuge, hypoglycaemic, restorative, vermifuge, antispasmodic, cardiotonic, sedative and tonic; and externally as a local anti-inflammatory compress in cases of skin inflammation (Fern 1992-2010).

Technological use

Some *Genista* spp./*Lotus* spp. such as *Genista tinctoria* or *Lotus corniculatus* have traditionally been highly appreciated for their good quality dyeing properties (e.g. Fern 1992-2010). The dye can be obtained from the whole plant, but especially from the flowers and young shoots; the stems can be dried and stored until the dye is required (Fern 1992-2010). In addition, a fibre obtained from the stems is used for coarse cloth and cordage (Fern 1992-2010).

On processing

Procurement: cultivation and gathering

When gathered for dyeing or pharmaceutical uses, the plant of *Genista tinctoria* is harvested in early summer and can be dried for later use; it should not be stored for more than 12 months since its active ingredients break down (Fern 1992-2010).

For bromatological uses, seeds from *Genista sp./Lotus sp.* must be gathered when ripe at the end of the summer (Fern 1992-2010).
Part III A: Results: the identified taxa

★ Summary

Genista/Lotus seeds have intermediate chances of being recovered in charred assemblages (vid. Table 55). General characteristics of the Leguminosae family, which might be of interest for this taxon, can be seen at p. 266.

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Table 55: Recovery chances of Genista sp./Lotus sp. seeds in the charred archaeobotanical record.

- Medicago L. sp. / Melilotus Mill. sp. / Trifolium L. sp.

Vernacular names: medick / sweetclover / clover

Nombres vernáculos: alfalfa, mielga / meliloto / trébol

Nomes vernáculos: luzerna / meliloto / trevo

Description of the macroremains

Laterally compressed seeds of elongated reniform shape and the typical radicle and hilum cavity of the Leguminosae family have been identified as belonging to the tribe Trifolae, which includes the genera Medicago / Melilotus / Trifolium. The absence of a prominent radicle, or beak, typical of the Trigonella spp. in these specimens excludes this genus. Legumes in the tribe Trifolae are usually difficult to discriminate from each other, even in the case of modern specimens (Flora iberica 1986+): the units representing Trifolium separated most clearly; those for Melilotus also grouped quite distinctly, but the units representing species of Medicago and Trigonella showed considerable overlap (Butler 1996).

Presence in the archaeological record

In this work, plant macroremains from this Leguminosae tribe have been determined at Lapiás das Lameiras, São Pedro de Canaferim and Cabeço do Pez. Trifolae finds are relatively frequent in the archaeological literature, proposed uses are as gathered or cultivated green fodder (Willecox 1991), fodder in dung used as fuel (Hillman, Colledge & Harris 1989), fuel (van Zeist & Bakker-Herres 1984a), field weeds (Helbaek 1969; van Zeist & Bakker-Herres 1982), food (Helbaek 1969; van Zeist & Bakker-Herres 1984b).
Ecological characteristics

Trifolieae plants are shrubs, sub-shrubs or annual or perennial herbs, with dehiscent and indehiscent fruits, with seeds variable in number from one to many and dot-shaped hilum, many of which have long been cultivated for fodder and their original distribution areas are difficult to determine (Flora iberica 1986+). Trifolieae seeds are rich in proteins and oils and many legumes of the tribe Trifolieae have for compounds oestrogenic and allelochemicals (many of which are toxins), concentrated in particular plant parts at particular moments of their development (Butler 1995): *Medicago* spp., and more particularly *M. sativa*, causes swelling and respiratory problems in ruminants when eaten and their roots exude saponins which inhibit the growth of surrounding plants; *M. sativa* is diuretic, anti-scurvy, oestrogenic and allergenic; *M. polymorpha* causes photosensitisation; *M. arabica* has trypsin inhibitors; *Melilotus* spp. contains coumarin, a substance that can cause haemorrhages when fermented; *Trifolium* spp. have a high tannin concentration that counterparts the saponins in *Medicago* spp.; *T. subterraneum* and *T. pratense* have oestrogens which can cause abortions and prevent pregnancies in ruminants, and cianogens that reduce slug and rodent predation.

*Medicago* and *Melilotus* have fruits of the camara type, so the entire fruit, instead of the seed, is dispersed. *Medicago* are usually covered by multiple rows of prickles to profit from exozoochory, dispersal attached to animal hairs (Cappers & Bekker 2013), dispersal by other modes is also present in the genus (Paula & Pausas 2009). Plants in the genus *Medicago* are shrubs or annual or perennial shrubs, with a generally indehiscent spiral or reniform fruit, with one or several reniform seeds. Specific differences are very slight and make determinations very difficult; in addition, the genus *Medicago* is closely related to the genus *Trigonella* (Flora iberica 1986+). *Trifolium* spp. are very variable annual or perennial herbs with generally indehiscent fruit with up to 8 seeds (Flora iberica 1986+), dispersal by zoochory is also frequent (Paula & Pausas 2009). *Melilotus* spp. are annual, biennial or perennial herbs with globose or ovoid dehiscent or indehiscent fruit with 1 or 2 seeds, very close to *Medicago* and *Trigonella* (Flora iberica 1986+).

Ethnographical information

Bromatological use

Different plant parts (leaves, seeds, roots and sprouts) of several Trifolieae legumes (mainly *Medicago* and *Trifolium* genera) have been used as for human food, cooked or green vegetables: *M. denticulata, M. sativa* and *M. officinalis, Trifolium corniculata, T. pratense* and *T. obtusiflorum*; many species have been also used for food conditioning: *M. officinalis, M. altissima* and *T. repens; T. repens* has been used as a preservative for animal-derived products, such as butter and cheese (Butler 1995). From classical times the main use for the Trifolieae legumes has been for fodder, both of legumes in the wild and cultivated (Aristophanes, Theophrastus, Virgil, Columella). In addition, *Medicago arborea* has also been used as a nectar source for domestic bees (Columella).
Cosmetic use

*Trifolium pratense* has been used for dying and *Medicago sativa* for paint making (Butler 1995); some *Melilotus* (*M. alba* and *M. sulcata*) and *Trifolium* (*T. resupinatum*) are used for high-valued perfume making (Butler 1995).

Pharmaceutical use

Many legumes in the tribe Trifoleae have oestrogenic and allelochemical compounds (many of which are toxins), concentrated in particular plant parts at particular moments of their development, which can be exploited for different chemical purposes, including medicinal, poisonous or insecticidal/repellent. These medicinal properties were recognised in classical literature, but the particular use is not always explicit. Various *Medicago* plants were used for increasing milk production in women and cattle (Pliny, Varro) and as purgatives (Varro) (Thompson 1949).

*Medicago sativa* has been used as diuretic, anti-scurvy and allergenic; *M. hispida* as diuretic and to desintegrate urinary stones; *Melilotus* spp. contains coumarin, a substance that can cause haemorrhages when fermented and exploited for the treatment of heart illnesses; *Medicago sativa*, *T. subterraneum* and *T. pratense* have oestrogens which can cause abortions and prevent pregnancies in ruminants; *T. subterraneum* and *T. pratense* contain cianogens that reduce slug and rodent predation; *T. arvense* has been used as antirheumatic and astringent; *T. pratense* is a sedative, antispasmodic and topical remedy for ulcers; *Melilotus officinalis*, *M. elegans* and *M. indica* have been used as insect repellent (moths and mosquitoes); *Melilotus indica* has also been used as a narcotic (Butler 1995).

Technological use

*Medicago arborea* and *Melilotus alba* have fibres that have been used in diverse crafts.

On processing

Procurement: cultivation and gathering

Trifolieae plants have traditionally been cultivated, intercropping is frequent, for winter fodder, security against crop failure, soil enrichment, etc. (Butler 1995).

Storing

Parching legume seeds is one of the measures that ensures storage (Butler 1995).
**Taphonomic proxies**

**Carbonisation**

Parching for storage provides a good opportunity to become charred (Butler 1995). When charred at temperatures over 250 °C, the endosperm of Trifolieae seeds becomes plastic and leaks through cracks in the testa, forming large vesicles that superficially may resemble charred testa, sometimes flowing over the testa surface and setting as a varnish; occasionally, the testa may detach with both endosperm and radicle attached to it so that only the fused paired cotyledons remain (Butler 1996).

**★ Summary**

Trifolieae seeds have medium to high probabilities of being recovered in charred assemblages in archaeological deposits (*vid. Table 56*). General characteristics of the Leguminosae family, which might be of interest for this taxon, can be seen at p. 266.

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Table 56: Recovery chances of Trifolieae seeds in the charred archaeobotanical record.

**- Fabeae / Vicieae**

**Description of the macroremains**

In this tribe category, all indeterminate seeds and seed fragments of pulses which preserve certain family and tribe characters (two cotyledons, hilum cavity, radicle, roundish shape) have been introduced. Leguminosae seed identification based on seed shape and size is very difficult since both attributes tend to vary widely even in seeds from the same plant (according to the position

Figure 62: Specimen from Lapiás das Lameiras determined as poorly preserved Leguminosae (Fabeae). Scale bar = 1 mm.
within the capsule) and because of the changes caused by carbonisation. Even the testa surface can express a wide range of patterning which varies within taxa (Butler 1990).

**Presence in the archaeological record**

In this work, São Pedro de Canaferirim and Lapiás das Lameiras have provided Fabeae plant macroremains.

**Ethnographical information**

**Bromatological use**

Legumes in the Fabeae tribe might be exploited for animal or human consumption, provided detoxifying of the seed is undertaken (vid. p. 266).

**Taphonomical proxies**

In the absence of available results from experiments carried out to check the resistance to carbonisation for legume seeds, data for peas (*Pisum sativum*) has been extrapolated (Table 57).

**★ Summary**

Seeds in the Fabeae tribe have high potential for recovery at archaeological charred assemblages, as they are dense and require detoxification, which is often carried out by roasting (vid. Table 57). However, some large-seeded specimens are likely to sink in flotation extraction (Hubbard 1975). General characteristics of the Leguminosae family, which might be of interest for this taxon, can be seen at p. 266. *Vid. infra* more information about species determined from this tribe.

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Table 57: Recovery chances of Fabeae seeds in the charred archaeobotanical record.

- **Lathyrus L. sp.**

  Vernacular names: vetchlings
  Nombres vernáculos: guijas
  Nomes vernáculos: chícharos
Description of the macroremains

Seeds identified as belonging to the genus *Lathyrus* have the typical Leguminosae radicle, hilum cavity and cotyledonary separation (Figure 63). Their somewhat quadrangular appearance excludes the possibility of other genus in this family. However, given the extreme variability in the genus, even in seeds from the same pods, and the fragmentary state of the remains, determination to species level is not possible.

Presence in the archaeological record

In this work, remains determined as *Lathyrus* sp. and as *Lathyrus* sp./*Vicia* sp. have been recovered at Lapiás das Lameiras, this latter type has also been recovered at Cabeço do Pez. Wild *Lathyrus* sp. seeds have been recovered in the Mesolithic layers from several 8th and 7th millennia Southern French sites (Marinval 1988; Kislev 1989; Vaquer & Ruas 2009) and the earliest finds in the Iberian Peninsula are from the 6th millennium layers of Can Sadurní and La Draga (Antolín et al. 2012; Antolín et al. 2014).

Ecological characteristics

*Lathyrus* is a large genus of more than 100 species in Flora Europaea (Tutin et al. 1964-2001). *Lathyrus* spp. are annual or perennial herbs, with horizontal underground organs (rhizomes) and
creeping aerial stems; they usually grow in meadows, slopes, forest clearances, wet and shaded areas, roadsides, riverbanks (Flora iberica 1986+). The seeds are protein-rich and highly nutritious but are toxic (they have a water-soluble non-protein neurotoxin amino acid) and might cause lathyrism, a crippling neurological disorder, if consumed in great abundance. In addition to L. cicera/sativus (discussed later in detail), other species in the genera have been domesticated (L. clymenum L., at least in the Aegean, Melamed et al. 2009) and many others wild and weedy which have been exploited in Europe.

Ethnographical information

Bromatological use

*Lathyrus* spp. seeds might be used as food, although in moderate quantities and mixed with cereals to counteract the toxins and avoid lathyrism, the whole plant can be consumed as green vegetable or given as animal fodder; the roots are eaten cooked (Valamoti 2009).

Symbolical use

Some *Lathyrus* spp. (*e.g.*, *L. odoratus*, *L. latifolius* L.) are cultivated for their ornamental value (Melamed et al. 2009).

On processing

Detoxification

*Lathyrus* spp. seeds need processing, usually boiling or leaching, for the removal of the water-soluble toxins, as described with *L. cicera/sativus* (Zohary, Hopf & Weiss 2012); their combined consumption with cereals contributes to counteracting their negative effects for human health (Valamoti 2009); the roots of several *Lathyrus* species, rich in starch, are consumed raw, boiled or roasted.

Cooking

Many *Lathyrus* spp. seeds are eaten raw, boiled or as bread or gruels, ground into flour, sometimes mixed with other grains (Melamed et al. 2009).

★ Summary

*Lathyrus* sp. seeds have high chances for preservation in charred assemblages (Table 57). General information about legume use might be also extensible for this taxon, *(eid.* p. 266 and 276).
**- Lathyrus cicera* L. / sativus* L.**

Vernacular names: red pea / grass pea

**Nombres vernáculos:** almorta silvestre, galgana / tito, muela, almorta, guiya, chícharo

**Nomes vernáculos:** araca, chícharo bravo / arrelique, chícharo

**Description of the macroremains**

Seeds from Leguminosae with a quadrangular shape in lateral view and triangular in frontal view have been ascribed to these taxa (Figure 64). The absence of a seed coat which would allow the observation of the papillae inhibits the determination between the two (Campbell 1997), morphologically undistinguishable.

**Presence in the archaeological record**

Remains determined as *Lathyrus cicera/Lathyrus sativus* have been recovered at Lapiás das Lameiras, this is the oldest evidence for Atlantic Iberia. *L. sativus* is one of the founder crops in the Early Neolithic assemblage (Zohary, Hopf & Weiss 2012), both *L. cicera/sativus* appear with certain steadiness in the archaeobotanical record of the Iberian Peninsula from the Neolithic (Buxó 2007; Peña-Chocarro & Zapata 1999; Peña-Chocarro & Zapata 2010). *L. cicera* appears in neighbouring areas from the Mesolithic (Marinval 1986b but Vaquer & Ruas 2009).

**Ecological characteristics**

*Lathyrus cicera* is quite possibly (but not yet established definitely, Zohary, Hopf & Weiss 2012) the wild ancestor of *L. sativus*, a domesticated pulse. *L. cicera* is an annual spontaneous Euro-Mediterranean plant, resistant to cold and heat and abundant in siliceous soils, cultivated in the South-Western Mediterranean and possibly domesticated there (Kislev 1989). It is also a weed in cereal crops.

*Lathyrus sativus* is an herbaceous annual creeping or climbing plant, up to 70 cm, with domesticated forms cultivated in the whole Mediterranean region but also naturalised subs spontaneous forms in grasslands, adapted to both drought stress and waterlogged growing conditions. It has a well developed taproot system, each plant contains a highly variable number of pods (from 15 to 60) and each pod contain between 1 and 5 seeds, with 26-28 % proteins. The seed coat colour is highly variable, which
Part III A: Results: the identified taxa

apparently might be correlated with flower colour and differences in nutritional values (in general, the more the pigmentation the more the tannins, but toxins are also influenced by the environment, growing conditions and locality). (Campbell 1997)

Ethnographical information

Bromatological use

*Lathyrus cicera/sativus* has been and still is cultivated for feed and fodder (Campbell 1997; Peña-Chocarro & Zapata 1999), in some regions it constitutes a delicacy served at restaurants (Valamoti, Moniaki & Karathanou 2011). Some seed coat colours are preferred over others for human consumption, according to traditional or nutritional values (Campbell 1997). Green seeds of *L. sativus* and *L. cicera* might be eaten as snacks (Luczaj et al. 2012; Peña-Chocarro & Zapata 1999) or cooked to remove the toxins. Animals might be fed both the grains and the whole plant of *L. cicera/sativus* on its own or mixed with others, as fodder (Peña-Chocarro & Zapata 1999).

On processing

Procurement: cultivation and gathering

*Lathyrus sativus* has traditionally been cultivated because of their edible seeds, it is frequently grown together with hulled barley; sowing is usually carried out in spring, but also winter/autumn sowing exists; gathering is usually carried out by hand uprooting as a way to reduce seed loss, but can also involve the used of scythes before pod shattering between the middle and the end of the summer, depending on the region; plants are left to dry a few days and are then threshed by animal trampling or by beating; by-products of winnowing and screening for the grains can be given as animal fodder (Buxó 1997; Campbell 1997; Enneking 1995; Peña-Chocarro & Zapata 1999; Peña-Chocarro & Zapata Peña 1999; Valamoti 2009).

Detoxification

*Lathyrus cicera/sativus* seeds need processing, usually boiling or leaching, for the removal of the water-soluble toxins (Zohary, Hopf & Weiss 2012), fermentation is also a highly effective means of detoxification (Enneking 1995). Their combined consumption with cereals contributes to counteracting their negative effects for human health (Valamoti 2009).

Cooking

*Lathyrus sativus* grains might be boiled whole, but more often are ground for splitting the cotyledons and making soup or ground into a flour to mix with other foodstuffs and make gruel, bread or cakes and sauces (Campbell 1997; Peña-Chocarro & Zapata 1999). Roasted (Peña-Chocarro & Zapata 1999) or
Inés L. López-Dóriga

salted boiled grains are served as snacks from street vendors (Campbell 1997). Presoaked grains were ground into flour more easily and in less time than unprocessed grains (Valamoti, Chondrou & Papadopoulou 2013).

★ Summary

*Lathyrus cicera/sativus* seeds have high chances for preservation in charred assemblages (Table 57). General information about legume use might be also extensible for this taxon (*vid.* p. 266, 276, and 277).

- *Lens cf. culinaris* Medik.

* (Lens cf. culinaris Medik. ssp. culinaris)

Vernacular names: lentil

Nombres vernáculos: lenteja

Nomes vernáculos: lentilha

Description of the macroremains

Two laterally compressed circular-shaped seeds with long hilum, relatively large in size (Figure 65), thus more likely a domesticated than a wild taxon, have been identified as *Lens cf. culinaris*. Size alone, however, is not a reliable argument in favour of its being a domesticated specimen, as the sizes of different species can overlap, particularly in the case of early cultivars and wild taxa whose size is in both cases relatively small (Butler 1990; Hubbard & Clapham 1992). The different species do not have other morphological distinctions in their seeds; moreover, these taxa manifest a wide range of
morphological variation in both its vegetative and reproductive parts (Weiss & Zohary 2011). *L. culinaris* cultivars are conventionally grouped in two intergrading clusters of seed sizes: small-seeds, 3–6-mm diameter, from small pods (subsp. *microsperma*) and large-seeds, 6–9 mm diameter, from large pods (subsp. *macrosperma*). The specimens recovered would belong in size to the former category, in addition to the latter category appearing rather late in archaeological sequences.

Recent work has called attention to the possible morphological misidentification of *Lens* spp. seeds with those of another pulse, *Vicia articulata* Hornem., at least in the Eastern Mediterranean where this legume thrives (Sarpaki & Skoula 2013).

**Presence in the archaeological record**

In this work, Leguminosae seeds determined as possible *Lens culinaris* have been recovered at Lapiás das Lameiras. *L. culinaris* is a founder crop of Old World Neolithic agriculture (Zohary, Hopf & Weiss 2012) and appears in Early Neolithic contexts in Mediterranean Iberia (Buxó 2007; Peña-Chocarro 2007). Wild *Lens* remains have been documented in several sites from the Late Palaeolithic, such as El Juyo (Crowe 1985; Ibañez-Angulo 1991), Mesolithic sites like l’Abeurador (Marinval 1988 but Vaquer & Ruas 2009) and Sta. Maira (Aura et al. 2005) and Early Neolithic contexts at La Falguera (Pérez Jordá 2006) and La Vaquera (Peña-Chocarro 2007).

**Ecological characteristics**

*Lens* spp. are annual, ephemeral herbs, self-pollinated and inter-specific hybrid (Zohary, Hopf & Weiss 2012); they generally grow in rocky areas (Flora iberica 1986+).

*Lens nigricans* (M. Bieb.) is a wild species, genetically remote from the domesticated lentil, traditionally thought to be autochthonous in the Iberian Peninsula (Zohary, Hopf & Weiss 2012), but which, according to some studies, could have also been domesticated in South-West Asia and dispersed by humans (Fuller, Willcox & Allaby 2012; Ladizinsky, Braun & Muehlbauer 1983). It provides few grains (Vaquer & Ruas 2009).

*Lens culinaris* Medik. / *L. culinaris* Medik. ssp. *culinaris*, the domesticated lentil, is an erect herb and hardly ever has wild forms (Flora iberica 1986+), it is indifferent to soils, tolerates droughts but not humid climates.

**Ethnographical information**

**Bromatological use**

*Lens culinaris* is a much appreciated rich food (the seed contains 25 % protein), standing as the tastier of the pulses (Weiss & Zohary 2011).
Pharmaceutical use

Sprouted lentils have been used as anti-scurvy (Oliver 1973).

On processing

Procurement: cultivation and gathering

It is usually sown up to mid-April and gathered in autumn (Kreuz 2007).

Cooking

*Lens* spp. are eaten in soup, paste, in mixture with wheat or rice (Zohary, Hopf & Weiss 2012) or with bitter vetch (Enneking *et al.* 1995).

Taphonomical proxies

Carbonisation

Because of the swelling of the cotyledons when charring in anoxic environment at 150 °C for 20 minutes, at 180 °C for 60 minutes, at 200 °C for 40 minutes and finally at 250 °C for 45 minutes, *Lens* spp. seeds usually loose their testa (Helbaek 1970). Carbonisation also produce the split of the cotyledons, the cracking of the surface (Antolín i Tutusaus 2012), and a change in size, which in some experiments means a reduction (Helbaek 1970) whist in others (anoxic environment at 150 °C for 20 minutes, at 180 °C for 60 minutes, at 200 °C for 40 minutes and finally at 250 °C for 45 minutes) an increase (Antolín i Tutusaus 2012).

When charred in assemblages, in anoxic environments (at 150 °C for 20 minutes, at 180 °C for 60 minutes, at 200 °C for 40 minutes and finally at 250 °C for 45 minutes), *L. culinaris* seeds can form aggregates of a small number of grains, due to the outpouring of the endosperm, but this is fragile and might rarely be preserved in the archaeological record; about 30 % of the lentils in a charred assemblage are not wholly carbonised and would be lost in the archaeological record (Antolín i Tutusaus 2012).

Fragmentation

*Lens culinaris* precharring fragmentation is difficult to detect, grains of this type have a shiny inner cotyledon surface, whilst postcharring fragmentation leave a porous surface when charred in assemblages, in anoxic environments (at 150 °C for 20 minutes, at 180 °C for 60 min., at 200 °C for 40 min. and finally at 250 °C for 45 min.) (Antolín i Tutusaus 2012).
Part III A: Results; the identified taxa

★ Summary

*Lens* sp. seeds have high chances for preservation in charred assemblages (Table 57). General information about legume use might be also extensible for this taxon (*vid.* p. 266, and 276).

- *Pisum cf. sativum* L.

Vernacular names: pea

Nombres vernáculos: guisante, chícharo

Nomes vernáculos: ervilha

Description of the macroremains

Identified as *Pisum cf. sativum* are large roundish pulses with relatively short hilum (Figure 66). Some poorly preserved remains, in which the characteristic hilum could not be appreciated or were not so roundish, have been determined as *cf. Pisum sativum*. The absent seed coat (testa) is crucial in the identification of the varieties: wild peas have a rough or granular coat whilst in domesticated peas it is smooth (Zohary, Hopf & Weiss 2012).

Figure 66: Left: modern seed from *Pisum sativum* in frontal-ventral view. Right: charred seed in frontal-lateral view from Lapiás das Lameiras determined as *Pisum cf. sativum*. Scale bar = 1 mm.

Presence in the archaeological record

In this work, plant remains potentially belonging to this taxon have been recovered at São Pedro de Canaferrim and Lapiás das Lameiras. Pea is one of the founder grain crops of South West Asian Neolithic agriculture (Zohary, Hopf & Weiss 2012). In Mesolithic layers from South East France, at l’Abeurador, wild peas have been retrieved (Marinval 1988; Vaquer & Ruas 2009); the first domesticated peas in the Iberian Peninsula appear in the Mediterranean (Buxó 2007; Buxó 1991; Buxó & Canal 2008; Marinval 1995) and the Interior Meseta, in El Mirador (Rodriguez & Buxó 2008). This is the oldest evidence for Atlantic Iberia.
Ecological characteristics

*Pisum sativum* L. is a crop complex of domesticated and wild races of peas, predominantly self-pollinated and interfertile (Zohary, Hopf & Weiss 2012), which shows a wide range of morphological variation (Weiss & Zohary 2011) and which has passed through different episodes of diversification (Mikić *et al.* 2014). Two, genetically proximate, might have been present in the Iberian Peninsula. Both are tall and climbing annual herbs, which prefer regions with a moderate rainfall, usually appearing in grasslands, roadsides and cropfields (Flora iberica 1986+).

*Pisum elatius* (M. Bieb) / *P. sativum* L. ssp. *elatius* (M. Bieb.) Aschers. & Graebn. is a wild, omni-Mediterranean type, tall and climbing, that thrives in mesic maquis formations; occasionally, it may colonise hedges and terraces in crop fields. In the Iberian Peninsula, two varieties are found (Flora iberica 1986+). Cultivated pea *P. sativum* L. is a cosmopolitan cultivated species which has two varieties, var. *sativum*, with the biggest seeds, and var. *arvense*, a weedy form with smaller seeds (Flora iberica 1986+). Pea pulses are rich in proteins (22 %).

Ethnographical information

Bromatological use

*Pisum sativum* has been used as food, either the seeds, very rich in protein (22 %), or the green plant, cooked or raw; sun-dried peas are eaten raw (Valamoti, Moniaki & Karathanou 2011). It might be used for fodder as well (Flora iberica 1986+).

On processing

Cooking

*Pisum sativum* seeds may simply be sun-dried and eaten (Valamoti, Moniaki & Karathanou 2011) or cooked.

Taphonomical proxies

Carbonisation

Several changes are brought about by the experimental carbonisation of *Pisum sativum* grains in controlled reducing conditions, as a function of time and temperature:

- morphological changes: up to 190 °C no major changes in size and shape are observed; at temperatures between 190 and 250 °C a decrease in the size is shown and the seeds become rounder; heating from 250 up to 340 °C does not provoke further changes in size and shape. Subsequently up
to 400 °C the size increases and the seeds become rounder. From 400 °C upwards the size gradually decreases, which corresponds to the gradual decrease in weight, and simultaneously the seeds become less round. The seeds are still recognizable even after heating at 700 °C for 1 h. (Braadbaart et al. 2004b; Braadbaart & van Bergen 2005).

- anatomical changes: loss of seed testa. After 60 min. of heat exposure at between 130 °C and 700 °C: at 220 °C the first cracks in the testa appear in 40 % of the peas; at 310 °C all peas have abundant cracks in the testa. The cotyledons start cracking at 270 °C and is extended to all peas heated from 370 °C upwards. At all temperatures the testa is still present, except at places where cracks have developed, some curling occurs at the edges of the cracks. At all temperatures the testa sticks to the cotyledons (Braadbaart et al. 2004b).

- weight loss: for all temperatures, between 130 and 700 °C, the total weight loss after 60 min. becomes stable; the strongest weight loss is found in the range of 220 to 270 °C; the total weight loss reaches a value of almost ca. 70 % at 400 °C and 80 % at 700 °C (Braadbaart et al. 2004b).

- structural changes: the internal structure of an untreated pea shows distinct cells, from 190 °C upwards, this distinct cell structure slowly disappears and at 270 °C some faint former cell boundaries can be seen, which become completely absent at 310 °C; cavities are formed between the cells and between 310 and 440 °C the quantity and size of the holes increase until they constitute about 50 % of the total volume, and from 440 °C upwards to about 80 %. From 270 °C, a vitrinite reflectance could be measured; it rises slowly between 270 to 400 °C and thereafter more rapidly. (Braadbaart et al. 2004b).

**Summary**

*Pisum sativum* seeds have high chances for preservation in charred assemblages (Table 57). General information about legume use might be also extensible for this taxon (*vid.* p. 266, and 276).

- *Vicia* L. sp.

  Vernacular names: vetch

  Nombres vernáculos: veza

  Nomes vernáculos: ervilhaca

**Description of the macroremains**

Roundish legume seeds with large hilum have been determined as *Vicia* sp / *Lathyrus* sp.
**Presence in the archaeological record**

In this work, remains determined as *Lathyrus* sp. / *Vicia* sp. have been recovered at Cabeço do Pez and Lapiás das Lameiras. *Vicia* spp. finds occur with relative frequency in South-western European sites, such as l’Aheurador (Vaquer & Ruas 2009).

**Ecological characteristics**

*Vicia* spp. are annual or perennial herbs, usually creeping and rarely erect, with a dehiscent fruit with up to 15 seeds (Flora iberica 1986+). They are tolerant to stress factors such as drought, cold, temporary waterlogging, pests, diseases and infertile soils (Enneking 1995) and grow in grasslands, nitrogen-rich soils, roadsides, rocky areas and shrubland clearances (Flora iberica 1986+). *Vicia* spp. grains are rich in proteins but are toxic, particularly for monogastric animals when consumed regularly in high quantities. They contain, among other toxins (Enneking et al. 1995), vicine, a water-soluble alkaloid that can provoke favism (anaemia and enzyme deficiency) (Bouby & Léa 2006).

**Ethnographical information**

**Bromatological use**

Despite the toxicity for monogastric animals, many Mediterranean *Vicia* spp. (*V. articulata* (syn. *V. monantha*), *V. benghalensis*, *V. cracca*, *V. ervilia*, *V. faba*, *V. hirsuta*, *V. narbonensis*, *V. pannonica*, *V. peregrina*, *V. sativa*, *V. sepium*, *V. tetrasperma*, *V. villosa*), Francis, Enneking & Abd El Moneim 1999) grains have been the object of cultivation for animal fodder, most particularly but not exclusively for ruminants, and sometimes for human consumption, as the toxins can be counteracted in many ways (Enneking et al. 1995). The immature seeds of various species (*V. villosa* and *V. lutea*) are eaten by children as vegetable snacks (Łuczaj et al. 2012). The leaves and young shoots of several *Vicia* spp. have been made into soups and herbal infusions have been made from leaves (Francis, Enneking & Abd El Moneim 1999).

**Pharmaceutical use**

*Vicia narbonensis* green seeds have a garlic-like sulphurous taste, and have formed part of early herbal remedies (Enneking & Maxted 1995).

**Symbolical use**

Some *Vicia* spp. have currently ornamental value (Francis, Enneking & Abd El Moneim 1999).
Part III A: Results; the identified taxa

On processing

Detoxification

As the toxins in *Vicia* spp. grains are water-soluble, preparations for human consumption include leaching or soaking (Bouby & Léa 2006) and fermentation, which is also an effective means for long-term preservation (Enneking *et al.* 1995).

★ Summary

*Vicia* sp. seeds have high chances for preservation in charred assemblages (Table 57). General information about legume use might be also extensible for this taxon (*vid.* p. 266 and 276).

- *Vicia* tp. *cracca* L.

Vernacular names: tufted vetch

Nombres vernáculos: alverja, algarrobilla de monte

Nomes vernáculos: ervilhaca

Description of the macroremains

Small Leguminosae seeds with their typical radicle and hilum cavity and cotyledonary separation, of roundish shape, almost spherical, have been identified as *Vicia* tp. *cracca* (Figure 67).

![Figure 67: Left: modern seed of *Vicia cracca*. Right: charred specimen from São Pedro de Canaferrim determined as *Vicia* tp. *cracca*. Scale bar = 1 mm.](image)

Presence in the archaeological record

In this work, both at Lapiás das Lameiras and São Pedro de Canaferrim remains determined as *Vicia* tp. *cracca* have been recovered. This taxon appears with relative frequency in other contexts in the Iberian Peninsula and Europe.
Ecological characteristics

*Vicia cracca* are annual or perennial erect herbs, very variable and with frequent hybridisations with *V. tenuifolia*; it grows in wet grasslands, riverbanks; the fruit has 3 or 4 seeds (Flora iberica 1986+).

Ethnographical information

Bromatological use

*Vicia cracca* has been cultivated as green fodder (Flora iberica 1986+). Moreover, their grains have been used in human diets, together with their leaves and young shoots in soups and infusions (Francis, Enneking & Abd El Moneim 1999).

★ Summary

*Vicia cracca* seeds have high chances for preservation in charred assemblages (Table 57). General information about legume use might be also extensible for this taxon (*vid.* p. 266, 276 and 287).

- *Vicia ervilia* (L.) Willd.

Vernacular names: bitter vetch

Nombres vernáculos: arveja, yero, tito

Nomes vernáculos: ervilha de pombo, orobo

Description of the macroremains

Some triangular-shaped grains with two cotyledons and angular hilum (Figure 68) have been ascribed to *Lathyrus cicer/sativus* or to *Vicia ervilia*, without having the means of deciding between the two genera due to the high morphological variability of seeds from those taxa depending on their position in the pod. Furthermore, no reliable diagnostic

![Figure 68: Left: modern seed of *Vicia ervilia* in lateral view. Right: charred specimen from LL determined as *Vicia ervilia / Lathyrus cicer/sativus*. Scale bar = 1 mm.](image-url)
traits to distinguish archaeological wild and domesticated forms exist (Zohary, Hopf & Weiss 2012), particularly in the absence of testa.

**Presence in the archaeological record**

In this work, remains determined as *Lathyrus cicera* / *Lathyrus sativus* / *Vicia ervilia* have been recovered at Lapiás das Lameiras. Both *L. sativus* and *V. ervilia* are founder crops from the Early Neolithic assemblage (Zohary, Hopf & Weiss 2012). In the Iberian Peninsula, *V. ervilia* finds are sparse (Buxó 2007), such as in contexts like El Toro (Peña-Chocarro 2007), Sant Pau (Buxó & Canal 2008) and Los Mármoles (Peña-Chocarro & Zapata 2010). This is the oldest evidence for Atlantic Iberia.

**Ecological characteristics**

*Vicia ervilia* is an annual herb, with erect culms reaching up to 45 cm, it appears in grasslands and naturalised in road sides (Flora iberica 1986+). It is cultivated on soils of medium to low fertility and is considered to be more tolerant to parasitical plants and pests than other legumes. Weedy races occasionally appear in crop fields and hedges (Zohary, Hopf & Weiss 2012). Seeds from *Lathyrus* spp. and *V. ervilia* are particularly toxic to humans and other monogastric animals but appropriate preparation makes them palatable, as their toxins are water-soluble. *V. ervilia* contains canavanine (Enneking et al. 1995).

**Ethnographical information**

**Bromatological use**

Both *L. sativus* and *V. ervilia* seeds and vegetative plant parts have traditionally been eaten. Their seeds are toxic in some circumstances (consumption in large quantities for monogastric animals and at flowering time to both monogastric and ruminant animals). This toxicity has been well recognised from the antiquity, as is recorded in the works of Hippocrates, Pliny and Dioscorides from the ancient Greco-roman world (Valamoti 2009). *V. ervilia* seeds might be also used as flour and leaven bread with barley (Pliny and Psiakis & Psiaki 2001 *apud* Valamoti 2009) or lentils (Enneking et al. 1995) and for fattening cattle (de Herrera 1513). The whole plants might used as a green fodder and for hay production (Ladizinsky 1979) and green vegetable in salads.

**Pharmaceutical use**

*V. ervilia* grain is considered to aid the recovery of ruminant animals which are in poor condition (Enneking et al. 1995). In Roman times, it was said to have unspecified medicinal properties (Pliny *apud* Zohary, Hopf & Weiss 2012). They have traditionally been used as aphrodisiac (Agelet & Vallès 2003).
On processing

Procurement: cultivation and gathering

Both *L. sativus* and *V. ervilia* have traditionally been cultivated because of their edible seeds (Valamoti 2009), it is frequently grown together with hulled barley (Buxó 1997). Depending on seasonal rainfall it is sown either in December (dry years) or February (wet years): early sowing in a wet year results in excessive vegetative growth and bacterial disease (Enneking *et al.* 1995). Gathering of *L. sativus* and *V. ervilia* is usually carried out by hand as a way to reduce seed loss (Enneking *et al.* 1995).

Detoxification

*Vicia ervilia* seeds intended for consumption have to be soaked in water with subsequent removal of the testae, aided by roasting or sun-drying of the grains (Enneking *et al.* 1995). *V. ervilia* can be used as leaven in barley bread (Pliny Psilakis & Psilaki 2001 *apud* Valamoti 2009), or mixed with cereal flour or lentil flour (Andalusian written source *apud* Enneking *et al.* 1995).

Taphonomical proxies

Carbonisation

The way in which *V. ervilia* seeds are prepared, following ethnographical accounts of traditional means of detoxification, greatly influences the way in which their remains are preserved in the archaeological record, after carbonisation at 220 °C in reducing conditions for 11 hours (*vid.* Table 58). However, this patterning varied among different specimens and some overlap was observed between different treatment categories (Valamoti, Moniaki & Karathanou 2011).

<table>
<thead>
<tr>
<th>Conditions prior to charring</th>
<th>Postcharring appearance</th>
<th>Cotyledon inner surface (macroscopic)</th>
<th>Cotyledon inner surface (SEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole untreated</td>
<td>Seeds intact, difficult to break, testae easily detached from seeds</td>
<td>Seeds break irregularly, not into cotyledons</td>
<td>Small bumps</td>
</tr>
<tr>
<td>Pounded (agate pestle and mortar)</td>
<td>No testae</td>
<td>Smooth, shiny</td>
<td></td>
</tr>
<tr>
<td>Whole, soaked 24 h, sun-dried</td>
<td>Break easily into cotyledons, testae easily detached</td>
<td>Shiny with small bumps</td>
<td></td>
</tr>
<tr>
<td>Soaked 24 h, sun-dried, pounded</td>
<td>No testae</td>
<td>Shiny with small, round, negative features</td>
<td>Small bumps</td>
</tr>
<tr>
<td>Pounded, soaked, sun-dried</td>
<td>No testae</td>
<td>Smooth, shiny</td>
<td></td>
</tr>
<tr>
<td>Whole, boiled 45 min.</td>
<td>Cotyledons break very easily, testae easily detached</td>
<td>Matt surfaces with small bumps, cotyledon inner surfaces depressed</td>
<td>Elongated cells with strong relief</td>
</tr>
</tbody>
</table>
Part III A: Results; the identified taxa

<table>
<thead>
<tr>
<th>Conditions prior to charring</th>
<th>Postcharring appearance</th>
<th>Cotyledon inner surface (macroscopic)</th>
<th>Cotyledon inner surface (SEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiled 45 min., pounded</td>
<td>No testae</td>
<td>Patches of matt and shiny surfaces, cotyledon inner surfaces depressed</td>
<td></td>
</tr>
<tr>
<td>Pounded, boiled 45 min.</td>
<td>No testae</td>
<td>Matt surfaces, cotyledon inner surfaces depressed</td>
<td></td>
</tr>
</tbody>
</table>

Table 58: Preservation of processing evidence on *Vicia ervilia* grains after charring (after Valamoti, Moniaki & Karathanou 2011).

★ Summary

*Vicia ervilia* seeds have high chances for preservation in charred assemblages (Table 57). General information about legume use might be also extensible for this taxon (*vid.* p. 266, 276, and 287).

- *Vicia cf. faba* L. var. *minor*

  Vernacular names: faba bean, broad bean, horse bean

  Nombres vernáculos: haba

  Nomes vernáculos: fava

Figure 69: Left: modern seed of *Vicia faba* var. *minor* in frontal and lateral view. Right: charred specimen from São Pedro de Canaferrim determined as *Vicia cf. faba* var. *minor*. Scale bar = 1 mm.

Description of the macroleaves

Have been identified as *Vicia cf. faba* large rectangular legume seeds, with lateral and ventral compression, and long hilum (Figure 69). It is of relatively small size, ascribable to the *Vicia cf. faba* var. *minor* size range (6-13 mm). Some authors consider that all archaeological faba remains should be called *V. faba*-like rather than *V. faba*, because of its morphological similarity with other species from the Vicieae, particularly from the *Vicia narbonensis* complex native to the Mediterranean basin and attractive for collection from the wild (Zohary, Hopf & Weiss 2012).
Presence in the archaeological record

In this work, remains determined as *Vicia* cp. *faba* var. *minor* have been recovered at both Lapiás das Lameiras and São Pedro de Canaferrim. This taxon has sparse occurrences during the 6th millennium in the Iberian Peninsula (Buxó 1991; Buxó 2007) with records in Los Mármoles (Peña-Chocarro & Zapata 2010) and La Caserna de Sant Pau (Buxó & Canal 2008); faba-like remains have been recovered at a 7400–7050 cal BP layer at Cova de l’Or (López 1980) and Cova de les Cendres (Buxó 1997). A possible *Vicia faba* seed has also been recorded at Peña Oviedo (cf. Díez Castillo 2008b). This is the oldest safe evidence for Atlantic Iberia, followed in the region by much later finds (Sanches 1997; Stika et al. 2013).

Ecological characteristics

*Vicia faba* is an annual erect herb, reaching up to 60 cm, that grows well in warm summer-dry Mediterranean environments and more northerly temperate parts of Europe, but not in very cold winters. Under domestication it has wide morphological variation and ecological adaptations, affecting vegetative habit, pod structure and shattering and seed morphology. According to these, some general types been recognised, among which *V. faba* var. *minor* is relevant for prehistorical agriculture in Europe. (Zohary, Hopf & Weiss 2012) It may sometimes grow subspontaneously and as a weed. The seeds are between 2 and 25 % protein.

Ethnographical information

Bromatological use

*Vicia faba* dry seeds might be a staple food and also unripe green pods are eaten. Both might be used as fodder.

Pharmaceutical use

*Vicia faba* has medicinal properties (Francis, Enneking & Abd El Moneim 1999), a decoction of the flowers has traditionally been used as diuretic and litholithic (Maxia et al. 2008).

★ Summary

*Vicia faba* seeds have high chances for preservation in charred assemblages (Table 57). General information about legume use might be also extensible for this taxon (*vid.* p. 266, 276, and 287).

- *Vicia tp. sativa* L.

Vernacular names: common vetch
Nombres vernáculos: arveja, algarroba, veza

Nomes vernáculos: ervilhaca, vicia

**Description of the macroremains**

Compressed small and roundish legume seeds, with smooth surface and very long hilum (Figure 70), have been identified as *V. sativa*, being impossible to determine if it is a wild or a domesticated taxa.

**Presence in the archaeological record**

In this work, remains determined as *Vicia* *sativa* have been recovered at Lapiás das Lameiras. Records of this taxon in the Iberian Peninsula are sparse, from sites such as La Vaquera (Peña-Chocarro 2007), Can Sadurní (Antolín *et al.* 2012) and Los Mármoles (Peña-Chocarro & Zapata 2010). This is the oldest evidence for Atlantic Iberia. It is yet unknown if the cultivar was introduced in Europe from Southwest Asia among the other crops, or if it was locally domesticated, possibly in different independent domestication events (Bouby & Léa 2006).

**Ecological characteristics**

*Vicia sativa* L. is a complex of very variable wild forms, weed and domesticates, distributed along the Mediterranean basin (Zohary, Hopf & Weiss 2012). According to different authors, between 6 and 8 main types are distinguished, which might be qualified ad subspecies (Bouby & Léa 2006). Wild forms might appear as weeds, on path borders, fallow fields, forest boundaries and water current edges (Bouby & Léa 2006). *V. sativa* ssp. *sativa*, the group of cultivars and some spontaneous forms and escapees, are weedy (Bouby & Léa 2006). Domesticated vetches are tall climbing herbs reaching up to 80 cm, which prefer nitrogen-rich soils up to 1000 m a.s.l. (Flora iberica 1986+). It may appear as a weed in lentil and bitter vetch crops (Zohary, Hopf & Weiss 2012). The grains are very rich in proteins but contain vicine, the favism toxin, and other neurotoxic and antinutritional cyanoamino acids (Enneking *et al.* 1995).
Ethnographical information

Bromatological use

*V. sativa* might be used for human food, particularly the grains, raw or boiled, as in the absence of the cyanogenic glycoside vicianine and the favism toxin vicine it is quite palatable (Francis, Enneking & Abd El Moneim 1999). The whole plant is usually used as fodder and for hay production (Ladizinsky 1979). Recommended dry rather than green (de Herrera 1513). Herbal infusions have been made of leaves of *V. sativa* (Francis, Enneking & Abd El Moneim 1999).

On processing

Cooking

*Vicia sativa* flour is mixed with rye in order to bake bread (Francis, Enneking & Abd El Moneim 1999).

★ Summary

*Vicia sativa* seeds have high chances for preservation in charred assemblages (Table 57). General information about legume use might be also extensible for this taxon (*vid.* p. 266, 276, and. 287).

- Malvaceae

Vernacular names: the mallow family

Nombres vernáculos: malváceas

Description of the macroremains

Several specimens of mitaform shape, with uneven thickness, being most thick at the outer edge, and triangular in cross-section, have been determined as Malvaceae. Preservation is poor so as to inhibit further determinations.

Presence in the archaeological record

In this work, Malvaceae remains have been recovered at São Pedro de Canaferrim. This taxon is frequent in other contexts from the Iberian Peninsula.
Part III A: Results; the identified taxa

Ecological characteristics

The Malvaceae family includes more than 150 taxa in Flora Europaea (Tutin et al. 1964-2001). Malvaceae are herbs, subshrubs, shrubs and sometimes small trees, usually indehiscent (Flora iberica 1986+); the characteristic fruit type for the European species (Abutilon, Alcea, Althaea and Malva) is a round and flat schizocarp composed of several individual 1-seeded mericarps, which are usually the dispersal unit (Cappers & Bekker 2013).

Dispersal strategy

Dispersal is based on autochory and barochory (Bonet & Pausas 2004).

Ethnographical information

Bromatological use

The leaves of many Malvaceae species are edible as greens, in salads (Fern 1992-2010).

Cosmetic use

A dye is obtained from some species of Malvaceae (Fern 1992-2010).

Pharmaceutical use

Many Malvaceae species have been traditionally exploited for their medicinal properties, particularly Althaea officinalis (Fern 1992-2010).

Symbolical use

Nowadays, Malvaceae are appreciated for their ornamental qualities (Fern 1992-2010).

Technological use

Fibres of the stems of some Malvaceae are used to make cordages (Fern 1992-2010).

★ Summary

Malvaceae seeds have intermediate chances of being recovered in charred plant macroremain assemblages (vid. Table 59). Vid. infra more details about several plant taxa in this family with plant macroremains determined in this work.
- *Lavatera* L. sp.

**Vernacular names**: mallow

**Nombres vernáculos**: malvavisco, malva arbórea

**Nomes vernáculos**: lavatera, malva alta, malvaísco

**Description of the macroremain**

One specimen has been determined as *Malva* sp./*Lavatera* sp.: the shape is mitaform and triangular in cross-section, the size is relatively big but the surface sculpture is poorly preserved.

**Presence in the archaeological record**

A specimen determined as *Malva* sp./*Lavatera* sp. has been recovered at Poças de São Bento.

**Ecological characteristics**

*Lavatera* spp. are annual, biennial or perennial herbs, shrubs and sometimes even trees, growing in disturbed habitats, cropfields, slopes, shrublands and riverbeds. The fruit is a schizocarp with single-seeded mericarps (Flora iberica 1986+). For *Malva* spp. *vid.* p. 300.

**Dispersal strategy**

Seeds of *Malva* and *Lavatera* are usually dispersed by barochory (Bonet & Pausas 2004).

**Ethnographical information**

**Bromatological use**

Both *L. arborea* and *L. trimestris* have been employed as foods: their leaves, particularly young ones, are eaten as greens, either raw or cooked, mixed with other greens (Fern 1992-2010).
Part III A: Results: the identified taxa

**Pharmaceutical use**

A poultice made of the leaves of *Lavatera arborea* has been traditionally used to treat sprains (Fern 1992-2010).

**Symbolical use**

Several species in *Lavatera* are cultivated for their ornamental value (Flora iberica 1986+).

★ **Summary**

*Lavatera* sp. seeds have intermediate chances of being recovered as charred macroremains (*vid.* Table 59). General information about the family - Malvaceae can be seen at p. 296. For *Malva* spp. *vid.* p. 300.

- *Malva* L. sp.

Vernacular names: mallow
**Nombres vernáculos**: malvas
**Nomes vernáculos**: malvas

**Description of the macroremains**

Several specimens of mitaform shape have been determined as *Malva* sp.; the absence of testa has not allowed the determination to species level. One specimen, a mitaform seed, with angular edges partially ridged, radicular lobe as long as cotyledonary lobe, favulariate surface has been determined as *Malva* sp./*Lavatera* sp. Four specimens with mitaform shape, angular edges partially ridged, radicular lobe as long as cotyledonary lobe and favulariate surface (Figure 71) have been determined as *Malva* tp. *sylvestris*.

![Figure 71: Left: modern achene of *Malva sylvestris*. Right: charred achene from Poças de São Bento determined as *Malva* sp. Scale bar = 1 mm.](image-url)
Inés L. López-Dóriga

Presence in the archaeological record

A specimen determined as *Malva* sp./*Lavatera* sp. and several specimens determined as *Malva* sp. *sylvestris* have been recovered at Poças de São Bento. Lapiás das Lameiras has provided a specimen determined as *Malva* sp.

Ecological characteristics

*Malva* spp. are annual or perennial herbs, sometimes with woody basal stems, which grow in very diverse habitats, such as grasslands, cropfields, disturbed soils, shorelines and burned areas. The fruit is a discoid schizocarp with single-seeded indehiscent mericarps (Flora iberica 1986+). When growing in nitrogen-rich soils, the leaves might concentrate toxic nitrogen quantities in their leaves (Fern 1992-2010).

Dispersal strategy

Dispersal is by barochory (Bonet & Pausas 2004).

Ethnographical information

Bromatological use

*Malva* spp. plants have tasty and interesting-looking immature fruits, widely eaten across Europe (Łuczaj et al. 2012). The leaves are eaten green as salads, the seeds of *Malva* spp. are also edible in a raw state, before full ripening they have a nutty taste, and they provide an oil which is probably edible; a decoction of the roots of *M. neglecta* is used as an egg-white substitute, a tea can be made from the dried leaves as well (Fern 1992-2010). The fruits from *M. sylvestris* have been traditionally eaten as food, sometimes when immature (Menendez-Baceta et al. 2012) in soups and salads (Flora iberica 1986+), also the leaves and flowers can be eaten as salads or tea substitutes (Fern 1992-2010); the leaves and stems might be given to domesticated animals as fodder (Pinto Carvalho 2005).

Cosmetic use

A dye is obtained from the plant and seed heads of *Malva* spp., also a hair rinse can be made of a decoction of the roots of *Malva nicaensis* (Fern 1992-2010).

Pharmaceutical use

The leaves of *M. alcea* and *M. moschata* are used as demulcent, to treat inflammatory and catarrhal conditions; all parts of the plant, but particularly the leaves and flowers, of *M. moschata* are antiphlogistic, astringent, demulcent, diuretic, emollient, expectorant, and laxative; the leaves and
Part III A: Results: the identified taxa

Flowers can be eaten as part of the diet, or a tea can be made from the leaves, flowers or roots; they have similar properties, but are considered to be inferior to *M. sylvestris* (Fern 1992-2010). Preparations of *M. sylvestris* have traditionally been applied externally to treat inflammations and infections, internally for sore throats (Pinto Carvalho 2005). A decoction of leaves for veterinary use: washing pigs (Pinto Carvalho 2005). The leaves of *Malva sylvestris* can be used as cataplasm, enema, decoction, direct ingestion, infusion for different medicinal purposes: as anti-inflammatory, vulnerary, anti-haemorrhoidal, laxative, digestive, lenitive or nutraceutical (Flora iberica 1986+; Maxia et al. 2008) and to relieve insect bites (Fern 1992-2010). The ingestion of the root is a reported abortive (Agelet & Vallès 2003).

**Symbolical use**

In addition to being appreciated for their ornamental value (Fern 1992-2010), *Malva* spp. have an important role in the popular imaginary, a Spanish saying equivalent to *pushing up daisies* (“criando malvas”) is usually used to euphemistically allude to people who are dead (buried in cemeteries).

**Technological use**

The stems of *M. alcea* and *M. sylvestris* provide a fibre to make cordage, textiles and paper, the root of *M. neglecta* is used a toothbrush (Fern 1992-2010). Cordage, textiles and paper might be made of the fibres extracted from the stems (Fern 1992-2010).

★ **Summary**

*Malva* sp. seeds have intermediate chances of being recovered as charred macroremains (*vid.* Table 59). General information about the family - Malvaceae can be seen at p. 296.

**Moraceae**

- *cf. Ficus carica* L.

*Vernacular names:* (plant) common fig tree; (fruit) common fig  
*Nombres vernáculos:* (planta) higuera; (fruto) higo, breva  
*Nomes vernáculos:* (planta) figueira; (fruto) figo
Inés L. López-Dóriga

Description of the macroremains

Seeds, seed fragments and a fragment of fruit-flesh with the negative of a seed have been identified as cf. *Ficus carica*, on the basis of seed morphology. Seeds are drop-shaped, have a dorsal ridge and smooth surface, the micropore under the beak is not always visible (Figure 72). The seed fragment allows the extremely thin coat density to be appreciated.

Presence in the archaeological record

Remains from *F. carica* have been tentatively identified in this work at the sites of El Toral III (zone A), Los Gitanos (A1) and Poças de São Bento (Phase B). The most ancient mentions for *F. carica* in the Iberian Peninsula is for the Middle-Late Neolithic in the North-East (Tarrús, Pons & Chinchilla 1982) and further occurrences spread during the Chalcolithic along the Mediterranean (Buxó & Piqué 2008) and Atlantic regions; a single uncarbonised find in Zambujal, Portugal, might be an intrusion (Stika *et al.* 2013; Stika, pers. comm.).

Ecological characteristics

Fig trees are deciduous monoecious shrubs or trees which usually grow up to 4 or 5 m, but can even reach 10 m. They easily grow wild in dry and sunny areas, with heavy and humid soils, or in rocky areas, up to 1700 m a.s.l. (Flora iberica 1986+). Nowadays *F. carica* spreads all over the Iberian Peninsula but its natural distribution prior to domestication is not well-known: it has been extensively cultivated and widely naturalized in S. Europe (Tutin *et al.* 1964-2001); however, according to genetical
evidence (Khadari et al. 2005), there was a natural wild population in the Western Mediterranean, including all the Mediterranean region of the Iberian Peninsula (Zohary, Hopf & Weiss 2012).

Its reproduction is based on a symbiotic relationship with a wasp: normal spring wasp-pollinated flowers produce figs in autumn, whilst brevas are produced by carpelar parthenogenesis in spring and summer; many of the cultivars are parthenogenic (Flora iberica 1986+). A fig tree can produce 2–3 crops a year, and the main edible crop matures in summer; figs are usually pear-shaped and up to 5 cm in diameter (Fern 1992-2010), depending on the variety they might have between 10 to 75 seeds (smaller varieties) or between 1000 to 2000 seeds (bigger ones) (Ramsay & Tepper 2010).

Dispersal strategy

The seeds are often dispersed by a wide range of frugivorous animals (Debussche & Isenmann 1989; Torroba Valmori 2013).

Ethnographical information

Bromatological use

The figs of *F. carica* are sweet and succulent, exquisite fruits, often dried for later consumption and commerce (Bakels & Jacomet 2003). The latex from the sap can be used to coagulate plant milks (Fern 1992-2010) and treat greens (Flora iberica 1986+). They can also be used to make liquors (San Miguel López 2004).

Pharmaceutical use

The aerial parts of *F. carica* can be used as topical application for cicatrising injuries (Maxia et al. 2008); the sap obtained by picking the fruits from the branches has traditionally been used to treat skin warts (pers. obs.). The sap and the half-ripe fruits are said to be poisonous, particularly eye irritant; a decoction of the leaves is stomachic and a steam bath of them can be used to treat painful or swollen piles; the latex from the stems is used to treat corns, warts and piles, and insect stings and bites; the fruit is mildly laxative, demulcent, digestive and pectoral, and when and cooked, act as a galactogogue and tonic; the roasted fruit is emollient and used as a poultice in the treatment of gumboils and dental abscesses; a syrup of figs, made from the fruit, is a well-known and effective gentle laxative; a decoction of the young branches is an excellent pectoral (Fern 1992-2010).

Storing leaves with the grain crop avoids infestation by insects (Pinto Carvalho 2005).

Symbolical use

Ethnobotanical sources note the symbolical importance of figs or fig trees (Pinto Carvalho 2005).
**Technological use**

The wood of *F. carica* is pliable and light, but porous, it is used for hoops, garlands and ornaments. When saturated with oil and covered with emery it is used as a substitute for a hone (Fern 1992-2010). It is also highly appreciated for making mallets for dehusking cereals (Peña-Chocarro *et al.* 2009) but as fuel it is considered of bad quality (San Miguel López 2004). Fruits have also been traditionally used to make toys (San Miguel López 2004) and leaves for wrapping foodstuffs, such as cheese (Pinto Carvalho 2005).

**On processing**

**Drying**

Figs for drying are exposed to the sun, dipped in boiling water and baked, sometimes covered with wheat flour, for long-term preservation (Pinto Carvalho 2005).

**Taphonomical proxies**

**Non-anthropic marks**

Seeds from a bird dejection were macroscopically examined and no apparent differences were seen in contrast with undigested seeds (pers. obs.).

**★ Summary**

Despite the seeds of *Ficus carica* are not particularly fit for becoming charred, the fruits are likely to be exposed to fire during processing and therefore their chances of recovery seeds are relatively high (Table 60). Zoochory should be taken into account as a potential way of introduction.

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Table 60: Recovery chances of *Ficus carica* seeds in the charred archaeobotanical record.
Part III A: Results: the identified taxa

**Plantaginaceae**

- *Plantago sp. L.*

*Vernacular names: plantains or fleaworts*

*Nombres vernáculos: llantén*

*Nomes vernáculos: tanchagem*

**Description of the macroremain**

An oblong navicular seed, with a semicircular transversal view, the hilum off-centred on ventral view and placed on a longitudinal ridge, with curled and broken margins, dorsal side with sculpture (Figure 73) has been determined as *Plantago* sp.. The closest match in *Flora iberica*, although absent in the studied region (Aedo & Castroviejo 2012), is *Plantago monosperma*, the only species in *Plantago* with navicular shape and ventral side canaliculated which does not have a centred hilum.

**Presence in the archaeological record**

A seed determined as *Plantago* sp. has been recovered at Phase B of Poças de São Bento. Seeds from this genus have been recovered in several sites, such as El Mirador (Rodríguez & Buxó 2008), usually interpreted as weeds; however, some European bog bodies have shown to contain seeds from this genus in their gut contents (Helbaek 1960).
Ecological characteristics

*Plantago* spp. are perennial or annual herbs, which usually grow in grasslands and slopes (Flora iberica 1986+). Their fruits are dehiscent capsules which break transversally (Flora iberica 1986+), freeing the seeds, displaced by the wind (Paula & Pausas 2009). The seeds have a mucilaginous coat and both the seeds and the husks contain high levels of fibre (Fern 1992-2010).

Dispersal strategy

Dispersal is by autochory: anemochory (Paula & Pausas 2009).

Ethnographical information

Bromatological use

The leaves of most *Plantago* spp. might be eaten, raw or cooked; those of *P. coronopus* are the most highly valued because of their tenderness: they might be blanched in boiling water for a few seconds before using them in salads; a flour might be made from the seeds of *P. maritima*, a soup of the boiled seeds of *P. major* and a salad or the sprouted seeds of *P. ovata* (Fern 1992-2010). Dried leaves of *P. major* might be used to make a tea; the mucilage from the seed coat might be used as food stabiliser (Fern 1992-2010).

Pharmaceutical use

Most *Plantago* spp., particularly the dried seeds and the seed husks, have traditionally been exploited for their medicinal properties (Fern 1992-2010): they contain mucilages which can be used as laxatives (particularly *P. afra* and *P. ovata*) and as emollient (*P. lanceolata*) (Flora iberica 1986+), against diarrhoea and to reduce the irritation of haemorrhoids; it also helps to remove toxins from the body; the leaves from *P. coronopus* are antiperiodic and ophthalmic; they are used as a remedy for ague and sore eyes; *P. major* is a safe and effective treatment for bleeding, externally, the leaves are used in treating skin inflammations, ulcers, cuts and stings; heated leaves are used as a wet dressing for wounds and swellings; the seeds are used in the treatment of parasitical worms; a distilled water made from the plant makes an excellent eye lotion; the oil in the seed embryo of *P. ovata* contains 50% linoleic acid and has been used as a preventative of atherosclerosis and in reducing cholesterol levels in the blood; a mouthwash made from the leaves of *P. media* helps to relieve toothache (Fern 1992-2010).

The leaves of *P. media* are used as fungicide in fruit trees (Fern 1992-2010).

Technological use

The starch of the seed coat of *P. ovata* has been sometimes used to stiffen linen (Fern 1992-2010).
Part III A: Results: the identified taxa

★ Summary

Chances for recovering *Plantago* seeds in charred assemblages are medium to high (*vid.* Table 61).

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Table 61: Recovery chances of *Plantago* sp. seeds in the charred archaeobotanical record.

- **Polygonaceae**

  **Vernacular names:** knotweed family

  **Nombres vernáculos:** centidonias

  **Description of the macroremains**

  Two trigonous nutlets, equilateral with rounded angles, apex point missing, base broken but truncate and smooth surface. Triangular seeds develop in one flower which consists of three carpels. The location of the maximum width point, at or below the centre, the position of the embryo, centred, and the absence of cell superficial structure, allows for the distinction of the family from three-sided Cyperaceae (Cappers & Bekker 2013).

  **Presence in the archaeological record**

  Poças de São Bento (Phase B) is the context studied in this work which has provided plant remains belonging to Polygonaceae. Finds of this taxon are relatively frequent in archaeological sites, often interpreted as agricultural weeds; however, they also appear in bog bodies gut contents (Helbaek 1960).

  **Ecological characteristics**

  Polygonaceae is a large plant family, with more than 400 taxa in Flora Europaea (Tutin *et al.* 1964-2001), most of which are annual, biannual or perennial herbs, sometimes woody; the fruit is an achene, trigonous or lenticular (Flora iberica 1986+). With the exception of a single genus which is not present in Europe, the photosynthetic pathway is C₃ (Sage & Monson 1999). A few species are domesticated: *Fagopyrum esculentum* and *Rheum hybridum*; *Persicaria*, *Polygonum* and *Rumex* are important genera (Cappers & Bekker 2013).

  **Dispersal strategy**

  Dispersal is varied, between anemochory, endozoochory and autochory (Paula & Pausas 2009).
Summary

Ethnographical uses of this family are very diverse (*vid. infra* for a particular genus of this family) and account for a medium-high probability of recovery in charred contexts (*vid. Table 62*).

- *Rumex* L. spp.

**Vernacular names:** docks and sorrels  
**Nombres vernáculos:** romazas, acederas  
**Nomes vernáculos:** labaça

Figure 74: From left to right: modern achene of *Rumex thyrsiflorus* in lateral view; charred specimens from Los Gitanos and Poças de São Bento determined as *Rumex* spp. in lateral and transversal views. Scale bar = 1 mm.

**Description of the macroremains**

Two types of remains have been identified as *Rumex* sp., left undetermined to species level because of poor preservation: several nutlets and a seed. Most nutlets show acute angles and apex, truncate base and side-centred embryo. The seed is small and with rugose surface sculpture and blunt edges, extremes eroded. In addition, we have identified two well preserved nutlets (Figure 74) of problematical determination due to the high polymorphism in this genus probably due to innumerable introgressions (*Flora iberica* 1986+). One of the nutlets has acute angles and apex, truncate base and side-centred embryo (Figure 74), which morphologically resembles *R. obtusifolius*, although its size is considerably smaller. A small trigonous nutlet, isosceles but almost equal, with colliculate surface, not as wide as long, acute unrigged angles, slightly pointy apex and rounded base but angles visible, most resembles *R. thyrsiflorus*. *R. thyrsiflorus* is not described in *Flora iberica*, but a short reference about its possible similarities with *R. papillaris* exists; according to some other references, it is a synonym for a subspecies of *R. acetosa* L. (*Anderberg & Anderberg 1999; Flora of North America 1993+*). However, the seed morphology of *R. acetosa* clearly does not match that of the charred specimen. All these species
conform within the genus *Rumex* the section Acetosa (Mill. DC). Misidentifications between the different species and subspecies in this section might occur (Flora of North America 1993+; Hubbard & Clapham 1992).

**Presence in the archaeological record**

In this work, seeds from *Rumex* spp. have been recovered at Phase B of Poças de São Bento and Los Gitanos (nutlets) and El Mazo (seed). Remains from this taxon are very frequent in archaeobotanical assemblages when a sorting size-bias is avoided. Several *Rumex* spp. have been intensively gathered and presumably exploited for human consumption in other European contexts (Behre 2008).

**Ecological characteristics**

*Rumex* spp. plants are generally found in river margins, their expansion therefrom is related to human activities, through the creation of ruderal propitious habitats. Most plants are tall (40-150 cm) annual, biennial or perennial herbs, that prefer humid or very humid soils, well exposed to sun-light, rich in nutrients and slightly acid, occasionally neutral or basic, and moderate heat, up to 2000 m a.s.l. (Flora iberica 1986+). The plants can contain quite high levels of oxalic acid, so the leaves should not be eaten raw in large amounts since the oxalic acid can lock-up other nutrients in the food, especially calcium, thus causing mineral deficiencies (Fern 1992-2010).

**Dispersal strategy**

Several species in this genus rely on anemochory, endozoochory for their dispersal (Paula & Pausas 2009) and barochory (Tela Botanica 2013).

**Ethnographical information**

**Bromatological use**

*Rumex* spp. leaves have been much appreciated as children’s snacks (Łuczaj *et al.* 2012) and many species have been used as greens (Pinto Carvalho 2005) or fodder; the seed might be eaten raw, cooked or ground into a powder and used to make a gruel or added to cereal flours for making bread (Fern 1992-2010).

**Cosmetic use**

The roots of *Rumex* spp. plants can be used without mordant to provide yellow, dark green to brown and dark grey dyes (Fern 1992-2010).
Pharmacological use

Many *Rumex* spp. have been traditionally exploited in folk medicine (Fern 1992-2010).

Technological use

Leaves of *Rumex* spp. plants have traditionally been used to wrap foodstuffs, such as butter (San Miguel López 2004).

On processing

Procurement: cultivation and gathering

The seeds from *Rumex* spp. plants are rather small and fiddly to harvest, the root is harvested in early spring and dried for later use (Fern 1992-2010).

Taphonomical proxies

Carbonisation

Seeds of *Rumex acetosella* survive to fire in low numbers if directly exposed but more abundantly if buried among other materials (Gustafsson 2000).

Non-anthropic marks

*Rumex* spp. seeds might be dispersed intact in corvids dejections (Vaquer & Ruas 2009).

Summary

On account of the type of seed and the way in which it might be processed, chances for recovering *Rumex* sp. seeds in archaeobotanical charred assemblages are medium to high (vid. Table 62). Zoochory should be taken into account as a potential way of introduction. *Vid. supra* general information about the family (p. 307).

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Table 62: Recovery chances of *Rumex* sp. fruits in the charred archaeobotanical record.
- Primulaceae

Vernacular names: the primrose family

Nombres vernáculos: primuláceas

Description of the macroremain

A trigonous seed, with a very irregular edge in which the hilum is placed, and an eroded but probably papillated surface has been identified as Primulaceae.

Presence in the archaeological record

A seed determined as belonging to the family Primulaceae has been determined at El Mazo.

Ecological characteristics

Plants of the Primulaceae family are usually herbs, sometimes woody in their base, perennial or annual; 11 genera are listed in Flora iberica; the fruit is a capsule which opens into 5 or 10 teeth and has abundant angular seeds (Flora iberica 1986+). The seeds ripen in summer (Fern 1992-2010).

Dispersal strategy

The dispersal modes might vary between autochory and zoochory (both endo and epizoochory) (Bonet & Pausas 2004; Paula & Pausas 2009).

Ethnographical information

Bromatological use

Many species in Primulaceae have been traditionally eaten, the leaves as green salads or boiled in soups, the flowers raw and as food flavouring (Fern 1992-2010).

Pharmaceutical use

Several Primulaceae species have been used in traditional folk medicines for a variety of purposes (Fern 1992-2010).
Summary

Chances for recovering Primulaceae seeds are medium (vid. Table 63). Zoochory should be taken into account as a potential way of introduction. Vid. infra for detailed information about a taxon in this family which has been determined in this work.

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Table 63: Recovery chances of Primulaceae seeds in the charred archaeobotanical record.

- *Anagallis arvensis* L. / *monelli* L.

**Vernacular names:** scarlet pimpernel / Mediterranean or flaxleaf pimpernel

**Nombres vernáculos:** murajes, andagallo / centaura real

**Nomes vernáculos:** morrião / morrião grande

Description of the macroremains

A seed triangular in transversal view and ellipsoidal in frontal view, with hilum in the centre and top in dorsal view, and the surface slightly papillate (Figure 75) has been determined as *Anagallis arvensis/monelli*. Seeds of these two *Anagallis* species have heterogeneous shapes and overlapping sizes and distinction between them based on a few charred individuals is not possible.

Presence in the archaeological record

In this work, *Anagallis arvensis/monelli* seeds have been determined at Poças de São Bento. Seeds from this taxon have been recovered in other contexts, particularly in agricultural contexts in which they are often interpreted as weeds. The prevalent dispersal mode is by ectozoochory (Bonet & Pausas 2004).
Part III A: Results; the identified taxa

Ecological characteristics

*Anagallis* spp. are low-growing erect (10 cm height by 40 cm width) herbs, drought-adapted. The fruits are globular capsules which ripen from summer to autumn and which contain between 10 and 30 seeds. Several varieties exist of each species according to morphological differences with low taxonomical value (Flora iberica 1986+).

*Anagallis arvensis* is an annual herb, now subcosmopolitan as a result of human dispersal from its original distribution area in Europe and NW Africa to most temperate regions. It grows in disturbed habitats, roadsides and wastelands, as a weed of cultivated lands, and in shrubby areas, up to 1700 m a.s.l. *A. arvensis* can grow on any soil, but requires a sunny position. The plant is reported to contain toxic substances, the seeds are poisonous to some mammals but not humans, but skin contact with the plant can cause dermatitis. The fruit is between 3.5 and 6 mm diameter and contains between 20 and 35 seeds, it ripens in summer (Flora iberica 1986+; Fern 1992-2010).

*Anagallis monelli* is a perennial herb that appears in SW Europe, in rocky hillsides up to 1450 m a.s.l. The fruit is between 2 and 5 cm diameter and contains between 12 and 28 seeds (Flora iberica 1986+).

Dispersal strategy

Autozoochory is the dispersal mode (Paula & Pausas 2009).

Ethnographical information

Bromatological use

Leaves of *A. arvensis* can be eaten raw, in salads, or the tender shoots cooked as a vegetable; because of the toxicity for some mammals (it is fatal to ovicaprines), its consumption is sometimes avoided (Fern 1992-2010).

Cosmetic use

The squeezed plant of *Anagallis arvensis* is used as a soap for washing and bathing (Fern 1992-2010).

Pharmaceutical use

*Anagallis arvensis* has been highly regarded as a salutiferous (Agelet & Vallès 2003) medicinal herb, especially taken internally as an infusion in the treatment of dropsy, epilepsy and mental problems, as antitussive, cholagogue, diaphoretic, diuretic, expectorant, nerve, purgative, stimulant and vulnerary (Fern 1992-2010). It can be applied externally as a poultice for skin infections and itches and to remove warts; large doses can cause headache, polyuria and tremor (Flora iberica 1986+).
On processing

Procurement: cultivation and gathering

For medicinal uses, the plant is best harvested in spring and can be dried for later use (Fern 1992-2010).

★ Summary

*Anagallis* seeds have intermediate chances for being recovered in charred assemblages (*vid. Table 63*). For general information about the family to which this taxon belongs *vid. supra* (p. 311).

- Rosaceae

Vernacular names: rose family

Nombres vernáculos: rosáceas

Description of the macroremains

The family Rosaceae is very varied in inflorescences and infrutescences, even within a single genus; the shape and size of the fruits can vary according to its position in the receptacle (Cappers & Bekker 2013). Simple roundish fruits with small seeds, and fruit fragments with remains of the five sepals (Figure 76) have been determined as Rosaceae.
Part III A: Results; the identified taxa

Presence in the archaeological record

Remains determined as Rosaceae have been recovered in the framework of this work at El Carabión in the Cantabrian region, and possibly in Lapiás das Lameiras (indeterminate fruit of Rosaceae/Ericaceae) in Portugal. Finds of Rosaceae in other contexts are frequent, particularly in Northern Iberia and the Cantabrian region (Zapata Peña 2000).

Ecological characteristics

Rosaceae are trees, shrubs or annual or perennial herbs, often with spines, the fruits are simple (achenes, drupes or folicules), multiple (poliachene, polidrupe or polifolicule) or complex (achenes within the receptacle, achenes in the axial part of the receptacle, and pomes) (Flora iberica 1986+). Interfamilial differences are being discussed (Flora iberica 1986+).

Dispersal strategy

The fruits are favoured by frugivorous animals which act as seed dispersers (Debussche & Isenmann 1989; Paula & Pausas 2009).

Ethnographical information

Bromatological use

The family contains many species of interest which have long been cultivated, some from the beginning of tree cultivation (Cydonia, Eriobotrya, Fragaria, Malus, Mespilus, Prunus, Pyrus, etc.)

Pharmaceutical use

Many Rosaceae genera have been intensively exploited for their medicinal properties in folk traditions (Crataegus, Filipendula, Prunus, etc.).

Symbolical use

Several genera in Rosaceae have long been appreciated for their ornamental value (Cotoneaster, Crataegus, Geum, Physocarpus, Potentilla, Pyracantha, Rosa, Sorbaria, Spiraea, etc.).
Rosaceae fruits are fleshy and therefore not easily preserved by carbonisation, and at the same time likely to be processed by roasting (Table 64). Zoochory might be accountable for the dispersal of seeds of plants of this family. *Vid. infra* more detailed information about specific taxa in this family.

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Table 64: Recovery chances of Rosaceae fruits in the charred archaeobotanical record.

**- Maloideae**

**Description of the macroremains**

Rosaceae seeds that can be identified according to size and shape, but whose preservation is poor and the surface sculpture could not be observed, have been determined as Maloideae subfamily. Seeds from fruits in this tribe are not always determined because they show some variation in shape and size between fruits according to different factors, and sometimes overlapping. Phylogeny in the Rosaceae family is far from being well understood (Flora iberica 1986+) and this subgroup of Rosaceae has also been known as families Pomaceae Lindl./Malaceae Small, subfamilies Maloideae C. Weber./Pomoideae Juss, tribes Malinae/Pyrinae or subtribes Maleae/Pyreae (Reveal 2012). In genera from this group, the fruit, pome, fuses with parts of the flower, and the five styles remains attached to the apex. Two types of pomes exist: pomes with pirenes and pomes with seeds (Flora iberica 1986+); the remains identified belong to the latter in which the mesocarp in fleshy but the ovary grows into a leathery or cartilaginous core in which the seeds are found within 2-5 locules (Cappers & Bekker 2013). The possible genera are therefore *Amelanchier*, *Malus*, *Pyrus* and *Sorbus* (Flora iberica 1986+). Distinction between domesticated and wild forms is not possible when the flesh of the fruit do not allow the observation of a conspicuous size selection.

**Presence in the archaeological record**

Two seeds from Maloideae fruits have been tentatively determined at Los Gitanos A2. Determinations to this tribe are abundant in the Cantabrian region (Zapata Peña 2000).

**Ecological characteristics**

Maloideae tribe consists exclusively of shrubs and small trees, sometimes spiny, whose fruits are pomes with or without pirenes (Flora iberica 1986+). The different species in this group have wild and domesticated forms which easily hybridise between themselves, complicating the distinction of
domestication events. The crop is variable interannually, as both apples and pears require winter chilling to ensure flowering and fruiting. *Sorbus* spp. will be described in the next section (p. 318).

*Malus* spp. are trees or shrubs, the pome is spheroidal, umbilicated in the base, the flesh is homogeneous and the core is formed by 2-5 locules, with 1-2 seeds per locule (Flora iberica 1986+). Crab apples (*Malus sylvestris* (L.) Miller or *M. sylvestris* ssp. *sylvestris*), from which domesticated apples (*M. domestica* L.) partly arise (Cornille *et al.* 2012) in combination with some other Asian species, spread around western Europe before domestication. They grow in deciduous and mixed forests and shrublands up to 1800 m a.s.l.; the plant is a tree between 2 and 7 m high, sometimes thorny (Flora iberica 1986+), and the fruits are about 1.5-3 cm diameter (Zohary, Hopf & Weiss 2012).

*Pyrus* spp. are trees or shrubs, sometimes thorny, with fruit piriform to globular, not umbilicated in the base, with 1-2 seeds per locule (Flora iberica 1986+). Wild pears (*Pyrus pyraster* Burgstd.), from which domesticated ones (*P. communis* L or *P. domestica* Med.) probably descend, are distributed over the Atlantic shore of Europe. Fruits are gritty, with the pulp having stone cells, and between 1.5-3 cm diameter (Zohary, Hopf & Weiss 2012).

*Amelanchier ovalis* are shrubs up to 3 m high, with globular pomes with sclerified seed testae, and generally one seed per locule; they grow between 300 and 2500 m a.s.l., in sparsely populated forests, forest margins and particularly rocky areas (Flora iberica 1986+).

**Ethnographical information**

**Bromatological use**

Maloideae fruits are edible, in some cases they are bitter and are made into jams. Also, cider, an alcoholic beverage, can be made of them after fermentation (Menendez-Baceta *et al.* 2012). In addition, the fruit of *Malus sylvestris* is a source of pectin, used as a thickener in jams (Fern 1992-2010).

**Cosmetic use**

A red to yellow dye is obtained from the bark of Malus sylvestris (Fern 1992-2010).

**Pharmaceutical use**

The fruit from *Malus sylvestris* is astringent and laxative; the crushed fruit pulp can be used to treat inflammations; the bark, and especially the root bark, is anthelmintic, refrigerant and soporific; an infusion is used in the treatment of fever; the leaves contain an antibacterial substance (Fern 1992-2010).

**Technological use**

The wood from *Malus sylvestris* is an excellent fuel (Fern 1992-2010).
On processing

Drying

Maloideae fruits might be dried to prevent microfloral growth and inhibit toxins, apart from reducing the astringent and bitter tastes (Wiltshire 1995). Drying can be carried out by sun or fire exposure, with the fruits in halves (Zohary & Hopf 2000), allowing for their quite long-term preservation (Riddervold & Ropeid 1988).

Fermentation

Maloideae fruits are harvested, crushed and left in wooden containers to ferment, then it can be drunk directly (Menendez-Baceta et al. 2012).

Carbonisation

For the preservation of the fruit flesh in Maloideae fruits, contact with fire should not have been direct and the fruit must have lost great part of its water content. Apple halves exposed to sudden heat (in a stove at 190 °C for 24 h) shrank evenly by about 15 %, their skin remain smooth except at the margins, where it wrinkled, and the cut surface was smooth, plain or bulgy. Apple halves carbonised after drying (a week in a room at 20 °C temperature and then carbonised at 190 °C in a stove) collapsed slowly and irregularly, between 15 and 35 %, the cut surface was hollow and the skin wrinkled (Helbaek 1952a).

★ Summary

Maloideae fruits are typical Rosaceae (vid. p. 315) fleshy fruits and therefore not easily preserved by carbonisation, and at the same time likely to be processed by roasting (vid. Table 64). Vid. infra details for further taxa determined in this tribe.

- **Sorbus** L. sp.

Vernacular names: rowan, whitebeam, wild service tree

Nombres vernáculos: (planta) serbal, mostajo; (fruto) serba

Nomes vernáculos: sorveira, mostajeiro

Description of the macroremains

Four fruit halves and two detached seeds have been determined as *Sorbus* sp. (Figure 77). The fruit halves are globular and small, between 1 and 1.5 cm diameter, in whose core the locules in which the seeds still are or were placed are visible. The flesh is not homogeneous as in *Malus* but with cells
Part III A: Results: the identified taxa

forming rounded groups (Flora iberica 1986+). According to the appearance of the halves inner surface, the slicing is precarbonisation. In addition, three of the half *Sorbus* sp. fruits (the third is partially eroded does not allow a proper evaluation) have a smooth skin. The detached seeds originate from one of the halves.

Presence in the archaeological record

Remains of *Sorbus* fruits have been recovered at Arangas and El Toral III; other Mesolithic contexts in Northern Iberia have provided this type of remains (Zapata Peña 2000).

Ecological characteristics

*Sorbus* spp. are shrubs or trees that grown in open areas from forests (clearings and hedges), in humid soils and all types of strata but preferentially siliceous, up to 2300 m a.s.l. (*S. doméstica* up to 1700 m; *S. aucuparia* between 600 and 2300 m; *S. aria* up to 2200 m; *S. intermedia* between 1000 and 1800 m a.s.l.) (Flora iberica 1986+). The fruits have between 1 and 5 seeds and are rich in vitamins A and C.
Ethnographical information

Bromatological use

Sorbus spp. fruits are edible raw and have a bittersweet flavour; when cooked they can be used in preserves; they have a very pleasant taste when left to ferment and can be ground into a powder and mixed with cereal flour (Fern 1992-2010). The leaves and flowers from S. aucuparia are used as a tea substitute and the roasted seed as a coffee substitute, an oil is also obtained from them (Fern 1992-2010).

Cosmetic use

A cosmetic face-mask is made from the fruits of S. aucuparia and is used to combat wrinkled skin; a black dye is obtained from all parts of the plant which contain tannin, but particularly from the young branches (Fern 1992-2010).

Pharmaceutical use

Sorbus spp. fruits are astringent; S. aria have been used as expectorants, diuretic and laxative (Fern 1992-2010); S. aucuparia as anti-scurvy, although its excessive raw consumption can result toxic; its seeds turn toxic after contact with water, which in small doses stimulates the respiratory system but can lead to death if overdosing (Zapata Peña 2001).

Technological use

The wood from Sorbus aucuparia is hard, fine grained, compact and elastic, highly recommended to make hoops for barrels, cogs and furniture (Fern 1992-2010). The tannin-rich parts can also be used in treating leather.

On processing

Fermentation

Sorbus spp. can be left in a dry cool dark place and left to overmature to acquire a very pleasant sweet taste (Fern 1992-2010).
Storing

Dried Sorbus spp. fruits can be preserved for a whole year, either in underground storage systems, within liquids, or, in dry climates, hanging in strings in dry and well-ventilated places (Rivera Núñez & Obón de Castro 1991b).

★ Summary

Sorbus sp. fruits are typical Rosaceae (vid. p. 315) fleshy fruits and therefore not easily preserved by carbonisation, and at the same time likely to be processed by roasting (vid. Table 64).

- Potentilla sp.

Vernacular names: cinquefoil

Nombres vernáculos: cincoenrama, comaro

Nomes vernáculos: cinco-em-rama, comaro

Figure 78: Left: Potentilla erecta and Potentilla caulescens modern seeds. Right: charred specimen from Los Gitanos determined as Potentilla sp.

Description of the macroremain

Small drop-shaped, laterally flattened, seed with obtuse beak and prominent ventral scar, the surface is badly preserved and cannot be correctly assessed (Figure 78), determination has been ascertained to Potentilla sp. in the Rosoideae subfamily of Rosaceae.

Presence in the archaeological record

A seed from sublayer A1 of Los Gitanos has been determined as Potentilla sp.
Ecological characteristics

*Potentilla* spp. are perennial, more rarely annual or biannual, herbs or subshrubs, in which interspecific hybridisations are frequent; they grow in open areas and slightly disturbed, the fruit is composed of polyachenes; the achenes are sculptured when fully mature (Flora iberica 1986+).

Ethnographical information

Bromatological use

The leaves from many *Potentilla* spp. are edible raw to use in salads (Fern 1992-2010).

Pharmaceutical use

Several *Potentilla* spp. are rich in tannins and have been used as astringent and anti-diarrheic (Flora iberica 1986+).

Symbolical use

Many *Potentilla* spp. have been cultivated for their ornamental value (Flora iberica 1986+).

★ Summary

Potentilla sp. seeds have medium to high chances for being recovered in charred assemblages (Table 65). *Vid.* information about the family Rosaceae to which this taxon belongs (p. 315).

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Table 65: Recovery chances of *Potentilla* sp. seeds in the charred archaeobotanical record.

- *Prunus spinosa* L.

Vernacular names: (plant) blackthorn; (fruit) sloe

Nombres vernáculos: (planta) endrino; (fruto) endrina

Nomes vernáculos: (planta) abrunheiro; (fruto) abrunho
Part III A: Results; the identified taxa

Description of the macroremains

A fragment of woody fruit endocarp with a slight reticulate on the outer surface has allowed for the identification of this taxon (Figure 79).

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Presence in the archaeological record

In this work, Lapiás das Lameiras has provided plant remains determined as *P. spinosa*. These types of remains are relatively common in the archaeological record, in the Iberian Peninsula remains from this taxon have been determined at Palaeolithic Sta. Maira (Aura et al. 2005), Early Neolithic La Draga (Antolín & Buxó 2011) and other Chalcolithic sites (López-Dóriga et al. 2011; Stika et al. 2013).

---

Ecological characteristics

*Prunus spinosa* are shrubs 1 m high and 2.5 wide, most often thorny, which grow in shrublands and forest margins, in rocky slopes up to 1900 m a.s.l., nowadays not very abundant in the South of the Iberian Peninsula; their fruits are globose or ovoid drupes, and they contain a single seed with sclerified rugose endocarp, which in maturity can split in two by their keel (Flora iberica 1986+). *P. spinosa* berries ripen at the end of summer or autumn (Fern 1992-2010).

---

Ethnographical information

Bromatological use

Berries from *P. spinosa* are eaten raw or roasted, which reduces their astringency (Wiltshire 1995). They form the basis of a macerated alcoholic drink, *patxaran*, made by maceration in a distilled alcohol called anisette, and highly appreciated in central Northern Iberia (Cavero, Akerreta & Calvo 2011), although this seems to be a “tradition” of recent introduction (Menendez-Baceta et al. 2012), possibly from the UK where sloes are traditionally added to gin. The seeds are also edible raw or cooked, as well as the flowers, and the dried leaves are a substitute for tea (Fern 1992-2010).
Cosmetic use

The pulped ripe fruit is used cosmetically in making astringent face-masks; several dyes can be obtained from different plant parts: a green dye can be obtained from the leaves, a dark grey to green dye can be obtained from the fruit and the bark produces a yellow dye (Fern 1992-2010).

Pharmaceutical use

Macerated or decocted berries from *P. spinosa* produce alcoholic intoxication and reduce arterial pressure, being used to treat stomach-ache and as digestive (Cavero, Akerreta & Calvo 2011). The flowers, bark, leaves and fruits are aperient, astringent, depurative, diaphoretic, diuretic, febrifuge, laxative and stomachic; all members of the genus *Prunus* contain toxic substances (amygdalin and prunasin) which break down in water to form hydrocyanic acid and which in small amounts stimulate respiration, improve digestion and give a sense of well-being (Fern 1992-2010).

Technological use

The bark is a good source of tannin and it is used to make an ink; the wood is very hard, used for woodworking, the branches are highly valued for making walking sticks (Fern 1992-2010).

On processing

Procurement: gathering and cultivation

*P. spinosa* berries are predictable annual resources which can be gathered from wild but tended shrubs or can even be cultivated. Hedges of *P. spinosa* shrubs are appreciated for keeping animals out from horticultural gardens (Pardo de Santayana 2003).

★ Summary

Contrary to other Rosaceae fruits (*vid.* p. 315), *Prunus* is a genus with stony endocarps which surround the seed, making them highly likely to be recovered in charred archaeobotanical assemblages (*vid.* Table 66). Still, the possibility of endozoochory might be taken into account as an agent of introduction.

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Table 66: Recovery chances of *Prunus spinosa* fruits in the charred archaeobotanical record.
Part III A: Results: the identified taxa

- **Rosa** L. sp.

Vernacular names: rose
Nombres vernáculos: (planta) rosal; (fruto) escaramujo, tapaculo
Nomes vernáculos: (planta) roseira; (fruto) cinorrodo

**Description of the macroremains**

Two angular and heteromorphic seeds have been determined as *Rosa* sp. achenes (Figure 80).

![Figure 80: Left: modern seeds of Rosa gallica. Right: Different views of a charred seed from El Toral III determined as Rosa sp. Scale bar = 1 mm.](image)

**Presence in the archaeological record**

In this work, this taxon has been determined in Zone A of El Toral III. *Rosa* sp. remains are not as common as other Rosaceae fruit remains. In the Iberian Peninsula, several Late Palaeolithic and Mesolithic records exist at Sta. Maira cave (Aura *et al.* 2005). One Middle Neolithic record in Northern France (Dietsch 2007).

**Ecological characteristics**

*Rosa* spp. are shrubs, often provided with a stoloniferous rhizome, and creeping or erect stems, often with varying densities of heterogeneous-sized and shaped thorns (Flora iberica 1986+). *Rosa* spp. fruits are known as pometum because of their multiples achenes, each with a seed, surrounded by a swollen fleshy receptacle (Cappers & Bekker 2013). It is a very complex genus with many heteromorphic taxa, with abundant hybridisations and introgressions, which can grow in a variety of...
habitat and altitudes a.s.l. (Flora iberica 1986+). Flowers of *Rosa* spp., particularly *R. gallica*, are very rich in tannins (Flora iberica 1986+).

**Ethnographical information**

**Bromatological use**

*Rosa* spp. fruits are edible, raw or made into jam. Young shoots have been also eaten (San Miguel López 2004).

**Cosmetic use**

A decoction of the petals of *Rosa* spp. has traditionally been used to make perfume (Pinto Carvalho 2005), and essential oils, particularly from *R. damascena* and *R. gallica* (Flora iberica 1986+). Rose perfumes have been traded from at least Roman times between Rome and Egypt and several rose species have been cultivated for that purpose.

**Pharmaceutical use**

A collyrium made of the galls induced in *Rosa canina* acts as an ocular anti-inflammatory (Agelet & Vallès 2003) and anti-diarrhoeic (Pinto Carvalho 2005); flowers from many *Rosa* spp. are also used to treat maladies in the skin and eyes (Pinto Carvalho 2005; San Miguel López 2004) and gain weight (Flora iberica 1986+).

**Symbolical use**

*Rosa* spp. flowers have played an important symbolical role in European modern history, and they have been used in a variety of decorations (e.g. San Miguel López 2004).

**On processing**

**Perfume making**

*Rosa* spp. petals are distilled in water to obtain perfume.
Part III A: Results; the identified taxa

★ Summary

Dispersal strategy

Whilst for the whole fruits of *Rosa* the case would be quite different, the seeds have intermediate probabilities of being recovered at archaeological deposits in a charred state (*vid. Table 67*). *Vid. supra* for more information about the Rosaceae family (p. 315).

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Table 67: Recovery chances of *Rosa* sp. seeds in the charred archaeobotanical record.

Rubiaceae

- *Galium* L. sp. / *Asperula* L. sp.

Vernacular names: bedstraw

Nombres vernáculos: amor de hortelano / agarrones

Nomes vernáculos: amor-de-hortelão

![Figure 81: Left: modern seed in ventral and dorsal view from *Galium aparine*. Right: charred specimen from Lapiás das Lameiras determined as *Galium* sp. / *Asperula* sp. in ventral, lateral and dorsal views. Scale bar = 1 mm.](image)

Description of the macroremain

*Galium* sp./*Asperula* sp. seeds are rounded, with a flat side that has a relatively large aperture leading to the interior, the surface texture is finely corrugated (Figure 81). Fresh seeds usually have small hairs and spines which are not preserved in archaeological charred specimens. A contested distinction between the two genera is sometimes made based on size and shape, but the overlapping of these characters make the separation dubious.
Presence in the archaeological record

Lapiás das Lameiras is the site studied in this work where a seed has been determined as *Galium* sp./*Asperula* sp. Finds like these are relatively common in agricultural prehistorical sites, with the seeds often being interpreted as crop weeds.

Ecological characteristics

*Galium* and *Asperula* are relatively large genera in Rubiaceae, with about 650 taxa in Flora Europaea. The seeds ripen in summer (Fern 1992-2010). Rubiaceae are annual or perennial herbs most often with a dry schizocarp with one or two mericarps, or biachenes dehiscent or indehiscent (Flora iberica 1986+).

*Galium* spp. and *Asperula* spp. are perennial or annual herbs with odoriferous flowers which grown in forests, open shrublands and as weeds in cropfields (Flora iberica 1986+).

Dispersal strategy

The most characteristic trait of the Rubiaceae is their dispersal by exozoochory, attached to animal furs and human clothing by the stings in their achenes.

Ethnographical information

Bromatological use

*Galium* spp. seeds can be prepared into drinks or foodstuffs (Fritz 1989) and used as drink aromatisers (Flora iberica 1986+). It has been considered a diet-food, consumed with oats, to avoid obesity (Gerrarde *apud* Fernald & Kinsey 1958). Several species are also used in the preparation of cheese (Flora iberica 1986+).

Cosmetic use

Rubiaceae plants are sometimes gathered for their fragrance; some species are used to obtain dyes: *G. verum*, among others, provides a red dye from its roots (Fern 1992-2010; Flora iberica 1986+).

Pharmaceutical use

*Galium aparine* and other *Galium* species have been used medicinally for a variety of purposes (Moerman 1986): as a laxative, a dermatological aid, a diuretic, a love medicine, a kidney aid and a venereal aid.
Symbolical use

Some species of *Galium*, such as *G. odoratum*, have been cultivated for their ornamental value.

Technological use

Dry *Galium* plants have been appreciated for making bedding for domesticated animals and fire-starters (Fern 1992-2010).

On processing

Cooking

*Galium* spp. seeds can be parched or dried and slightly roasted, for use as a drink similar to coffee, or as a foodstuff (Fritz 1989).

★ Summary

*Galium/Asperula* seeds have relatively high chances for being recovered in charred assemblages of plant macroremains (*vid.* Table 68). Ectozoochory should be taken into account as a potential way of introduction in archaeological domestic contexts.

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Table 68: Recovery chances of *Galium* sp. / *Asperula* sp. seeds in the charred archaeobotanical record.

**Scrophulariaceae**

- *Linaria* Mill. sp.

  Vernacular names: toadflax
  Nombres vernáculos: gallito
  Nomes vernáculos: ansarina
Description of the macroremain

Round and flat seed, surrounded by a short and relatively thick wing, its aureolate-reticulate surface patterning (Figure 82) allows this seed to be distinguished from another of very similar shape, *Spergula morisonii*. Among the *Linaria* spp., it most resembles *L. supina*, although *L. alpina*, *arvensis*, *triornithophora* and *vulgaris* have proximate shapes. Although in current specimens the observation of the seed under high-power microscopy is an important taxonomical criterion (*Flora iberica* 1986+), the heteromorphology of the genus inhibits the determination of a single specimen.

Presence in the archaeological record

A *Linaria* sp. remain has been identified in Phase B of Poças de São Bento. Finds of this taxon are sparse in other contexts.

Ecological characteristics

*Linaria* is a large genus (more than 250 taxa in *Flora Europaea*) of very diverse plants, both in morphology and ecological habits. *Linaria* spp. plants, sometimes from a single species, have several varieties or subspecies that can be annual, biannual or perennial and do not show a clear correspondence with specific geographies or ecological preferences (*Flora iberica* 1986+). The fruit is an ovoid capsule with several seeds.

Dispersal strategy

The dispersal mode is autochory (*Paula & Pausas* 2009).

Ethnographical information

Bromatological use

The leaves of *Linaria vulgaris*, particularly the young shoots, are edible cooked (*Fern 1992-2010*).
Part III A: Results; the identified taxa

Cosmetic use

A yellow dye is obtained from the whole plant, particularly from the flowers, of *Linaria vulgaris* (Fern 1992-2010).

Pharmaceutical use

*Linaria vulgaris* has a long history of herbal use: it has been widely employed as a diuretic, antiphlogistic, astringent, cathartic, detergent, depurative, diuretic, hepatic, ophthalmic, laxative and purgative; it is employed internally in the treatment of oedema, cystitis, jaundice, liver diseases, gall bladder complaints and skin problems; externally it is applied to haemorrhoids, inflamed eyes, skin eruptions, sores and ulcers; however, it should be used with caution and should not be given to pregnant women, because dosage is critical, the plant might be slightly toxic (Fern 1992-2010). A tea made from the plant has been also used as an insecticide (Fern 1992-2010).

★ Summary

The recovery potential of *Linaria vulgaris* seeds in a charred state is intermediate (*vid.* Table 69).

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Table 69: Recovery chances of *Linaria vulgaris* seeds in the charred archaeobotanical record.

Solanaceae

* cf. *Atropa bella-donna* L.

Vernacular names: deadly nightshade

Nombres vernáculos: belladona

Nomes vernáculos: beladona
Description of the macroremain

The seed had a reniform shape, with thinner apical sides (Figure 83). The embryo and hilum were not preserved. It had a partially preserved conspicuous reticulate surface sculpture, of irregular but mostly quadrangular and pentagonal very small unaligned cells. Its general morphology approaches the Papaveraceae family, whilst the surface sculpture the Solanaceae. Because of the extremely fragile state of preservation, the seed disintegrated into powder upon examination, shortly after taking the first two pictures. *Atropa bella-donna* L. seeds are extremely variable in shape, some of them resemble this specimen.

Presence in the archaeological record

A probable seed from *Atropa bella-donna* has been found at São Pedro de Canaferrim. Finds of this taxon in the archaeobotanical record are sparse.

Ecological characteristics

*Atropa bella-donna* is a perennial but short-lived plant 90 cm tall by 80 cm wide with black juicy spherical berries with a high number of seeds which ripen from summer to autumn (Cappers & Bekker 2013). The fruit has 13-18 mm diameter and the seeds 1.5-2 × 1.3-1.8 mm (Flora iberica 1986+). Its potential habitats are woodlands, sunny or shady hedges, hedgerows and disturbed areas; it succeeds in any well-drained moisture retentive soil, in sun or partial shade, but prefers calcareous soils, between 400 and 2000 m a.s.l. in the Iberian Peninsula (Flora iberica 1986+), but it is not present in Sintra mountain chain (Pinto da Silva 1989).

As the English common name points out, it is a very poisonous plant, especially the root: all parts of the plant contain tropane alkaloids (the leaves contain on average 0.4 % active alkaloids, whilst the root contains around 0.6 %); the alkaloid content varies according to the development of the plant, being low when the plant is flowering and very high when bearing green berries; when grown as a medicinal plant, the highest levels of the medically active alkaloids are obtained from light, permeable soils, sunny positions and hot summers (Fern 1992-2010).
Part III A: Results: the identified taxa

Dispersal strategy

Dispersed by endozoochory (Kay 2008) by birds (Torroba Valmori 2013), as they are avoided by frugivorous mammals because of the toxins contained (Debussche & Isenmann 1989).

Ethnographical information

Pharmaceutical use

Although it is poisonous, *A. bella-donna* has a long history of medicinal use (as analgesic, antidote, antispasmodic, diuretic, hallucinogenic, mydriatic, narcotic and sedative) and has a wide range of applications (Fern 1992-2010): to dilate the pupils, to relieve intestinal colic, to treat peptic ulcers, to reduce tremors and rigidity whilst improving speech and mobility in Parkinson’s disease, as an antidote in cases of mushroom poisoning, in cases where localised and painful inflammation radiates heat, sunstroke and painful menstruation. This species has also been found to be effective in detoxifying soils, particularly when infected with the bacterial parasite *Agrobacterium tumefaciens* (Fern 1992-2010).

On processing

Procurement: cultivation and gathering

*Atropa bella-donna* is widely cultivated for the medically active compounds it contains (Fern 1992-2010). The roots are harvested in the autumn and can be 1-3 years old, the older roots are very large and difficult to dig up. The leaves are harvested in late spring and dried for later use. The entire plant is harvested when coming into flower (Fern 1992-2010).

★ Summary

Seeds of *Atropa bella-donna* have intermediate chances of being recovered in charred assemblages (Table 70).

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Table 70: Recovery chances of *Atropa bella-donna* seeds in the charred archaeobotanical record.

- *Solanum cf. nigrum* L.

Vernacular names: black nightshade
Nombres vernáculos: tomatito de moro, hierba mora

Nomes vernáculos: erva-moira

Description of the macroremain

A small almost ovoid and flat seed has been identified as *Solanum cf. nigrum* on the basis of the surface sculpture, with small unaligned irregular cells (Figure 84). *Solanum* seeds are generally heteromorphic and determinations to species level on the basis of a single specimen are difficult.

Figure 84: Left: Modern seed of *Solanum nigrum*. Right: charred seed from São Pedro de Canaferrim determined as *Solanum cf. nigrum*. Scale bar = 1 mm.

Presence in the archaeological record

A *Solanum nigrum* seed has been tentatively identified at São Pedro de Canaferrim; remains from this taxon are sparse in the Iberian Peninsula (Antolín et al. 2012) and assumed to have not been intentionally gathered (Antolín & Jacomet 2015), but fairly common among the weeds of Early Neolithic of Central Europe (Bogaard 2004).

Ecological characteristics

*Solanum nigrum* L. and related species are worldwide annual herbaceous plants, but predominantly Eurasian, in moderately light and warm situations, from sea level up to 1200 m a.s.l. (*Flora ibérica* 1986+) very abundant in the Sintra mountain chain (Pinto da Silva 1989). It grows between 30 and 80 cm high, requires moisture (from rainfall or irrigation) and is susceptible to frost. They are often weeds of arable lands and gardens, also appearing in nitrogen-rich soils of disturbed habitats, such as rubbish tips, roadsides, hedgerows, around houses, under trees, on forest and grassland margins, riverbanks and gullies. It is a highly variable species with numerous subspecies or varieties: it is an annual herb with woody stem in the base, up to 80 cm tall by 30 cm wide, with juicy berries in a range of varying colours from green through purple to black (Edmonds & Chweya 1997) and with a high number of seeds (Cappers & Bekker 2013) which ripen from summer to autumn (Fern 1992-2010).

The leaves of *S. nigrum* provide appreciable amounts of protein and amino acids, minerals (calcium, iron and phosphorus), vitamins (A and C), fat and fibre; berries yield high mounts of iron, calcium and
Part III A: Results: the identified taxa

vitamins B and C and carotene; seeds contain vitamin C and carotene. These nutrient values vary with soil fertility, plant variety, age of the plant and cooking procedure. However, if not prepared conveniently or consumed whole, the toxins (solasonine) present in some plant parts at different stages of its growth can cause health problems in humans and other animals, and eventually cause death (Edmonds & Chweya 1997).

Dispersal strategy

Its dispersal mode is endozoochory (Paula & Pausas 2009)

Ethnographical information

Bromatological use

Leaves and shoots of *S. nigrum*, conveniently prepared, are widely used as leafy herbs and vegetables, and their berries as fruits (Edmonds & Chweya 1997; Tardío et al. 2006). Related species are used as fodder, animal forage composed of or contaminated with *S. nigrum*, transforms the toxin content, that could otherwise affect the animals, when ensiled (Edmonds & Chweya 1997).

Pharmaceutical use

*Solanum nigrum* L. and related species have been and still are widely used for various medicinal purposes since Dioscorides. “The generic name *Solanum* is generally considered to be derived from the Latin *solamen*, and to refer to the quieting or sedative effects associated with many of the species”. It has been used, either externally (by the application of fresh leaves) or internally (via the ingestion of juices from the berries or infusions from the leaves and roots), as a remedy for convulsions and as a soporific, to cool fever and hot inflammations, such as those of inflamed throats, ears and eyes, epidermal fungi, ulcers and gout. Leaves might be also used as a detoxicant drug, as in opium poisoning. Dried aerial parts of the plant are used as a diuretic, antihypertensive, antibiotic, purgative, sedative, narcotic and antineuralgic (Flora iberica 1986+; Edmonds & Chweya 1997; Fern 1992-2010).

Extracts from these plants might also be of use in mollusc control (Edmonds & Chweya 1997), whilst the plants seem to be effective in detoxifying the soil, particularly when it is infected with the bacterial parasite *Agrobacterium tumefaciens* (Fern 1992-2010).

On processing

Procurement: cultivation and gathering

Plants of *S. nigrum* might be cultivated, despite their ubiquity: their propagation is from seeds, which are extracted from the berries by the application of pressure, dried and stored until sowing in
spring. Properly stored seeds can remain viable for years and germinate from a few days after sowing if temperatures above 15 °C and moisture are ensured. (Edmonds & Chweya 1997)

Detoxification

Leaching with water or milk and boiling, but not drying, removes the toxins from the vegetative parts of *S. nigrum* (Edmonds & Chweya 1997).

Cooking

*Solanum nigrum* leaves and young shoots are boiled or stewed and used as a condiment, in soups and sauces (Edmonds & Chweya 1997). Berries might be eaten raw when ripe, but also used in cakes, preserves and jam (Edmonds & Chweya 1997).

Taphonomical proxies

Non-anthropic marks

Ripe berries of *S. nigrum*, which fall from the plant when mature and only occasionally remain on them, are succulent and attractive to a variety of birds and animals, such as rodents, lizards, rabbits and cattle. Seeds are effectively dispersed by them, as they pass undamaged through the digestive tracts (Edmonds & Chweya 1997). Fruits of *S. nigrum* are avoided by frugivorous mammals because of the toxins contained, but preferred by birds (Debussche & Isenmann 1989).

★ Summary

Seeds of *Solanum nigrum* have intermediate chances of being recovered in charred assemblages (*vid.* Table 71).

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Table 71: Recovery chances of *Solanum nigrum* seeds in the charred archaeobotanical record.

- Umbelliferae (Apiaceae)

Vernacular names: umbellifers, the carrot or parsley family

Nombres vernáculos: umbelíferas
Description of the macroremains

The fruit of umbellifers is a schizocarp, a 2-seeded fruit that splits into two 1-seeded, usually elongated, mericarps; heterocarpy and seed dimorphism is frequent in the family (Cappers & Bekker 2013).

A small schizocarp with the typical apex, ventral side convex with two valves and dorsal side with 6 distinct but not very prominent vitae (Figure 85), has allowed determination as Umbelliferae. The strongest similarity upon comparison with the reference collection and a specific atlas is with some *Pimpinella* spp. and *Apium* spp. (Arenas-Posada & García-Martín 1993).

A possible umbel elongated schizocarp, with two distinct elongated seeds within, has been potentially identified in transversal section within a piece of pottery. Due to the circumstances of the find, morphological determination to a further level is impossible.

Presence in the archaeological record

Both a seed (sublayer A1) and a seed impression have been recovered in Los Gitanos (thin-section slide from pottery vessel from layer A4). Several species from this family appear in central European sites from the Neolithic onwards; some might have been exploited from the wild [*carrot* (*Daucus carota* L.), *celery* (*Apium graveolens* L.), etc.] whilst others originally come from the Mediterranean region and might have been garden-grown or imported [*dill* (*Anethum graveolens* L.), parsley (*Petroselinum crispum* (Mill.) *A.W.Hill*); others locally available (e.g. parsnip, *Pastinaca sativa* L.) might have been exploited as well (Zohary, Hopf & Weiss 2012).
Inés L. López-Dóriga

Ecological characteristics

Umbelliferae is one of the widest families of plant species, of about 1500 taxa in Flora Europaea (Tutin et al. 1964-2001). They are annual, biennial or perennial herbs, subshrubs or even shrubs (Flora iberica 1986+). Some important species are *Daucus carota*, *Apium graveolens* and *Pastinaca sativa*. *D. carota* has annual and biannual forms. Wild forms of carotene-coloured roots extend over most temperate Europe and hybridise with domesticated forms (Zohary, Hopf & Weiss 2012). *Apium graveolens* thrive in marshy places in most Europe (Zohary, Hopf & Weiss 2012). *Pastinaca sativa* has biennial wild forms in temperate Europe (Zohary, Hopf & Weiss 2012).

Dispersal strategy

Many species in this family have spiny hairs for epizoochory and other are winded for anemochory (Paula & Pausas 2009).

Ethnographical information

Bromatological use

In Roman times, *D. carota* was used as food and medicine, the garden-grown forms being tastier than the wild ones but less potent medicinally (Zohary, Hopf & Weiss 2012). *A. graveolens* L. was exploited in Roman times for its leaves and roots, with medicinal use (Zohary, Hopf & Weiss 2012). *P. sativa* was used in Roman times for its root, cooked or for animal fodder (Zohary, Hopf & Weiss 2012).

Pharmaceutical use

Many species in the Umbelliferae family have been used as medicines in folk traditions (Fern 1992-2010).

★ Summary

Recovery probabilities for charred Umbelliferae schizocarps are intermediate (*vid*. Table 72).

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Table 72: Recovery chances of Umbelliferae schizocarps in the charred archaeobotanical record.
Ulmaceae

-cf. *Celtis australis* L.

Vernacular names: nettle tree
Nombres vernáculos: almez, latonero
Nomes vernáculos: agreira, lóðao

**Description of the macroremains**

Several fruit endocarp fragments, relatively thin (0.5 mm) and curved, with smooth inner surface and rough outer surface (Figure 86), have been determined as cf. *C. australis*, after excluding all other possible taxa for the region. Determination among *Celtis* spp. is inconsistently treated in the literature (Matsutani 1987; Messager et al. 2008; Simchoni & Kislev 2011; Zarafshar, Akbarinia & Sattarian 2010), but *C. australis* is the only species currently existing in the Iberian Peninsula (Flora iberica 1986+). For quantification, the number of nutshell fragments has been divided by 8.

![Figure 86: Left: modern endocarp fragments of a *Celtis australis* fruit. Right: ventral and dorsal view of two charred endocarp fragments determined as cf. *Celtis australis* from Poças de São Bento. Scale bar = 1 mm.](image-url)
Presence in the archaeological record

Plant macroremains determined as *C. australis* have been determined in Phase C of Poças de São Bento. Finds of this taxon are scarce in the Iberian Peninsula and limited to the Pleistocene layers of El Niño cave in Albacete (García Moreno *et al.* 2014) and Gran Dolina, Atapuerca, in Burgos (Allué *et al.* 2015), preserved by mineralisation. A few other remains are known from other parts of the Mediterranean (Messager *et al.* 2008; Simchoni & Kislev 2011).

Ecological characteristics

*Celtis australis* is a circum-Mediterranean taxon that can penetrate into more humid interior regions (Simchoni y Kislev 2011). They are deciduous small trees or shrubs, growing isolated or in small groups, without forming forests. They usually grow in rocky environments (ravines, cracks in rocks, etc.), over fresh, light and stony soils, between 200-1200 m (Flora iberica 1986+). The fruits ripen in autumn (Fern 1992-2010).

Dispersal strategy

The endocarps from *Celtis australis* might be dispersed by frugivorous animals (Debussche & Isenmann 1989).

Ethnographical information

Bromatological use

*Celtis australis* drupes are sweet and edible but the stone occupies most of the volume of the fruit, and can be eaten raw or made into licorice (Renfrew 1973; Tardío *et al.* 2006); the seeds are also edible raw or cooked, and the oil can be extracted for culinary use (Fern 1992-2010). The leaves are also edible (Hanelt 2001).

Cosmetic use

A yellow dye can be obtained from the bark of *C. australis* (Fern 1992-2010).

Pharmaceutical use

Dry leaves and the half-mature fruit of *C. australis*, or a decoction of both, have several medicinal properties (Fern 1992-2010; Hanelt 2001).
Part III A: Results: the identified taxa

Technological use

The wood is very appreciated due to its elasticity and durability, in multiple technological uses (Flora iberica 1986+; Simchoni & Kislev 2011).

★ Summary

On account of its woody endocarp and the ways in which the fruit might be processed, *Celtis australis* is a likely taxon to be recovered at archaeological sites with charred preservation for plant macroremains (*vid. Table 73*). However, endozoochory as a dispersal agent should be also considered.

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Table 73: Recovery chances of *Celtis australis* endocarps in the charred archaeobotanical record.

**Urticaceae**

- *Urtica* L. sp. (*U. dioica* L. / *U. membranacea* Poir in Lam. / *U. urens* L.)

**Vernacular names:** nettle

Nombres vernáculos: ortiga

Nomes vernáculos: urtiga

**Description of the macroremains**

Two small seeds of ovoid-flatenned shape, with lustrous smooth surface and lateral ridges and eroded apical part have been determined as *Urtica* sp. One of them broke up upon examination.

**Presence in the archaeological record**

An achene of *Urtica* sp. and another of cf. *Urtica* sp. have been recovered at El Mazo.

**Ecological characteristics**

*Urtica* spp. are annual or perennial herbs with stinging hairs in their leaves and stems, usually growing in nitrogen-rich soils such as fallow fields, wetlands and roadsides in humid areas. The seeds are dispersed by the wind and ripen between summer and autumn (Fern 1992-2010). According to its
current distribution, only *U. dioica, U. membranacea* and *U. urens* would grow in the Cantabrian region. *U. dioica* is a perennial herb, with slightly woody base, which grows in coastal wetlands and disturbed areas between 100 and 2500 m s.a.l. *U. urens* is an annual herb, about 10 cm wide by 80 cm high, which grows in disturbed habitats up to 1500 m a.s.l. (Flora iberica 1986+). *U. membranacea* will be described later (p. 343).

**Dispersal strategy**

Dispersal is usually by anemochory (Paula & Pausas 2009).

**Ethnographical information**

**Bromatological use**

Despite their stinging hairs, *Urtica* spp. plants might be used as food, for humans and other animals. *Urtica* spp. plants should be cut and left untouched a few days to let them lose their stinging qualities, they can then be given to sheep as green fodder (pers. comm.). *Urtica* spp. seeds are rich in oils.

Boiled leaves of *Urtica* spp., particularly *U. membranacea*, are used as a soup ingredient in some regions (Flora iberica 1986+). The aerial parts of *U. dioica* are eaten raw in salads, they can also be boiled and prepared as omelettes (Menendez-Baceta et al. 2012).

**Pharmaceutical use**

*Urtica* spp. plants, particularly *U. dioica*, are widely reported in traditional ethnobotanical compilations as having very diverse medicinal uses (Flora iberica 1986+). A plaster or decoction of leaves and roots of *Urtica dioica/membranacea* have traditionally been used to treat cholesterol, diabetes, hypertension, alopecia, dermatological and urinary maladies (Pinto Carvalho 2005).

**Technological use**

*Urtica* spp. fibres, both *U. dioica* and *U. membranacea* (Pinto Carvalho 2005), are valuable for textile weaving, providing a texture similar to that of silk. Cloths made of nettle fibres (usually *U. dioica*) are sometimes preserved in archaeological sites with exceptional preservation. It is now thought that the importance of nettle fibre exploitation has traditionally been underestimated due to the difficulties involved in identifying fibres from flax, hemp and nettle (Bergfjord et al. 2012).
On processing

Cooking

Boiling removes the stinging qualities of *Urtica* spp. leaves.

Fibre extraction

The extraction of fibre from *Urtica* spp. for weaving can follow the same procedure as that well-known for flax (*Linum usitatissimum*) (Pinto Carvalho 2005).

★ Summary

*Urtica* seeds have few probabilities of being recovered at charred assemblages in archaeological deposits (*vid.* Table 74). More information about *Urtica membranacea* is provided *infra*.

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Table 74: Recovery chances of *Urtica* sp. seeds in the charred archaeobotanical record.

- *Urtica membranacea* Poir. in Lam.

**Vernacular names:** membranous nettle

**Nombres vernáculos:** ortiga

**Nomes vernáculos:** urtiga-de-caudas

Figure 87: Left: modern achene of *Urtica membranacea*. Right: several views of a charred specimen from Poças de São Bento determined as *Urtica membranacea*. Scale bar = 1 mm.
Description of the macroremain

Small broad ovoid achene (containing a seed), cordate or stylised heart-shaped; in lateral view, it is biconvex flat, it has a mucronate apex, a flat base with papillate pointy hilum, lateral ridges and a lustrous colliculate surface (Figure 87). The base and hilum is clearly different from that of *U. dioica*, which is frequently identified at archaeological sites. *U. dubia* (*U. caudata*) is too flat, *U. pilulifera* too big and *U. urens* has a different surface sculpture and is too big.

Presence in the archaeological record

An achene determined as *Urtica membranacea* has been recovered in Phase B of Poças de São Bento.

Ecological characteristics

*Urtica membranacea* thrives in the maritime regions of the Iberian Peninsula, preferring shady, nutrient-rich and wet areas, up to 1000 m a.s.l. It is an annual herb, now ruderal that grows on fallow fields and roadsides (Flora iberica 1986+).

Dispersal strategy

Dispersal is usually by anemochory (Paula & Pausas 2009).

★ Summary

This taxon has few probabilities of being found in archaeological deposits (*vid.* general information for the genus *Urtica*, p. 341).

Violaceae

- *tp. Viola L. sp.*

*Vernacular names:* wild pansy

*Nombres vernáculos:* violeta, amor perfecto, pensamiento silvestre

*Nomes vernáculos:* violeta, amor perfeito bravo
Part III A: Results: the identified taxa

Description of the macroremains

Several similar charred items in groups of 2 or 3, drop shaped, with obtuse apex and slightly prominent ridges parting from the apex to 1/3 of the lateral sides, smooth surface all around (Figure 88) have been tentatively determined as tp. Viola sp..

Presence in the archaeological record

Plant remains tentatively identified as Viola sp. have been recovered at Phase B of Poças de São Bento and La Vaquera (López García et al. 2003). Seeds from this genus have also been recovered at the gut contents of some European bog bodies (Helbaek 1960).

Ecological characteristics

Viola spp. are annual or perennial herbs, sometimes subshrubs, which grow in humid areas; the fruits from Violaceae are usually capsules (Flora iberica 1986+). When a weed in agricultural fields, V. tricolor matures after the gathering of the crop. The seeds ripen in spring (Flora iberica 1986+).

Dispersal strategy

They are dispersed by myrmecochory (Paula & Pausas 2009).

Ethnographical information

Bromatological use

The leaves and flowers from several Viola spp. are edible raw or cooked (Fern 1992-2010).

Cosmetic use

The essence from Viola spp. plants is used in perfume making (Flora iberica 1986+).
Pharmaceutical use

*Viola* spp. plants have been intensively used for medicinal purposes, particularly *V. odorata* and *V. arvensis* (Flora iberica 1986+). A medicinal preparation of boiled or toasted flowers from *Viola* spp. plants is used to treat coughs and sore throats; *V. riviniana* is used for headaches (San Miguel López 2004).

Technological use

The whole plant of *V. alba* is used for making hats (San Miguel López 2004).

On processing

**Procurement: cultivation and gathering**

*Viola* spp. plants are often transplanted from the wild into domestic gardens (San Miguel López 2004).

Taphonomical proxies

**Non-anthropic marks**

Buried hoards of seeds from *Viola* sp., probably consumed by ants, are split and the endosperm is absent (pers. obs.).

★ Summary

*Viola* sp. have low to medium probabilities of being recovered in the charred record on account of their seed structure and their uses (*vid*. Table 60).

<table>
<thead>
<tr>
<th>Preservational / Ethnobotanical</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
<td>✓</td>
<td></td>
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<tr>
<td>Medium</td>
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<tr>
<td>High</td>
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</tbody>
</table>

Table 75: Recovery chances of *Viola* sp. seeds in the charred archaeobotanical record.
Summary

More than 12150 determined plant remains, belonging to 67 taxa, have been studied in this thesis. Most of the taxa identified are summer germinating species, with multiple potential uses according to the ethnographical information available for them (vid. Table 76) and have high chances of being preserved in archaeological deposits with charred preservation for plant macroremains (vid. Figure 89).
<table>
<thead>
<tr>
<th>Taxa</th>
<th>Region</th>
<th>Ecological characterisation</th>
<th>Weediness</th>
<th>Potential uses for each plant part</th>
<th>Chances for recovery in charred assemblages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Habitat</td>
<td>Life cycle</td>
<td>Fruit ripening</td>
<td>Photosynthes is</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dispersal mode</td>
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<tr>
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<td></td>
<td>Potential weed</td>
</tr>
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<td>Height (as a weed)</td>
</tr>
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<td></td>
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<td></td>
<td>Bromatological ecological</td>
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<td></td>
<td></td>
<td></td>
<td>Cosmetical</td>
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<td>Pharmaceutic</td>
</tr>
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<td>Symbolical</td>
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<td>Technological</td>
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<td>Ethnobotanical</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Preservational</td>
</tr>
<tr>
<td>Pinus pinea</td>
<td>Portugal</td>
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<td>Evergreen perennial</td>
<td>Spring-Summer</td>
<td>C_3</td>
</tr>
<tr>
<td>Gramineae (Poaceae)</td>
<td>Cantabrian, Portugal</td>
<td>Grassland Annual-Biennial-Perennial</td>
<td>Summer</td>
<td>C_3, C_4</td>
<td>Autochory-Anemochory</td>
</tr>
<tr>
<td>Avena sp. (fatua/sativa/sterilis)</td>
<td>Cantabrian, Portugal</td>
<td>Grassland Annual</td>
<td>Summer</td>
<td>C_3</td>
<td>Anemochory</td>
</tr>
<tr>
<td>Lolium sp. (perenee/multiflorum/rigidum)</td>
<td>Portugal</td>
<td>Grassland Annual-Perennial</td>
<td>Summer</td>
<td>C_3</td>
<td>Anemochory</td>
</tr>
<tr>
<td>Triticeae</td>
<td>Portugal</td>
<td>Cropfield</td>
<td>Annual</td>
<td>Summer</td>
<td>C_3</td>
</tr>
<tr>
<td>Hordeum vulgare</td>
<td>Cantabrian, Portugal</td>
<td>Cropfield</td>
<td>Annual</td>
<td>Summer</td>
<td>C_3</td>
</tr>
<tr>
<td>Triticeae</td>
<td>Cantabrian, Portugal</td>
<td>Cropfield</td>
<td>Annual</td>
<td>Summer</td>
<td>C_3</td>
</tr>
<tr>
<td>Triticeum “nudum”</td>
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<td>Summer</td>
<td>C_3</td>
</tr>
<tr>
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<td>Annual</td>
<td>Summer</td>
<td>C_3</td>
</tr>
<tr>
<td>Triticeum “vestitum”</td>
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<td>Annual</td>
<td>Summer</td>
<td>C_3</td>
</tr>
<tr>
<td>Triticeum dicoccum</td>
<td>Portugal</td>
<td>Cropfield</td>
<td>Annual</td>
<td>Summer</td>
<td>C_3</td>
</tr>
<tr>
<td>Triticeum monococcum</td>
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<td>Cropfield</td>
<td>Annual</td>
<td>Summer</td>
<td>C_3</td>
</tr>
<tr>
<td>Chamaerops humilis</td>
<td>Portugal</td>
<td>Shrubland</td>
<td>Evergreen perennial</td>
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<td>C_3</td>
</tr>
<tr>
<td>Pistacia lentiscum</td>
<td>Portugal</td>
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<td>Evergreen perennial</td>
<td>Autumn</td>
<td>C_3</td>
</tr>
<tr>
<td>Corylus avellana</td>
<td>Cantabrian</td>
<td>Open forest</td>
<td>Deciduous perennial</td>
<td>Autumn</td>
<td>C_3</td>
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<tr>
<td>Echium sp.</td>
<td>Portugal</td>
<td>Grassland  Annual-</td>
<td>Summer-</td>
<td>C_3</td>
<td>Autochory (Barochory)</td>
</tr>
<tr>
<td>Taxa</td>
<td>Region</td>
<td>Ecological characterisation</td>
<td>Fruit ripening</td>
<td>Photosynthes is</td>
<td>Dispersal mode</td>
</tr>
<tr>
<td>----------------------------</td>
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</tr>
<tr>
<td></td>
<td>Habitat</td>
<td>Life cycle</td>
<td></td>
<td>Dispersal</td>
<td>Height (as a weed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mode</td>
<td></td>
</tr>
<tr>
<td><em>Chenopodium sp.</em></td>
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<td>Annual-Perennial</td>
<td>Summer-Autumn</td>
<td>C₃</td>
<td>Autochory</td>
</tr>
<tr>
<td><em>Chenopodium album</em></td>
<td>Portuguese</td>
<td>Annual-Perennial</td>
<td>Summer-Autumn</td>
<td>C₃</td>
<td>Autochory</td>
</tr>
<tr>
<td><em>Salsola sp.</em></td>
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<td>Summer-Autumn</td>
<td>C₄</td>
<td>Autochory</td>
</tr>
<tr>
<td><em>Compositae (Asteraceae)</em></td>
<td>Portuguese</td>
<td>Annual-Perennial</td>
<td>Summer</td>
<td>C₃-C₄-CAM</td>
<td>Anemochory-Autochory</td>
</tr>
<tr>
<td><em>Senecio aquaticus</em></td>
<td>Cantabrian</td>
<td>Annual-Biennial-Perennial</td>
<td>Summer</td>
<td>CAM</td>
<td>Anemochory-Autochory</td>
</tr>
<tr>
<td><em>Carduaceae / Cynareae</em></td>
<td>Cantabrian</td>
<td>Annual-Biennial-Perennial</td>
<td>Summer</td>
<td>C₃</td>
<td>Anemochory-Autochory</td>
</tr>
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<td><em>Cruciferae (Brassicaceae)</em></td>
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<td>Annual-Biennial-Perennial</td>
<td>Spring-Summer</td>
<td>C₃</td>
<td>Autochory</td>
</tr>
<tr>
<td><em>Brassica sp. / Sinapis sp.</em></td>
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<td>Spring-Summer</td>
<td>C₃</td>
<td>Autochory</td>
</tr>
<tr>
<td><em>Corema album</em></td>
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<td>Evergreen perennial</td>
<td>Spring-Summer-Autumn</td>
<td>C₃</td>
<td>Endozoochory</td>
</tr>
<tr>
<td><em>Ericaceae</em></td>
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<td>Shrubland</td>
<td>Summer</td>
<td>C₃</td>
<td>Autochory-Autochory</td>
</tr>
<tr>
<td><em>Arbutus unedo</em></td>
<td>Cantabrian</td>
<td>Rocky areas</td>
<td>Evergreen perennial</td>
<td>Autumn</td>
<td>Endozoochory</td>
</tr>
<tr>
<td><em>Erica sp.</em></td>
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<td>Shrubland</td>
<td>Evergreen perennial</td>
<td>C₃</td>
<td>Autochory</td>
</tr>
<tr>
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<td>Temperate forest</td>
<td>Autumn</td>
<td>C₃</td>
<td>Autochory-Zoochory</td>
</tr>
<tr>
<td>Taxa</td>
<td>Region</td>
<td>Ecological characterisation</td>
<td>Weediness</td>
<td>Potential uses for each plant part</td>
<td>Chances for recovery in charred assemblages</td>
</tr>
<tr>
<td>------------------------------</td>
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</tr>
<tr>
<td></td>
<td>Habitat Life cycle</td>
<td>Fruit ripening Photosynthes is Dispersal mode</td>
<td>Potential weed Height (as a weed) Bromatological Cosmet ic Pharmaceuticals Symbol ical Technological Ethnobotanical Preservational</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geranium sp.</td>
<td>Portugal</td>
<td>Nitroph ilous Annual-Biennial-Perennial</td>
<td>Summer-Winter C₃</td>
<td>Autochory</td>
<td>Yes - Yes - Yes - -</td>
</tr>
<tr>
<td>Coronilla sp. / Galega sp.</td>
<td>Portugal</td>
<td>Annual-Perennial</td>
<td>Summer C₃</td>
<td>Anemochory-Zoochory</td>
<td>Yes &gt; 50 cm Yes Yes Yes - -</td>
</tr>
<tr>
<td>Genista sp. / Lotus sp.</td>
<td>Portugal</td>
<td>Rocky areas Annual-Perennial</td>
<td>Summer C₃</td>
<td>Autochory</td>
<td>- - Yes - Yes - Yes</td>
</tr>
<tr>
<td>Medicago sp. / Melilotus sp. / Trifolium sp.</td>
<td>Portugal</td>
<td>Annual-Perennial</td>
<td>Summer C₃</td>
<td>Zoochory</td>
<td>Yes - Yes</td>
</tr>
<tr>
<td>Fabae</td>
<td>Portugal</td>
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<td>Summer C₃</td>
<td>Autochory-Cultivation</td>
<td>- - Yes</td>
</tr>
<tr>
<td>Lathyrus sp.</td>
<td>Portugal</td>
<td>Annual-Perennial</td>
<td>Summer C₃</td>
<td>Autochory-Cultivation</td>
<td>Yes &gt; 50 cm Yes - Yes Yes -</td>
</tr>
<tr>
<td>Lathyrus cicer/a sativus</td>
<td>Portugal</td>
<td>Annual-Perennial</td>
<td>Summer C₃</td>
<td>Autochory-Cultivation</td>
<td>Yes &gt; 50 cm Yes - Yes - -</td>
</tr>
<tr>
<td>Lens culinaris</td>
<td>Portugal</td>
<td>Rocky areas Annual-Perennial</td>
<td>Summer C₃</td>
<td>Cultivation</td>
<td>- - Yes - Yes - -</td>
</tr>
<tr>
<td>Paeonia sativum</td>
<td>Portugal</td>
<td>Annual-Perennial</td>
<td>Summer C₃</td>
<td>Cultivation</td>
<td>- - Yes - - - -</td>
</tr>
<tr>
<td>Vicia sp.</td>
<td>Portugal</td>
<td>Annual-Perennial</td>
<td>Summer C₃</td>
<td>Autochory-Cultivation</td>
<td>Yes - Yes Yes Yes Yes -</td>
</tr>
<tr>
<td>Vicia cracca</td>
<td>Portugal</td>
<td>Annual-Perennial</td>
<td>Summer C₃</td>
<td>Autochory-Cultivation</td>
<td>Yes &lt; 50 cm Yes - - - -</td>
</tr>
<tr>
<td>Vicia ervilia</td>
<td>Portugal</td>
<td>Annual-Perennial</td>
<td>Summer C₃</td>
<td>Cultivation</td>
<td>Yes &lt; 50 cm Yes - Yes - -</td>
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<tr>
<td>Vicia faba var. minor</td>
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<td>Summer C₃</td>
<td>Cultivation</td>
<td>- - Yes - Yes - -</td>
</tr>
<tr>
<td>Vicia sativa</td>
<td>Portugal</td>
<td>Annual-Perennial</td>
<td>Summer C₃</td>
<td>Cultivation</td>
<td>Yes &gt; 50 cm Yes - - - -</td>
</tr>
<tr>
<td>Malvaecae</td>
<td>Portugal</td>
<td>Nitroph ilous Annual-Biennial-Perennial</td>
<td>Summer C₃</td>
<td>Autochory (Zoochory)</td>
<td>Yes &gt; 50 cm Yes Yes Yes Yes Yes</td>
</tr>
<tr>
<td>Lavatera sp.</td>
<td>Portugal</td>
<td>Nitroph ilous Annual-Biennial-Perennial</td>
<td>Summer C₃</td>
<td>Autochory (Zoochory)</td>
<td>Yes &gt; 50 cm Yes - Yes Yes -</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Taxa</th>
<th>Region</th>
<th>Ecological characterisation</th>
<th>Weediness</th>
<th>Potential uses for each plant part</th>
<th>Chances for recovery in charred assemblages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Habitat</td>
<td>Life cycle</td>
<td>Fruit ripening</td>
<td>Photosynthes is</td>
<td>Dispersal mode</td>
</tr>
<tr>
<td>Malva sp.</td>
<td>Portugal</td>
<td>Nitrophilous Annual-</td>
<td>Summer</td>
<td>C₃</td>
<td>Autochory (Barochory)</td>
</tr>
<tr>
<td>Ficus carica</td>
<td>Cantabrian-</td>
<td>Sunny areas Perennial</td>
<td>Spring-</td>
<td>C₃</td>
<td>Endozoochory</td>
</tr>
<tr>
<td>Plantago sp.</td>
<td>Portugal</td>
<td>Annual-Perennial</td>
<td>Summer</td>
<td>C₃</td>
<td>Anemochory</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td>Portugal</td>
<td>Nitrophilous Annual-</td>
<td>Summer</td>
<td>C₃</td>
<td>Endozoochory-Anemochory-Autochory</td>
</tr>
<tr>
<td>Rumex spp.</td>
<td>Cantabrian-</td>
<td>Nitrophilous Annual-</td>
<td>Summer</td>
<td>C₃</td>
<td>Endozoochory-Anemochory-Autochory</td>
</tr>
<tr>
<td>Primulaceae</td>
<td>Cantabrian</td>
<td>Nitrophilous Annual-</td>
<td>Summer</td>
<td>C₃</td>
<td>Autochory-Zoochory</td>
</tr>
<tr>
<td>Anagallis arvensis/monelli</td>
<td>Portugal</td>
<td>Nitrophilous Annual-</td>
<td>Summer</td>
<td>C₃</td>
<td>Ectozoochory</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Cantabrian-</td>
<td>Open forest, nitrophilous</td>
<td>Summer</td>
<td>C₃</td>
<td>Endozoochory</td>
</tr>
<tr>
<td>Maloideae</td>
<td>Cantabrian</td>
<td>Open forest</td>
<td>Summer-</td>
<td>C₃</td>
<td>Endozoochory</td>
</tr>
<tr>
<td>Sorbus sp.</td>
<td>Cantabrian</td>
<td>Open forest</td>
<td>Summer-</td>
<td>C₃</td>
<td>Endozoochory</td>
</tr>
<tr>
<td>Potentilla sp.</td>
<td>Cantabrian</td>
<td>Nitrophilous Perennial</td>
<td>Summer</td>
<td>C₃</td>
<td>Endozoochory</td>
</tr>
<tr>
<td>Prunus spinosa</td>
<td>Portugal</td>
<td>Open forest</td>
<td>Summer</td>
<td>C₃</td>
<td>Endozoochory</td>
</tr>
<tr>
<td>Rosa sp.</td>
<td>Cantabrian</td>
<td>Open forest</td>
<td>Summer</td>
<td>C₃</td>
<td>Endozoochory</td>
</tr>
<tr>
<td>Galium sp. / Asperula sp.</td>
<td>Portugal</td>
<td>Open forest, Annual</td>
<td>Summer</td>
<td>C₃</td>
<td>Ectozoochory</td>
</tr>
</tbody>
</table>
The region noted for each taxon is the region where the archaeobotanical remains studied have been recovered; the regions where the taxon might be present might be different. The ecological characterisation generally follows the data obtained from Flora iberica (Flora iberica 1986+), complemented with other specific references for fruit ripening times (Fernández 1992-2010), photosynthetic pathways (Sage & Monson 1999) and dispersal modes (Bonet & Pausas 2004; Paula & Pausas 2009). Although the habitats in which the different taxa thrive might be wide, particularly when the precision of the determination is low (i.e. at family level), the listed habitat tries to be as general as possible and the one which most species or varieties within the taxon share. The prevalent dispersal mode has been considered in this table; other dispersals (in which the seed might be damaged), which could have relevance in the appearance of seeds in archaeological contexts, might be possible: this is the case of plant species which might be grazed by animals (Bonn 2004), domestic or not, and whose seeds might be transported in animal dung. The potential uses for each plant are mostly based on a thorough general compilation work (Fernández 1992-2010), complemented with some other sources (e.g., Pinto Carvalho 2005; San Miguel López 2004). Recovery chances in the charred archaeobotanical record summarise the data provided at the end of each taxon description.

Table 76: Synopsis of relevant characteristics (ecological aspects and ethno-botanical uses) of the studied taxa.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Region</th>
<th>Ecological characterisation</th>
<th>Weediness</th>
<th>Potential uses for each plant part</th>
<th>Chances for recovery in charred assemblages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Habitat</td>
<td>Life cycle</td>
<td>Fruit ripening</td>
<td>Photosynthetic</td>
</tr>
<tr>
<td>Linaria sp.</td>
<td>Portugal</td>
<td>Open areas</td>
<td>Annual-Biennial-Perennial</td>
<td>Summer-Autumn</td>
<td>C₃</td>
</tr>
<tr>
<td>Atropa bella-donna</td>
<td>Portugal</td>
<td>Nitrophilous</td>
<td>Perennial</td>
<td>Summer-Autumn</td>
<td>C₃</td>
</tr>
<tr>
<td>Solanum nigrum</td>
<td>Portugal</td>
<td>Nitrophilous</td>
<td>Annual</td>
<td>Summer-Autumn</td>
<td>C₃</td>
</tr>
<tr>
<td>Umbelliferae (Apiaceae)</td>
<td>Cantabrian</td>
<td>Cosmopolitan</td>
<td>Annual-Biennial-Perennial</td>
<td>Summer</td>
<td>C₃</td>
</tr>
<tr>
<td>Celtis australis</td>
<td>Portugal</td>
<td>Rocky areas</td>
<td>Perennial</td>
<td>Autumn</td>
<td>C₃</td>
</tr>
<tr>
<td>Urtica sp. (dioica/membranacea/arens)</td>
<td>Cantabrian</td>
<td>Nitrophilous</td>
<td>Annual-Biennial-Perennial</td>
<td>Summer-Autumn</td>
<td>C₃</td>
</tr>
<tr>
<td>Urtica membranacea</td>
<td>Portugal</td>
<td>Nitrophilous</td>
<td>Annual-Biennial-Perennial</td>
<td>Summer-Autumn</td>
<td>C₃</td>
</tr>
<tr>
<td>Viola sp.</td>
<td>Portugal</td>
<td>Nitrophilous</td>
<td>Annual-Biennial-Perennial</td>
<td>Spring</td>
<td>C₃</td>
</tr>
</tbody>
</table>

33 The region noted for each taxon is the region where the archaeobotanical remains studied have been recovered; the regions where the taxon might be present might be different. The ecological characterisation generally follows the data obtained from Flora iberica (Flora iberica 1986+), complemented with other specific references for fruit ripening times (Fernández 1992-2010), photosynthetic pathways (Sage & Monson 1999) and dispersal modes (Bonet & Pausas 2004; Paula & Pausas 2009). Although the habitats in which the different taxa thrive might be wide, particularly when the precision of the determination is low (i.e. at family level), the listed habitat tries to be as general as possible and the one which most species or varieties within the taxon share. The prevalent dispersal mode has been considered in this table; other dispersals (in which the seed might be damaged), which could have relevance in the appearance of seeds in archaeological contexts, might be possible: this is the case of plant species which might be grazed by animals (Bonn 2004), domestic or not, and whose seeds might be transported in animal dung. The potential uses for each plant are mostly based on a thorough general compilation work (Fernández 1992-2010), complemented with some other sources (e.g., Pinto Carvalho 2005; San Miguel López 2004). Recovery chances in the charred archaeobotanical record summarise the data provided at the end of each taxon description.
Part III B: Results: the carpological assemblages

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8 Cantabrian region

8.1 Arangas

For the description of the context, *vid.* 10.1.1 Arangas (p. 60).

8.1.1 Plant macroremain assemblages

Non-woody plant macroremains from Arangas are relatively poor, with only one taxon, *Corylus avellana*, being numerous through the sequence (*vid.* Table 128 and Figure 91) and the different areas of the site (*vid.* Figure 90).

---

Figure 90: Distribution of plant macroremain types in Arangas cave.
8.1.1.1 Mesolithic phase (ca. 7500 cal BCE): Layers 4 and 3

Only a few hazelnut (*Corylus avellana*) charred shell fragments have been recovered from Layer 4. Samples from Layer 3 are very rich in charred hazel (*Corylus avellana*) nutshell fragments but they also contained three fruit halves and three detached seeds of rowan, wild service tree or whitebeam (*Sorbus* sp.), together with some barley remains (three *Hordeum vulgare* grains) (*vid.* Figure 91). These latter have been presumed intrusive because domesticated barley is an allochthonous plant which should have reached the Cantabrian region not before the Early Neolithic (which for the region does not occur until the 5th millennium cal BCE). A radiocarbon date obtained from one of the grains confirmed its Bronze Age chronology (*vid.* Table 6). Fragmentation is relatively low but the overall preservation is bad, because most specimens have an incomplete or absent epidermis.

8.1.1.2 Neolithic phase (ca. 3000 cal BCE): Layer D

The assemblage of plant remains from this layer is composed of abundant hazelnut shell fragments (*Corylus avellana*), a basal fragment of acorn cotyledon (*Quercus* sp.) and barley grains and grain fragments (*Hordeum vulgare*) (*vid.* Figure 91). Complementary to the high fragmentation of the whole assemblage, bad preservation is patent in the absence of epidermis in many of the remains (hazelnut and barley). Most barley grains also have hollows and all present soil concretions adhering to their surface. In the best preserved specimens, tentative observations have been made allowing for the distinction between grains with twisted and straight hilum, and possible naked and hulled varieties.
8.1.2 Overview

A presence-absence list of the taxa recovered (vid. Table 77) has been published previously (Arias et al. 2014).

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
<th>Mesolithic phase (ca. 7500 cal BCE)</th>
<th>Neolithic phase (ca. 3000 cal BCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Hordeum vulgare</em></td>
<td>Caryopsis</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. vulgare</td>
<td>Caryopsis</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. nudum</td>
<td>Caryopsis</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Corylus avellana</em></td>
<td>Pericarp fragment</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Quercus</em> sp.</td>
<td>Cotyledon fragment</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Sorbus</em> sp.</td>
<td>Fruit fragment, seed</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Indeterminates</td>
<td>Plant tissue</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 77: Taxonomical adscription of the charred plant macroremain assemblage at Arangas.

The assemblage recovered, because its preservation is by charring, represents only the plants or plant parts which were used in a way which promoted their coming into contact with fire and were not destroyed by it (e.g. Zapata Peña 2000). In addition, the spectrum of taxa and plant parts recovered evidence the importance of the size bias in these samples, as only remains distinguishable with the naked eye have been sorted. Most of the samples have determined plant remains and undetermined ones are very scarce. Fragmentation is low for remains other than hazelnut (vid. Table 78).

<table>
<thead>
<tr>
<th>Samples</th>
<th></th>
<th>Mesolithic phase (ca. 7500 cal BCE)</th>
<th>Neolithic phase (ca. 3000 cal BCE)</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td></td>
<td>Layer 4</td>
<td>Layer 3</td>
<td>Total</td>
</tr>
<tr>
<td>No. with plant macroremains</td>
<td>2</td>
<td>37</td>
<td>39</td>
<td>20</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>2</td>
<td>37</td>
<td>39</td>
<td>12</td>
</tr>
<tr>
<td>% with non-woody plant macroremains</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
<td>70 %</td>
</tr>
<tr>
<td>NDR No. of determined remains</td>
<td>3</td>
<td>360</td>
<td>363</td>
<td>74</td>
</tr>
<tr>
<td>No. of determined remains without dominant taxon</td>
<td>0</td>
<td>9</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>Fragmentation MNI (Minimum number of individuals)</td>
<td>1</td>
<td>44</td>
<td>45</td>
<td>18</td>
</tr>
<tr>
<td>MNI (Minimum number of individuals without dominant taxon)</td>
<td>0</td>
<td>9</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>0.33</td>
<td>0.12</td>
<td>0.12</td>
<td>0.34</td>
</tr>
</tbody>
</table>
Inés L. López-Dóriga

<table>
<thead>
<tr>
<th></th>
<th>Mesolithic phase (ca. 7500 cal BCE)</th>
<th>Neolithic phase (ca. 3000 cal BCE)</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Layer 4</td>
<td>Layer 3</td>
<td>Total</td>
</tr>
<tr>
<td>Index without dominant taxon (MNI/NDR)</td>
<td>- 1</td>
<td>1</td>
<td>0.92</td>
</tr>
<tr>
<td>NT (No. of taxa)</td>
<td>1 3</td>
<td>3 5</td>
<td>6 3</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>1 3</td>
<td>3 3</td>
<td>4 3</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
<td>0.25 0.75</td>
<td>0.75</td>
<td>0.75 0.75</td>
</tr>
<tr>
<td>Index (SU NT / Site NT)</td>
<td>0.17 0.50</td>
<td>0.50</td>
<td>0.83 1</td>
</tr>
</tbody>
</table>

Table 78: Taphonomical description of the charred plant macroremain assemblage at Arangas.

Most plant remains have soil concretions adhering to their surface, which according to some experiments (Antolín i Tutusaus 2012), is a result of the plant remains being exposed to weathering once charred. They also have incomplete epidermises, probably as a result of erosion rather than to charring. All this is indicative of a slow rate of deposition of charred plant remains, which could have been dispersed in layers from their original position around hearths.

No attempt has been made to identify the acorn (*Quercus* sp.) to species level, as the embryo (which could be employed as a diagnostic character according to Vázquez Pardo et al. 2004) is not present in the cotyledon fragment recovered. However, it has been possible to observe that the fragmentation of the cotyledon is postdepositional, possibly occurred upon excavation, processing of the sample or storage.

### 8.1.3 Discussion

The fragmentation rate is high in all assemblages, but particularly so in those with a lower richness, composed mostly of hazelnut (*Corylus avellana*) remains. However, in comparison with all the other Cantabrian contexts studied, their fragmentation is relatively low and most hazelnut remains belong to type 2 (fragments between 17-60 mm$^2$) instead of type 1 (less than 17 mm$^2$). It is difficult to assess whether this effect is a result of a sorting bias or a result of hazelnut shell fragmentation being originally less accused. In case of the latter, more likely as a similar size bias exists in *Corylus* fractions from all sites, this could be due to a different depositional origin (*e.g.* charred hazelnut shells break into smaller fragments than uncharred ones; López-Dóriga 2015, Mithen & Score 2000) or more limited trampling after deposition. It is difficult to test these hypotheses given the present data.

A few barley (*Hordeum vulgare*) grains were documented at Layer 3, together with other archaeological remains which had been typologically ascribed to the Mesolithic and which have been radiocarbon dated to the same period (*vid*. Table 5). These barley grains were thought to be clearly intrusive because the formation of the layer was much earlier, than the probable introduction of barley to the Cantabrian region (not before the 5th millennium cal BCE). A radiocarbon date on one of the grains confirmed this suspicion and proved their Bronze Age chronology. Although the said Layer was identified at several cave areas, the intrusive grains all came from Area B (*vid*. p. 60 and Figure 8), where the upper surface of the layer was detected to have been eroded in an undetermined prehistorical
Part III B: Results: the carpological assemblages

This fact might induce suspicions on the coherence of the whole assemblage from the same zone of the cave (Area B) from which these remains originated; which would also affect to the presence of *Sorbus* and the total counts of the hazelnut remains (abundant hazelnut remains have also been recovered from other cave areas, Areas C and D, free from suspicion of possessing intrusive materials). However, it has been previously observed that cereal grains are probably more likely to suffer percolation than other remains due to their particular morphology designed to penetrate the soil (Zapata Peña 2002). However, in the absence of further radiocarbon dates, the whole assemblage of Area B must be considered with caution.

On the contrary, barley grains from Layer D, of Neolithic chronology, come from a different area of the site (Area E, *vid.* Figure 8) in which postdepositional erosion or bioturbation has not been detected, thus their suspicion of being intrusive is unfounded. Most barley (*Hordeum vulgare*) grains show clear consequences of charring such as hollows, protrusions and morphological distortions occurring more or less strongly, which inform about particular charring conditions: probably high temperatures or a lengthy exposure at low temperatures (Braadbaart 2008). These charring conditions would result in the destruction of potentially present chaff (Boardman & Jones 1990); it is therefore impossible to tell at what stage of crop processing the carbonisation occurred: whether the crop was threshed, screened or dehusked before charring, if carbonisation was accidental and affected a clean crop or if it was intentional and intended for the removal of a crop by-product. Additionally, the biased naked-eye selection of plant remains has resulted in the skipping of all crop-processing information which might have been provided by potential weed remains. Postdepositional (probably of recent origin) fragmentation has also been observed in one of the barley remains.

Crab-apple remains (*Sorbus* sp.) have been also found in the Mesolithic layers with Bronze Age intrusions, in the form of fruit halves and detached seeds (probably detached from the remainder parenchymatic tissue, which might have been part of the fruit’s flesh, upon recovery or sample processing). Because remains such as fruit halves are less likely than cereal grains to suffer percolation (Zapata Peña 2002) and because Maloideae fruits are typical Mesolithic macroremains of the Cantabrian region (Zapata Peña 2000), these remains would not be considered intrusive in this work. Radiocarbon dating them directly would solve this issue. Because of the appearance of the halves’ inner surface, it has been possible to establish that the slicing of the fruit was carried out prior to carbonisation, thus pointing to its intentional character, probably linked to their preparation for consumption or preservation (Zapata Peña 2000; Wiltshire 1995). In addition, two of the half *Sorbus* sp. fruits (the third is partially eroded and leaves space for doubts) have a smooth skin, which according to some experiments, indicates that they were charred without having been dried previously (Helbaek 1952a). This would indicate that they were being roasted for consumption or storage at the time of charring. One of the halves, the one from which presumably the detached seeds originate, shows evidence of postdepositional erosion.

In both the Mesolithic and Neolithic layers, the most abundant remains are fragments of hazelnut shell. The continued exploitation of wild plant resources when domesticates were already available (layer D) is further attested by the addition of a new specimen to the spectrum of wild resources at this site (a *Quercus* sp. acorn cotyledon). In addition to *Sorbus* sp. remains, this assemblage evidences the summer and autumn exploitation of the typical Atlantic forest; both its margins and sparsely populated areas where *Sorbus* and *Corylus* grow, and possibly other woodland areas where different species of *Quercus*
In Neolithic times, this forest exploitation came to be complemented with the agriculture of cropfields. Given the present data, it is impossible to know if some sort of crop-processing took place in the site, if barley (*Hordeum vulgare*) was cultivated nearby, or if only processed or semi-processed products arrived there, potentially cultivated elsewhere. Given the low determination resolution (3 naked grains, 1 hulled grain fragment and 7 grains of undetermined variety), it is difficult to establish whether the two varieties were cultivated or not, or if one (hulled) was a weed of the other (naked). In any case, the barley crop might have been employed for human consumption or animal fodder.

### 8.2 El Carabión

For the description of the context, *vid. 10.1.2 El Carabión* (p. 65).

#### 8.2.1 Plant macroremain assemblages

The assemblages of non-woody plant macroremains from El Carabión are restricted in abundance and richness and diachronic changes might not be observed (Figure 92).

![Figure 92: Abundance of plant taxa (by number of remains) at El Carabión.](image)
Part III B: Results: the carpological assemblages

8.2.1.1 1st phase: N3 (ca. 10,000 cal BCE)

Samples from N3 have provided a hazelnut (*Corylus avellana*) charred shell fragment and a small pome fruit probably belonging to the Rosaceae family.

8.2.1.2 2nd phase: N1 (6500-4500 cal BCE)

Samples from N1, much more abundant in number, have given the same taxonomical results (*vid.* Table 125).

8.2.2 Overview

Only two types of remains belonging to two plant taxa have been recovered at El Carabión (*vid.* Table 79).

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
<th>N3 (1st phase, ca. 10,000 cal BCE)</th>
<th>N1 (2nd phase, 6500-4500 cal BCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Corylus avellana</em></td>
<td>Pericarp fragment</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Fruit</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 79: Taxonomical adscription of the charred plant macroremain assemblage at El Carabión.

Few taxa (*Corylus avellana*, Rosaceae) have been identified in the samples from this site and the number of unidentified items is very small (n=1). This might be a result of several factors. On the one hand, a bias introduced by the study of plant remains obtained by just one recovery method. In this case, wet-sieving with screens of large mesh size, and sorting with the naked eye; as well as the reduced size of the sampled area. On the other hand, shell-middens, because of the high level of calcium carbonate, are not ideal deposits for the preservation of charred plant macroremains which become easily eroded in that ambient (Braadbaart, Poole & van Brussel 2009). In addition, any charred assemblage is biased by the different chances of plants and plant parts to result carbonised and thus preserved (*e.g.* Zapata Peña 2000). Given the restrictions of the sampling strategy and the doubts raised by the divergent dating results (*vid.* p. 66), no attempt has been made to quantify the MNI (*vid.* Table 80) nor to analyse the sample from the taphonomical point of view as it is quite probable that the deposit is a result of different depositional events (*vid.* p. 132) accumulated over several millennia.
8.2.3 Discussion

The typically Holocene plant resources in this assemblage (Rosaceae and Corylus avellana) might have become charred when an accident occurred during the preparation for consumption or storage (this is the most likely case for Rosaceae and could also explain the charring of hazelnuts). They might have even been stored somewhere in the rock-shelter: both products have good storage qualities and can be preserved for about a year in the best dry and dark conditions, after a minimal preparation (vid. Cunningham 2005; Riddervold & Ropeid 1988). Also, Corylus avellana nuts, freshly gathered or stored for a time, might have been eaten raw or roasted and their shells discarded into the fire after consumption.

Little can be said about the plant exploitation strategies followed by the human groups occupying this site: wild fruits were gathered probably in different periods, possibly in the environment of the site or possibly elsewhere. These fruits, typical of clearings and margins of Atlantic Holocene forest, are gathered between the summer and autumn but have a relatively long storage-life.

8.3 El Mazo

For the description of the context, vid. 10.1.3 El Mazo (p. 69).

8.3.1 Plant macroremain assemblages

Non-woody plant macroremains from El Mazo (6500-5500 cal BCE) are relatively diverse and appear disperse through the whole sequence (vid. Table 129, Figure 93, and Figure 94).
As expected, after the excavation of this layer allowed the observation of abundant charred plant material, non-woody plant macroremains are relatively abundant but badly preserved. Abundant hazelnut (*Corylus avellana*) pericarp fragments and fragments of indeterminate non-woody plant tissue (probably fruit flesh, possibly from hazelnuts) have been recovered from both the light and heavy fraction of flotation samples. One of the fragments of hazelnut shell shows a perforation made by an insect (tp. *Balaninus nucum*). Abundant charred fungi sclerotia (tp. *Cenococcum geophilum*) and oblong featureless items, possibly arthropod faecal pellets (Scott *et al.* 2010), have been recovered from flotation samples. It can be hypothesised that these charred oblong faecal pellets might have been produced by the predator of the aforementioned hazelnut. Two of the samples studied show bioturbation evidence in the presence of uncharred seeds with rodent teeth marks and rodent faecal pellets.
8.3.1.2 SU 115

This layer with sparse soil has provided only one determinable plant macroremain, a possible nettle (cf. *Urtica* sp.) seed, in addition to abundant fragments of indeterminate plant tissue (possibly fruit flesh). One of the samples has uncharred rodent faecal pellets and charred fungi sclerotia (tp. *Cenococcum geophilum*).

8.3.1.3 SU 114

Despite the recovery of abundant charred non-woody plant macroremains, their taxonomical identification has not been possible. Abundant charred plant indeterminate tissue (possibly fruit flesh) and a fragment of parenchymae (tissue from an underground storage organ) have been recovered, together with a charred faecal pellet from an arthropod. Additionally, the sample also shows bioturbation evidence in rodent uncharred faecal pellets and modern seeds with teeth marks.

8.3.1.4 SU 107

This layer was observed to be rich in charred plant macroremains upon excavation. The abundance of wood charcoal contrasts, however, with the little determined non-woody plant remains. The wet-sieved samples have provided a few charred hazelnut (*Corylus avellana*) shell fragments. The light flotation fractions have supplied abundant indeterminate plant tissue (possibly fruit flesh and seed coats or epicarps), indeterminate seeds which have not allowed taxonomical determination and non-vegetal material such as charred fungi scletoria (tp. *Cenococcum geophilum*) and possible arthropod faecal pellets. Only a very fragile nettle seed (*Urtica* sp.) had been determined to genus level, before breaking into pieces upon analysis. Bioturbation has little impact, only two samples contain uncharred rodent faecal pellets.

8.3.1.5 SU 111

This layer reportedly contained abundant charred plant macroremains seen upon excavation. Only the light fraction from flotation samples has been analysed and no determinable non-woody plant macroremains have been recovered: abundant fragments of indeterminate plant tissue (possibly fruit flesh) and an indeterminate seed have been retrieved, in addition to a few charred possibly faecal pellets from arthropods and fungi sclerotia (tp. *Cenococcum geophilum*).

8.3.1.6 SU 110

This layer was observed upon excavation to be rich in charred plant macroremains, but no determinable non-woody plant macroremains have been recovered in the light flotation fractions. The assemblage studied is rich in indeterminate plant tissue (possibly fruit flesh and seed coats or epicarps)
and contains an indeterminate seed. In addition, charred faecal pellets from arthropods and fungi sclerotia (tp. *Cenococcum geophilum*) appear in several samples. One sample contains uncharred rodent faecal pellets.

8.3.1.7 SU 105

Wet-sieved samples from this layer have provided abundant charred fragments of *Corylus avellana* shell; the light fraction from flotation samples have supplied abundant carbonised fragments of indeterminate plant tissue (possibly fruit flesh), and more limitedly, indeterminate charred seeds, stalks and seed coats or epiacars. Charred fungi sclerotia (tp. *Cenococcum geophilum*) and arthropod faecal pellets are also abundant.

8.3.1.8 SU 113

This layer was observed to contain abundant charred plant macroremains upon excavation, most of which have later proved to be wood charcoal fragments. Two samples from the light flotation fraction have been analysed and have shown to be rich in indeterminate plant tissue (possibly fruit flesh). In addition, one of the samples has provided hazelnut shells, an indeterminate fruit fragment and a fragment of parenchyma. The other sample shows evidence of bioturbation consisting in rodent uncharred faecal pellets and also contained fungi sclerotia (tp. *Cenococcum geophilum*).

8.3.1.9 SU 112

As was observed upon excavation, this layer was rich in charred plant macroremains, but none in the light flotation fractions could be identified taxonomically. Non-woody plant macroremains are mostly indeterminate plant tissue (possibly fruit flesh) and seed coat or pericarp fragments. In addition, abundant charred fungi sclerotia (tp. *Cenococcum geophilum*) and arthropod faecal pellets have been recovered. Additionally, one of the samples contains uncharred rodent faecal pellets.

8.3.1.10 SU 120

Only one flotation sample from this layer has been studied, providing with a small hazelnut (*Corylus avellana*) shell fragment and indeterminate plant tissue (possibly fruit flesh).

8.3.1.11 SU 103

Two wet-sieved samples from this layer have been studied, one did not contain any non-woody plant macroremain, and the other provided abundant charred hazelnut shell fragments. The flotation samples only supplied indeterminate charred plant tissue (possibly fruit flesh) and a few arthropod faecal pellets.
8.3.1.12 **SU 102**

This concreted layer has produced very scarce charred non-woody plant macroremains. The wet-sieved samples were completely devoid of charred plant material other than wood charcoal, but one contained uncharred seeds with rodent teeth marks. Only one of the two light fractions from the flotation samples gave positive results, consisting of just one fragment of indeterminate plant tissue and two arthropod faecal pellets.

8.3.1.13 **SU 106**

A wet-sieved sample from this layer was analysed and provided abundant charred fragments of hazelnut (*Corylus avellana*) shell.

8.3.1.14 **SU 119**

This layer, apparently rich in charred plant macroremains upon excavation, indeed provided very abundant wood charcoal fragments but little non-woody plant charred material in the light fraction of flotation samples, only indeterminate fragments of plant tissue (possible fruit flesh). A sample also contained a single faecal pellet from an arthropod.

8.3.1.15 **SU 104**

This layer, rich in ashes and thermoaltered pebbles, was interpreted as a hearth in primary or secondary position, but regrettably only a wet-sieved sample was available for plant-macroremain analysis. It produced a few charred hazelnut (*Corylus avellana*) shell fragments with and without epidermis.

8.3.1.16 **SU 117**

A sample picked *in situ* for radiocarbon dating was analysed from this possible hearth or hearth sweeping and seen to consist of a single hazelnut (*Corylus avellana*) shell fragment.

8.3.1.17 **SU 101.1**

This layer, surrounding a hearth, was observed to be rich in charred plant macroremains. The analysis of the light flotation fractions showed that its richness is particularly due to the abundance of wood charcoal, although non-woody plant macroremains are also amply preserved. These are mostly charred hazelnut pericarp fragments, chunks of indeterminate tissue (possibly fruit flesh), a fragment of parenchymae, and a piece of seed coat or epicarp. In addition, charred oblong items determined as
arthropod faecal pellets and spherical fungi sclerotia (tp. *Cenococcum geophilum*) have been found. Only one sample showed evidence of bioturbation, with uncharred rodent faecal pellets.

**8.3.1.18 SU 116**

This small layer, rich in echinoderm remains, has been considered the result of a single activity. The light fractions from flotation samples contained scarce non-woody charred plant macroremains, consisting of a few fragments of indeterminate plant tissue, together with some fungi sclerotia (tp. *Cenococcum geophilum*) and an arthropod faecal pellet.

**8.3.1.19 SU 118**

This mixed bioturbated layer indeed showed bioturbation evidence in the light fraction of flotation samples, consisting of uncharred seeds with rodent teeth marks. The charred non-woody plant macroremains are mostly chunks of indeterminate plant tissue (possibly fruit flesh) and fragments of parenchymae, together with two indeterminate seeds and a seed coat or epicarp fragment. In addition, two arthropod pellets and some fungi sclerotia (tp. *Cenococcum geophilum*) have also been recovered.

**8.3.1.20 SU 101**

This layer, apparently rich in charred plant macroremains, was considered highly bioturbated upon excavation. Wood charcoal is very abundant in the examined light flotation fractions. The samples are also rich in indeterminate plant tissue fragments (possibly fruit flesh) and indeterminate seeds. Half of a strawberry tree fruit (*Arbutus unedo*) has been determined in one of the samples. In addition, the samples contain some arthropod pellets and fungi sclerotia (tp. *Cenococcum geophilum*). One of the samples has provided evidence for bioturbation in uncharred seeds with rodent marks.

**8.3.1.21 SU 100/101**

Two wet-sieved samples come from the first survey in this area, where the distinction between the two layers was not clear. The samples have yielded some hazelnut (*Corylus avellana*) shell fragments and indeterminate fruit flesh chunks. The bioturbation suspicions are confirmed by very abundant uncharred seeds with rodent marks in both samples.

**8.3.1.22 SU 100**

This superficial layer was appreciated to be highly bioturbated and mixed upon excavation, and this was confirmed in the analysis of the light flotation fractions, of which only one was free from either uncharred seeds with rodent teeth marks or rodent dung pellets. However, relatively abundant and
diverse charred remains, many of which have allowed thorough taxonomical determinations, have been recovered from this suspicious layer. Among the determined plant macroremains, a strawberry tree (*Arbutus unedo*) seed, two heath (*Erica* sp.) seeds, one hazelnut (*Corylus avellana*) medium sized shell fragment, a Primulaceae seed and a dock (*Rumex* sp.) seed. Indeterminate remains consist of a bud fragment, two fruit fragments, three leaf fragments, four stalk fragments and abundant indeterminate plant tissue (possibly fruit flesh and seed coat or epicarp fragments) and indeterminate seeds. In addition, the usual fungi sclerotia (tp. *Cenococcum geophilum*) and arthropod faecal pellets are also abundant.

### 8.3.2 Overview

The three types of analysed samples have provided quite different types of remains (*vid. Table 81*): whilst in the wet-sieved and *in situ* samples mainly only one type of remain has been retrieved, *Corylus avellana* L. pericarp fragments, and a few other unidentified fragments of non-woody plant tissue; the light flotation fractions have yielded a miscellany of plant material (small seeds, parenchyma, unidentified plant tissues) and very few samples have had hazelnut shell fragments identified. This is a good example of the bias that studying single types of sample can produce.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wet-sieve</td>
</tr>
<tr>
<td>Seeds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primulaceae</td>
<td>Seed</td>
<td></td>
</tr>
<tr>
<td><em>Rumex</em> sp.</td>
<td>Seed</td>
<td>✓</td>
</tr>
<tr>
<td><em>Urtica</em> sp.</td>
<td>Seed</td>
<td>✓</td>
</tr>
<tr>
<td><em>cf. Urtica</em> sp.</td>
<td>Seed</td>
<td>✓</td>
</tr>
<tr>
<td>Fruits</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Arbutus unedo</em></td>
<td>Seed and fruit</td>
<td>✓</td>
</tr>
<tr>
<td><em>Corylus avellana</em></td>
<td>Pericarp</td>
<td>✓</td>
</tr>
<tr>
<td><em>Erica</em> sp.</td>
<td>Seed</td>
<td>✓</td>
</tr>
<tr>
<td>Indeterminates</td>
<td>Fruit, seed, bud, leaf, tissue</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 81: Taxonomical adscription of the charred plant macroremain assemblage at El Mazo.

In addition, within the flotation light fractions, other types of remains have been recovered: fungi mycorrhizal sclerotia (tp. *Cenococcum geophilum*) and microzoooarchaeological remains: malacofauna (shell fragments, urchin spines), microfossils (foraminifera, ostracods, sponge spicules) and possible arthropod charred faecal pellets. Some samples have provided intrusive remains such as uncharred seeds with rodent teeth marks and uncharred rodent faecal pellets.

The assemblage is relatively rich in abundance and richness (*vid. Table 82*), especially taking into account that it is a shell-midden, and preservation conditions for charred plant macroremains are not ideal in rich calcium carbonate deposits (Braadbaart, Poole & van Brussel 2009). Although all samples contain charred wood charcoal fragments, only about a half has non-woody plant macroremains, and
Part III B: Results: the carpological assemblages

about a third contains remains that could be taxonomically determined. This is probably a result of erosion, which has also produced a very high fragmentation rate in most remains (vid. Table 82), with the exception of two layers (SU 100 and SU 115) and overall poor preservation; in addition to the high fragmentation in nutshells, many specimens are eroded. *Corylus avellana* nutshells have lost most of their epidermis, one of the *Urtica* sp. seeds broke up upon examination, the *Rumex* sp. seed has lost its coat and the Primulaceae is so eroded that further determination is not possible. Only the strawberry tree half fruit (*Arbutus unedo*) is considerably well preserved.

The analysis of flotation fractions has revealed that bioturbation affects the whole sequence, and not only the upper layers detected upon excavation, with recent intrusions of uncharred rodent faecal pellets or uncharred seeds with teeth marks in all layers. In addition, there is abundant, probably ancient, controversial evidence: charred oblong featureless items which seem to be arthropod faecal pellets (Scott *et al.* 2010) and charred fungi sclerotia (tp. *Cenococcum geophilum*, Alonso & López 2008). They are controversial because their relationship with human activities and other types of evidence of plant exploitation is unclear.

Whilst in general, species richness is reduced, the richest in the assemblages is the one from SU 100. In absence of a radiocarbon date for this layer, it cannot be ruled out that its richness might be due to its post-Mesolithic character. However, taxonomically, no plant remain suggests a post-Mesolithic chronology, as no domesticate remain has been found. In addition, an alternative explanation for the good preservation of the remains would be their location in the top of the sequence and less affected by trampling. High bioturbation has been detected upon excavation of the layer and abundant clearly modern uncharred seeds have been observed. However, the taxa to which uncharred and charred remains correspond are dissimilar, and charred seeds are less often displaced by animals (Miksicek 1987 but Tryon 2006). Given this, it is more likely that the charred seeds in this layer, and the whole sequence, are ancient, despite the existence of a modern uncharred seed input and the potential vertical and horizontal displacement of charred seeds within the sequence due to bioturbation activities.

*Corylus avellana* shell fragments are mostly recovered from the heavy flotation fractions and wet-sieved samples. Not all the heavy fractions had been sorted at the time of writing this work, so the charred plant assemblage studied is biased towards light elements from flotation fractions and hazelnut shells are quite likely numerically under-represented.
|                  | 3 | 108 | 115 | 114 | 107 | 111 | 110 | 105 | 113 | 112 | 120 | 103 | 102 | 106 | 119 | 104 | 117 | 101 | 116 | 118 | 101 | 100 /10 | 100 | Whole seq. |
|------------------|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Samples          |   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| No.              | 1 | 8   | 2   | 1   | 9   | 3   | 6   | 16  | 2   | 4   | 1   | 4   | 4   | 1   | 1   | 2   | 1   | 4   | 2   | 2   | 6   | 2   | 4   | 86  |
| No. with non-woody plant macroremains | 1 | 4   | 1   | 0   | 5   | 1   | 2   | 5   | 1   | 0   | 1   | 1   | 1   | 0   | 1   | 1   | 3   | 0   | 2   | 3   | 2   | 4   | 40  |
| % with non-woody plant macroremains   | 100 | 50  | 50  | 0 % | 56  | 33  | 33  | 31  | 50  | 0 % | 100 | 25  | 25  | 100 | 0 % | 100 | 100 | 75  | 0 % | 100 | 50  | 100 | 100 | 47  |
| No. with determined non-woody plant macroremains | 1 | 4   | 1   | 0   | 3   | 0   | 0   | 2   | 1   | 0   | 1   | 1   | 0   | 1   | 0   | 1   | 1   | 3   | 0   | 0   | 1   | 1   | 3   | 25  |
| % with determined non-woody plant macroremains | 100 | 50  | 50  | 0 % | 33  | 0 % | 0 % | 13  | 50  | 0 % | 100 | 25  | 0 % | 100 | 0 % | 100 | 100 | 75  | 0 % | 0 % | 17  | 50  | 75  | 29  |
| NDR              | 3 | 43  | 1   | 0   | 3   | 0   | 0   | 18  | 2   | 0   | 1   | 10  | 0   | 12  | 0   | 3   | 1   | 11  | 0   | 0   | 1   | 7   | 6   | 122 |
| Fragmentation    |   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| MNI (Minimum number of individuals)   | 1 | 4   | 1   | 0   | 2   | 0   | 0   | 2   | 1   | 0   | 1   | 2   | 0   | 2   | 0   | 1   | 1   | 1   | 0   | 0   | 1   | 1   | 6   | 27  |
| MNI (Minimum number of individuals without dominant taxon) | 0 | 3   | 0   | 1   | 1   | 5   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 1   | 0   | 1   | 0   | 0   | 0   | 0   | 0   | 12  |
| Index (MNI/NDR) | 0.33 | 0.09 | 1.00 | -  | 0.67 | -  | -  | 0.11 | 0.50 | -  | 1.00 | 0.20 | -  | 0.17 | -  | 0.33 | 1.00 | 0.09 | -  | -  | 1.00 | 0.14 | 1.00 | 0.22 |
| Index without dominant taxon (MNI/NDR) | 0 | 0.07 | 0   | -  | 0.33 | -  | -  | 0.00 | 0   | -  | 0.00 | 0.08 | -  | 0.33 | 0   | 0   | -  | -  | 0   | 0   | 0   | 0.10 |
| Species richness|   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| NT (No. of taxa) | 1 | 1   | 1   | 0   | 2   | 0   | 0   | 1   | 1   | 1   | 0   | 1   | 1   | 1   | 0   | 1   | 1   | 1   | 0   | 0   | 1   | 1   | 5   | 6   |
| MNS (Minimum number of species)     | 1 | 1   | 1   | 0   | 2   | 0   | 0   | 1   | 1   | 1   | 0   | 1   | 1   | 1   | 0   | 1   | 1   | 1   | 0   | 0   | 1   | 1   | 5   | 6   |
| Index (MNS = NT)                   | 0.17 | 0.17 | 0.17 | 0.00 | 0.33 | 0.00 | 0.17 | 0.17 | 0.00 | 0.17 | 0.17 | 0.00 | 0.17 | 0.17 | 0.00 | 0.17 | 0.17 | 0.00 | 0.00 | 0.17 | 0.17 | 0.83 | 1   |
8.3.3 Discussion

The presence of *Corylus avellana* evidences the exploitation of the margins and sparsely forested areas in the Atlantic forests in which hazel thrives.

The oldest presence of *Arbutus unedo* non-woody plant macroremains has been here attested in the shape of seeds and a fruit fragment. Whilst the seeds could have arrived at the site by endozoochory (in the stomach contents of a hunted animal, for example), the fruit fragment is a neat fruit half; this, as happens with other fruits such as crab apples, rowans, wild service trees and whitebeams, could be a result of its preparation for storage or consumption (Zapata Peña 2000). *Arbutus unedo* is not currently present in the immediate environment but a few kilometres away (Aedo & Castroviejo 2012). It is however not unlikely that the distribution has changed over time, as this tree is not currently abundant in the region, but can grow anywhere provided the soil is calcareous: it is likely that its distribution was wider. It is also possible that plant gathering activities took place at some distance and this highly valued fruit would have been deliberately sought after. Gathering time for the mature fruits would have been September, but as the fruit is sliced in half, a possible preparation for storage, its edible life could have extended some months from autumn (Riddervold & Ropeid 1988).

Whilst the presence of remains from nuts and berries (*Corylus avellana* and *Arbutus unedo*) would be very difficult to explain without the intentional human factor; the seeds from other remains, such as the herbaceous plants (*Urtica* sp., *Rumex* sp., Primulaceae) might be considered with more caution. Whilst all of them might have been intentionally gathered and exploited for diverse uses, such as bromatological (the leaves of all of them as green vegetables), medicinal (the dry vegetative plant parts of all of them) or technological (the fibres of *Urtica* sp.); their unintentional deposition cannot be rejected as a possibility: their seeds might have been in the immediate environment (because they are nitrophilous species it is quite possible that they were growing in the rock-shelter where organic matter from the midden was decomposing) and might have resulted charred by accident, they might have even been in the stomach contents of hunted animals (Vaquer & Ruas 2009). Some herbs are indicative of a highly-nitrophilous habitat with plentiful nutrients in the soil, where taxa such as Primulaceae, *Rumex* sp. and *Urtica* sp. thrive. An ideal habitat for these taxa could be either a riverbank which suffers periodical floods, or a disturbed area, such as would be the immediate environment of an occupation site, where domestic refuse is discarded. Perhaps the inhabitants of the site exploited the same plants that their own activities promoted.

The presence of seeds of *Erica* sp., a shrub for which different pharmaceutical, technological and ornamental uses are known, indicates the creation of possibly anthropic origin of vegetation clearances or perhaps the exploitation of resources in the mountainous chain, beginning 1 kilometre to the south, where shrubland vegetation would abound.
8.4 El Toral III

For the description of the context, *vid.* 10.1.4 El Toral III (p. 74).

8.4.1 Plant macroremain assemblages

El Toral III has provided a rich assemblage of non-woody plant macroremains in which many charred plant items have not been possibly identified to any taxonomical level (*vid.* Table 130, and Figure 95).

---

**Figure 95:** Abundance of plant taxa (by NMI of seeds or fruits) at El Toral III by zone/phase.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Zone A</th>
<th>Zone B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardueae/Cynarae</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Corylus avellana</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>cf. Ficus cannica</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Poaceae</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Rosa sp.</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sorbus sp.</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

---

8.4.1.1 Zone A: 1st phase (ca. 7500 cal BCE)

**Figure 96:** Abundance of plant remains per category by SU in zone A of El Toral III. Profile pictures: Igor Gutiérrez Zugasti.
8.4.1.1.1 SU 10

This layer reportedly contained sparse wood charcoal fragments. The light fraction of the flotation sample examined has provided a few charred non-woody plant remains, none taxonomically determinable. The assemblage is composed of some fragments of seed testa and tissue resembling fruit flesh. In addition, three oblong charred featureless items, probably arthropod faecal pellets, have been recovered.

8.4.1.1.2 SU 9

This archaeologically quasi-sterile layer has produced an indeterminate charred seed and plant tissue fragments (type fruit flesh), together with some fungi sclerotia (tp. *Cenococcum geophilum*) and arthropod faecal pellets.

8.4.1.1.3 SU 5

This layer, perceived as disturbed upon excavation, contained as non-woody plant macroremains an indeterminate seed, fragments of pericarp, fruit flesh and stalks or stems and a rose (*Rosa* sp.) seed. In addition, abundant fungi sclerotia (tp. *Cenococcum geophilum*) and arthropod faecal pellets.

8.4.1.1.4 SU 7

This disturbed layer did not provide any charred plant macroremains.

8.4.1.1.5 SU 7.1

Despite being archaeologically sterile, this layer has yielded abundant charred non-woody plant macroremains, most indeterminate. Among the undetermined, an indeterminate seed, many stem or stalk fragments, spines, seed testa fragments and fruit flesh-type tissue. The determined are a wild grass (Gramineae) and a plant in the daisy family (Compositae, tribe Cardueae/Cynareae) seed fragments. Fungi sclerotia (tp. *Cenococcum geophilum*) and arthropod faecal pellets are also abundant.

8.4.1.1.6 SU 6

Wet-sieved or heavy flotation fractions have provided hazelnut (*Corylus avellana*) shell fragments and two chunks of indeterminate tissue (type fruit flesh). The only light flotation fraction has produced a possible fig (cf. *Ficus carica*) seed and several indeterminate fragments of fruit pericarp, fruit flesh tissue and a stem or stalk fragment, together with some fungi sclerotia (tp. *Cenococcum geophilum*) and arthropod faecal pellets.
8.4.1.1.7 SU 4

Light flotation fractions from this layer have yielded only one determinable non-woody plant macroremain, a rowan or whitebeam (Sorbus sp.) seed. In addition, several indeterminate stems of stalks, spines, fruit flesh and fruit pericarp, as well as some fungi sclerotia (tp. Cenococcum geophilum) and arthropod faecal pellets, have been recovered. Wet-sieved and heavy flotation fractions are rich in hazelnut (Corylus avellana) shell fragments.

8.4.1.1.8 SU 13

Wet-sieved and heavy flotation fractions have produced the typical hazelnut (Corylus avellana) shell fragments and an indeterminate plant tissue compound with rodent marks. Light flotation fractions are composed of indeterminate seed coats, spines, fruit flesh and pericarp fragments, together with arthropod faecal pellets and fungi sclerotia (tp. Cenococcum geophilum). One of the samples also has two Sorbus sp. seeds.

8.4.1.2 Zone B: 2nd phase (ca. 5500 cal BCE)

8.4.1.2.1 Square M9

SU 19

Abundant hazelnut (Corylus avellana) shell fragments, two with larvae exit holes (tp. Balaninus nucum) have been recovered in heavy flotation fractions and wet-sieved samples from this layer. Light
flotation fractions have provided three crab-apple (*Sorbus* sp.) seeds and indeterminate fruit flesh and epicarp fragments, together with some arthropod faecal pellets.

**SU 18**

The only sample from this layer is a light flotation fraction which contained indeterminate fruit flesh-like tissue fragments. In addition, faecal pellets from arthropods have been recovered in the sample.

**SU 17**

Some hazelnut (*Corylus avellana*) shell fragments have been recovered from wet-sieved or heavy flotation fractions, in addition to one indeterminate stem or stalk fragment. Other indeterminate remains, such as fruit flesh-like tissue, an indeterminate seed and plant tissue aggregates have been recovered in the light flotation fractions, together with two *Sorbus* sp. pome halves with smooth skin and two seeds from the same taxon. The usual fungi sclerotia and microfauna faecal pellets are also part of the assemblage.

**8.4.1.2.2 Square OS**

**SU 22**

Despite being a layer without almost any soil, abundant non-woody plant charred macroremains have been recovered: in wet-sieved or heavy flotation fractions, hazelnut (*Corylus avellana*) shell fragments, one with larvae exit hole and another with egg laying hole; in the light flotation fraction, indeterminate seed testa fragments and fruit flesh-like pieces, as well as fungi sclerotia and arthropod faecal pellets.

**SU 21**

Samples from this layer, with sparse soil, are very rich in hazelnut (*Corylus avellana*) shell fragments. The only light flotation fraction also contained a hazelnut shell fragment and several indeterminate fruit flesh-like tissue and seed coats, as well as fungi sclerotia and arthropod faecal pellets.

**SU 20**

The light flotation fraction did not yield determinable plant remains, but only indeterminate seed coat fragments and fruit flesh-like tissue, with the usual fungi sclerotia and faecal pellets. Some *Corylus*
avellana shell fragments in the wet-sieved or heavy flotation fractions have larvae exit holes (tp. Balaninus nucum).

8.4.2 Overview

Non-woody plant macroremains from El Toral III are not much diverse in their taxonomical ascription (vid. Table 83).

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
<th>Recovery</th>
<th>Zones</th>
<th>Phases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Zone A - 1st</td>
<td>Phase (ca. 7500</td>
</tr>
<tr>
<td></td>
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<td>zone BCE)</td>
<td>Zone B - 2nd</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>phase (ca. 5500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>cal BCE)</td>
</tr>
<tr>
<td>Seeds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compositae (tribe</td>
<td>Seed</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cardueae/Cynareae)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gramineae</td>
<td>Caryopsis</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fruits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corylus avellana L.</td>
<td>Pericarp</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>cf. Ficus carica L.</td>
<td>Seed</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Rosa sp.</td>
<td>Achene</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sorbus sp.</td>
<td>Seed, pome</td>
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<td>✓</td>
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</tr>
<tr>
<td>Indeterminates</td>
<td>Fruit, seed,</td>
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<td>✓</td>
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<tr>
<td></td>
<td>tissue</td>
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</tr>
</tbody>
</table>

Table 83: Taxonomical adscription of the charred plant macroremain assemblage at El Toral III.

Different types of plant macroremains have been recovered from the two types of samples, according to the techniques of recovery (vid. Table 83). On the one hand, the flotation samples have provided a miscellany of charred plant material (small seeds, parenchymae, stem and stalk fragments, plant tissue fragments similar to fruit flesh) and only in 2 out of the 16 samples hazelnut shell fragments have been identified. On the other hand, in the mesh samples, mainly only one type of remain has been retrieved, Corylus avellana L. pericarp fragments, and a few other unidentified fragments of non-woody plant tissue. This is very exemplifying of the bias that studying one type of sample can produce. Unfortunately, both types of samples have not been available for analysis for all SUs (vid. Table 15), thus the bias in the taxa recovered in this respect is considerable.

Furthermore, within the flotation samples, several types of microzooarchaeological remains have been recovered: malacofauna (shell fragments, urchin spines), microfauna (small bones and fragments of bones) and microfossils (sponge spicules, foraminifera, ostracods). Abundant charred ancient oblong featureless items determined as arthropod faecal pellets (Scott et al. 2010) and fungi sclerotia (tp. Cenococcum geophilum, Alonso & López 2008) have been found. Their relationship to human activities is understudied and far from clear but they might be pointing to the presence of some plant parts, such as nut kernels and underground organs, which might have been processed at the site and have not been preserved due to the characteristics of their tissues (rich in water and oils).
Thanks to the application of the flotation technique, the plant spectrum recovered is relatively wide (in comparison with other sites of the same period and region where flotation has not been carried out). Most samples not only have plant macroremains, but also, determined ones. This is so despite the fact that, on the one hand, charring tends to produce a bias towards certain plant parts which are processed with fire and which are dense and dry (e.g. Zapata Peña 2000); and on the other hand, shell-middens are problematical environments for the preservation of charred plant macroremains, because of the high level of calcium carbonate, in which they become easily eroded (Braadbaart, Poole & van Brussel 2009). Therefore, despite the preservational limitations, the good results should encourage excavators to sample more especially in the more adequate conditions in order to obtain more plant data.

Differences between the two fragmentation indices (vid. Table 84) are insignificant. The fragmentation rate is very high, but consistently uniform; the species richness index is low, notably lower in the 2nd phase in comparison with the 1st.

It is worth noting the presence of charred plant macroremains in the clayey layers which are archaeologically sterile (SUs 9, 7.1, 7, and 5). This could be a result of percolation from other overlying layers, but in that case there might be some similarities in the plant species or plant parts present. Not only the abundance of stem and stalk fragments is most conspicuous in these layers; the layers also contribute to the enrichment of the site species richness. Therefore, as clear differences exist, an explanation other than percolation must be looked for. The type of remains, vegetative plant parts from all the plant and not just wood or seeds, could indicate the plant macroremains have resulted charred in generalised fires, either of natural origin (vid. Scott 2010; Scott & Damblon 2010), or anthropic, perhaps due to some sort of vegetation-clearing activity in another area of the site after a period of abandonment. Another possibility is that the uncharred remains became buried by natural reasons whilst the site was uninhabited and were later charred when human activity occurred again, perhaps by the creation of hearths on the top. The recognition of hearths in archaeological sites depends on a variable set of factors (vid. Groenendijk 1987).
Table 84: Taphonomical description of the charred plant macroremain assemblage at El Toral III.

<table>
<thead>
<tr>
<th>Samples</th>
<th>SU 10</th>
<th>SU 9</th>
<th>SU 5</th>
<th>SU 7</th>
<th>SU 6</th>
<th>SU 4</th>
<th>SU 13</th>
<th>1st phase</th>
<th>SU 17</th>
<th>SU 18</th>
<th>SU 19</th>
<th>SU 20</th>
<th>SU 21</th>
<th>SU 22</th>
<th>2nd phase</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>14</td>
<td>29</td>
<td>10</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>28</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>13</td>
<td>31</td>
<td>9</td>
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<td>4</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>25</td>
<td>56</td>
</tr>
<tr>
<td>% with non-woody plant macroremains</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>93%</td>
<td>93%</td>
<td>90%</td>
<td>0%</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>80%</td>
<td>89%</td>
</tr>
<tr>
<td>No. with determined non-woody plant macroremains</td>
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<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>12</td>
<td>24</td>
<td>9</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>% with determined non-woody plant macroremains</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>83%</td>
<td>86%</td>
<td>79%</td>
<td>90%</td>
<td>0%</td>
<td>100</td>
<td>80%</td>
<td>80%</td>
<td>86%</td>
<td>82%</td>
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<table>
<thead>
<tr>
<th>No. of determined remains</th>
<th>0</th>
<th>0</th>
<th>1</th>
<th>0</th>
<th>2</th>
<th>49</th>
<th>67</th>
<th>64</th>
<th>183</th>
<th>55</th>
<th>0</th>
<th>193</th>
<th>37</th>
<th>173</th>
<th>178</th>
<th>636</th>
<th>819</th>
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</thead>
<tbody>
<tr>
<td>MNI (Minimum number of individuals)</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>25</td>
<td>10</td>
<td>-</td>
<td>19</td>
<td>4</td>
<td>16</td>
<td>17</td>
<td>66</td>
<td>91</td>
</tr>
<tr>
<td>MNI (Minimum number of individuals without dominant taxon)</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>-</td>
<td>1.00</td>
<td>0.12</td>
<td>0.10</td>
<td>0.14</td>
<td>0.14</td>
<td>0.18</td>
<td>-</td>
<td>0.10</td>
<td>0.11</td>
<td>0.09</td>
<td>0.10</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Index without dominant taxon (MNI/NDR)</td>
<td>-</td>
<td>-</td>
<td>1.00</td>
<td>-</td>
<td>1.00</td>
<td>0.02</td>
<td>0.01</td>
<td>0.03</td>
<td>0.04</td>
<td>0.07</td>
<td>-</td>
<td>0.02</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>NT (No. of taxa)</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>0</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Index (SU NT=MNS / Site NT=MNS)</td>
<td>-</td>
<td>-</td>
<td>0.17</td>
<td>-</td>
<td>0.33</td>
<td>0.33</td>
<td>0.32</td>
<td>0.33</td>
<td>1.00</td>
<td>0.33</td>
<td>-</td>
<td>0.33</td>
<td>0.17</td>
<td>0.17</td>
<td>0.17</td>
<td>0.33</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species richness</th>
<th>SU 10</th>
<th>SU 9</th>
<th>SU 5</th>
<th>SU 7</th>
<th>SU 6</th>
<th>SU 4</th>
<th>SU 13</th>
<th>1st phase</th>
<th>SU 17</th>
<th>SU 18</th>
<th>SU 19</th>
<th>SU 20</th>
<th>SU 21</th>
<th>SU 22</th>
<th>2nd phase</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>NT (No. of taxa)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Index (SU NT=MNS / Site NT=MNS)</td>
<td>-</td>
<td>-</td>
<td>0.17</td>
<td>-</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
<td>1.00</td>
<td>0.33</td>
<td>-</td>
<td>0.33</td>
<td>0.17</td>
<td>0.17</td>
<td>0.17</td>
<td>0.33</td>
</tr>
</tbody>
</table>
8.4.3 Discussion

The plant spectrum at El Toral III evidences the summer and autumn exploitation of the marginal or sparsely forested areas with hazel (*Corylus*) and rowan, wild service tree or whitebeam (*Sorbus* sp.) of the typical Holocene Atlantic forest, in both phases of occupation. Hints of potential storage preparations (or perhaps cooking choices) for *Sorbus* sp. and *Corylus avellana* during the 2nd phase (Zone B) exist, in the form of fruit halves with smooth skin and discarded infested nuts.

The charred plant tissue similar to fruit flesh might possibly be *Corylus avellana* charred kernels. This type of tissue is very difficult to determine taxonomically (*vid.* p. 163) and therefore the presence of hazelnut kernels can only be hypothesised. It is also interesting to note that both several egg-laying holes and larvae-exit holes have been tentatively recognised in different nutshell fragments. Either hazelnut gathering was carried out with carelessness, gathering both infested and healthy specimens, and then many of them would have to be discarded into the fire; or the nuts were stored for a period before discard, in which larvae had time to develop and exit. This latter could be part of the preparations for ulterior long-term storage.

The two half *Sorbus* sp. fruits have a smooth skin, which according to some experiments, indicates that they were charred without previous drying (Helbaek 1952a). This would indicate that they were being roasted for consumption or storage at the time or charring.

A not very well preserved seed that resembles those of figs (*Ficus carica*), but not so clearly as to be determined without certain doubts, has been tentatively identified in a Mesolithic layer. The main issue is that fig seeds are polymorphic and with a single individual it is very difficult to safely confirm this determination. Current knowledge of the wild fig distribution prior to its possible Neolithic domestication is far from good (Khadari *et al.* 2005), but this might be the oldest evidence of fig in a Mesolithic context outside the natural distribution area for wild fig (Zohary, Hopf & Weiss 2012). On the one hand, it might be an intrusion of a later chronology, either due to the displacement of the seed between layers whilst deposited or an introduction upon excavation. An introduction upon excavation would be unlikely, as it could account for the introduction of uncharred modern seeds but less probably of charred seeds, scarcer as a natural phenomenon (Miksicek 1987). However, percolation of small-sized materials is relatively frequent in palimpsest-like depositional contexts and some animals effectively displace such small pieces of charred materials (Tryon 2006), although the excavators had not detected any bioturbation or postdepositional alteration in this layer (SU 6, *vid.* p. 75). Therefore, the precise age of the seed could only be safely checked with a $^{14}$C date on the seed. On the other hand, should the seed be indeed of fig and of Mesolithic chronology, either the wild fig distribution area needs to be reconsidered, or there was some sort of displacement between the Cantabrian region and the Mediterranean part of the Peninsula in which figs grew naturally, a few hundreds kilometres apart. This displacement could either be human-induced, such as the exchange of products between populations or population movements carrying products; or it could be natural, due to endozoochory (without human intervention, under the form of animal droppings; in the case of human activity, arrival at the site within the stomach contents of hunted animals). None of these explanations are altogether unlikely: figs are not perishable food-stuffs but rather the contrary, they can be preserved for a long time in a dried form and have long been traded over large distances (*e.g.* Bakels & Jacomet 2003); equally, many animals
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disperse undamaged fig seeds over large distances (Debussche & Isenmann 1989). Wild or naturalised fig (*Ficus carica*) trees in the Cantabrian region currently grow in sunny areas, many within karst depressions known as dolines, gaining protection from winds. Depending on the type of reproduction, figs would have been produced in spring and summer (brevas) or in autumn (true figs).

Some herbs (a composite and a wild grass) and rose remains (*Rosa* sp.) are also present in the 1st phase (Zone A), but their relationship with human activities is unclear, as they appear within otherwise archaeologically sterile layers. They might be indicating their growth in the immediate environment of the site, representing some sort of open area. All these plant products could have been gathered between spring and autumn, but as they are easily stored, previously dried, they could have been consumed through-out the year.

8.5 Mazaculos II

For the description of the context, *vid.* 10.1.5 Mazaculos II (p. 79).

8.5.1 Plant macroremain assemblages

Only hazelnut (*Corylus avellana*) shell fragments have been recovered in these assemblages (*vid.* Table 126 and Table 85), both in the Exterior (10,000-5700 cal BCE) and the Interior (6000-4000 cal BCE) sequences (*vid.* Figure 98).

8.5.2 Overview

Non-woody plant macroremains from Mazaculos are rather poor in both number and in species richness (*vid.* Table 85).

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
<th>Exterior (10,000-5700 cal BCE)</th>
<th>Interior (6000-4000 cal BCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Corylus avellana</em></td>
<td>Pericarp</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Indeterminates</td>
<td>Tissue</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 85: Taxonomical adscription of the charred plant macroremain assemblage at Mazaculos II.
Part III B: Results: the carpological assemblages

Any charred plant assemblage is biased by the different chances of plants and plant parts to be exposed to fire and to survive it (e.g., Zapata Peña 2000). In addition, these plant remains recovered are a clear example of the bias produced as a consequence of wet sieving with large meshes and sorting with the naked eye. In addition to the bias introduced by the retrieval techniques employed, the scarcity (50 fragments) and low species richness (1 taxon) of plant macroremains might be explained due to the fact that shell-middens, because of the high level of calcium carbonate, are highly erosive environments for the preservation of charred plant macroremains (Braadbaart, Poole & van Brussel 2009). The remains preserved, despite their notorious resistance, show a high degree of fragmentation (vid. Table 86).

<table>
<thead>
<tr>
<th>Samples</th>
<th>Exterior (10,000-5700 cal BCE)</th>
<th>Interior (6000-4000 cal BCE)</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>2-3</td>
<td>1</td>
</tr>
<tr>
<td>No. with plant macroremains</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>% with determined non-woody plant macroremains</td>
<td>0 %</td>
<td>100 %</td>
<td>67 %</td>
</tr>
</tbody>
</table>

| NDR No. of determined remains | 0 | 1 | 1 | 2 | 39 | 1 | 8 | 48 | 50 |

| Fragmentation | MNI (Minimum number of individuals) | 1 | 2 | 1 | 2 | 4.00 | 1.00 | 3.00 | 8.00 | 10.00 |
|               | Index (MNI/NDR) | 1.00 | 1.00 | 1.00 | 0.10 | 1.00 | 0.38 | 0.17 | 0.20 |

| Species richness | NT (No. of taxa) = MNS (Minimum number of species) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|                 | Index (MNS = NT) | 1.00 | 1.00 | 0.50 | 0.25 | 1.00 | 0.33 | 0.13 | 0.10 |

Table 86: Taphonomical description of the charred plant macroremain assemblage at Mazaculos II.

Because of the dispersed distribution of the nutshell fragments over the archaeological layers and the low numbers recovered per SU, their taphonomical study is scarcely instructive: both the preservation of the nutshells (the presence of absence of epidermis, Fairbairn, Kulakoglu & Atici 2014) and the post/precharring breakage analysis (López-Dóriga 2015) have shown, as expected, that the remains are heterogeneous and probably arise from more than one charring event. This is inferred from the fact that, in the same samples, remains both with and without epidermis (i.e. charred at different temperatures) and fragmented before and after charring have been found. Moreover, the close examination of the breakage patterns in the nutshells has shown that most fragments have fresh edges and therefore have been fragmented after recovery, presumable upon sieving.

It is worth noting the absence of Corylus avellana shells in Layer 3, where charred plant material was conspicuous upon excavation, and their scarcity in the whole Exterior sequence. In the Interior zone, hazelnut shells are more abundant in the upper Neolithic layer, than in the underlying Mesolithic ones.
8.5.3 Discussion

Little can be said about the plant exploitation strategies developed by the human groups occupying this site: wild fruits were gathered probably at different periods, possibly in the environment of the site or possibly elsewhere. These fruits, typical of clearings and margins of Atlantic Holocene forest, are gathered between the summer and autumn. These typically Holocene plant resources might have become charred when an accident occurred during preparation for consumption or storage. They might have even been stored somewhere in the rock-shelter: they have good storage qualities and can be preserved for about a year in the best dry and dark conditions, after a minimal preparation (vid. Cunningham 2005). Also, Corylus avellana nuts, freshly gathered or stored for a time, might have been eaten raw and their shells discarded into the fire after consumption.

8.6 Los Gitanos

For the description of the context, vid. 10.1.6 Los Gitanos (p. 83).

8.6.1 Plant macroremain assemblages

Plant macroremain assemblages from Los Gitanos become impoverished in species richness and abundance progressively as the analyses advance in the sequence, from the more recent to the older sublayer (vid. Table 131, Figure 99, and Figure 100).

Figure 99: Abundance of plant remains per category by sublayer in layer A of Los Gitanos. Profile Photograph by Ontañón et al. 2013
8.6.1.1 1st phase (5000-4000 cal BCE)

8.6.1.1.1 Sublayer A4

This sublayer has proven to have a very poor representation of plants, restricted to two fragments of hazelnut (*Corylus avellana*) shell. This extremely limited assemblage leaves little space for comments. Two samples contain uncharred seeds.

8.6.1.1.2 Sublayer A3

Plant macroremains are scarce in this sublayer, only an acorn (*Quercus* sp.) cotyledon fragment and a few hazelnut (*Corylus avellana*) pericarp fragments. One of the samples contains uncharred seeds.

8.6.1.2 2nd phase (ca. 3000 cal BCE)

8.6.1.2.1 Sublayer A2

The assemblage in this sublayer, despite its high fragmentation rate, is the most diverse in relation to the MNI, although it has a lower minimum number of species. Determined plant macroremains belong to
8.6.1.2.2 Sublayer A1

This sublayer has the maximum number of species determined and its species richness index shows a relatively diverse assemblage. Preservation of plant macroremains is considerably good in this sublayer: the fragmentation index, although high, is much lower than in other sublayers. Conspicuous preservation differences exist between different taxa, confirming in this case the tertiary depositional origin (vid. p. 132) inferred for disperse assemblages over archaeological layers. Whilst Corylus avellana shell fragments are homogeneously badly preserved (their epidermis is absent and their fragmentation rate is high); other taxa, such as cereal grains and acorn cotyledon show different degrees of erosion. On the one hand, a Triticum grain is eroded to such a degree that it has lost all its epidermis and its typical shape is compromised, the only criteria allowing its identification is the deep hilum, something similar has happened to the Avena grain; but the other Triticum grain is very well preserved allowing its determination to a naked species (T. “nudum”). On the other hand, whilst acorn cotyledons are in general fragmented (more than split into cotyledon halves), two Quercus fragments have allowed the observation of its embryo cavity, one of them even preserving the embryo itself. Remains of Umbelliferae, Compositae (tribe Cardueae/Cynareae), Potentilla sp. and cf. Ficus carica are also badly eroded and have not allowed a thorough determination. Other small seeds from herbs, excluding their fragmentation, are relatively well preserved: Rumex sp., Gramineae tp. Bromus.

8.6.2 Overview

A preliminary report has been published before (Ontañón et al. 2013), some corrections to the results have been carried out since then: taxonomical identifications and quantification methods have been improved (vid. Table 87).

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
<th>Recovery</th>
<th>Phases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wet-sieve</td>
<td>Flot</td>
</tr>
<tr>
<td>Grasses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Avena sp.</td>
<td>Caryopsis</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Gramineae tp. Bromus</td>
<td>Caryopsis</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Triticum “nudum”</td>
<td>Caryopsis</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Triticum sp.</td>
<td>Caryopsis</td>
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<td></td>
</tr>
<tr>
<td>Other seeds</td>
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<td></td>
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<tr>
<td>tp. Cruciferae/Ericae</td>
<td>Seed</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Compositae (tribe Cardueae/Cynareae)</td>
<td>Achene</td>
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<td></td>
</tr>
<tr>
<td>Umbelliferae</td>
<td>Schizocarp</td>
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<td></td>
</tr>
</tbody>
</table>
Part III B: Results: the carpological assemblages

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
<th>Recovery</th>
<th>Phases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wet-sieve</td>
<td>Flot</td>
</tr>
<tr>
<td>Rumex sp.</td>
<td>Nutlet</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>tp. Senecio aquaticus</td>
<td>Seed</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fruits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corylus avellana L.</td>
<td>Pericarp</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>cf. Ficus carica</td>
<td>Seed</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>cf. Maloideae</td>
<td>Seed</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Quercus sp.</td>
<td>Seed</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Potentilla sp.</td>
<td>Seed</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Indeterminates</td>
<td>Tissue, seed</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

Table 87: Taxonomical adscription of the charred plant macroremain assemblage at Los Gitanos.

It is clear by the type of remains recovered in each of the flotation light fractions that this technique and the use of small-sized meshes is necessary for the recovery of diverse and minimally representative assemblages. Within the flotation samples, several types of uncharred microzooarchaeological remains, such as malacofoana (shell fragments, urchin spines), microfauna (small bones and fragments of bones), microfossils (foraminifera) or coprolites from arthropods and small rodents, and other type of charred remains, such as fungi mycorrhizal sclerotia (tp. Cenococcum geophilum), have been recovered. These latter remains might be related to the processing of some plant parts, such as nut kernels and underground organs, which have not been preserved in the charred assemblages.

Albeit always restricted, an inverse relationship between age and the abundance and species richness of plant macroremains exists in this assemblage, from the oldest and scarcest remains to the youngest and richest. However, it is also true that the excavated area and the number of samples is quite limited, particularly in the lower sublayers, and the strict positive correlation between the number of samples and richness, both in quantity and number of species, is obvious (vid. Table 88).
Fragmentation indices are high but variable. Remains are in general badly preserved: e.g. hazelnut shell fragments never preserve their outer epidermis and their fragmentation rate is so high that most remains are smaller than 16 mm². The presence of uncharred seeds in samples from all the sequence confirms the suspicions on the existence of bioturbation detected upon excavation and particularly recommends direct radiocarbon dating some of the charred plant remains.

### 8.6.3 Discussion

The scarcity of remains and the high degree of fragmentation and erosion of usually resistant remains, such as hazelnut shells, point to the probable character of the studied deposit as a tertiary dumping area (Ontañón et al. 2013). Therefore, the area in which other domestic activities, such as food preparation, took place must have been elsewhere, possibly right outside the cave or at some distance.

Wheat remains have been recovered in the upper layer, but given the present circumstances, it is difficult to ascertain whether it was locally cultivated, if it was processed in the site or arrived from elsewhere already processed, or even if it was fed to domesticated animals which might have been kept.

The possible presence of figs (*Ficus carica*) has been suggested by two remains which resemble fig seeds. The problem is that fig seeds are polymorphic and, particularly with such a small number (n = 2), their determination is difficult to affirm with certainty. Should they be indeed figs, they might have arrived accidentally (most likely by endozoocohory, in stomach contents of hunted animals) or could have arrived intentionally, as a result of their exploitation. The beginnings of fig cultivation and its predomestication distribution are not well-known (Khadari et al. 2005; Zohary, Hopf & Weiss 2012) but figs of unknown domesticated/wild status were present in the Mediterranean part of the Iberian Peninsula since at least the 4th millennium cal BCE (Tarrús, Pons & Chinchilla 1982). Figs at Los Gitanos might have been gathered from fig-tree cultivars or feral specimens grown in the region, as naturalised fig trees are a common feature in the current landscape of the Cantabrian region (Aedo & Castroviejo 2012); or they might have been gathered from either wild or cultivated specimens from the south or east, and might have been then transported and exchanged, as dried figs have excellent qualities for storage.

Table 88: Taphonomical description of the charred plant macroremain assemblage at Los Gitanos.

<table>
<thead>
<tr>
<th>Species richness</th>
<th>1st phase (5000-4000 cal BCE)</th>
<th>2nd phase (ca. 3000 cal BCE)</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A4</td>
<td>A3</td>
<td>Total</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>0.5</td>
<td>0.12</td>
<td>0.16</td>
</tr>
<tr>
<td>Index without dominant taxon (MNI/NDR)</td>
<td>0</td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td>NT (No. of taxa)</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
<td>0.07</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Index (SU NT / Site NT)</td>
<td>0.08</td>
<td>0.17</td>
<td>0.17</td>
</tr>
</tbody>
</table>
Because the Maloideae remains are simply seeds and not sliced half fruits, an accidental origin is as likely as an intentional one: Rosaceae fruits are prominently displaced by frugivorous animals (Debussche & Isenmann 1989) which might have been hunted and processed in the site, discarding or exploiting their stomach contents (Buck & Stringer 2014); but also, pips from fruits could have also been discarded into the fire after the consumption of the fruit.

The presence of seeds from herbaceous plants might be explained by the intentional contribution of the plants to the site for different exploitation purposes, such as bromatological or medicinal, or could have been present accidentally, transported by the wind (cf. Avena sp.) or within the guts (Rumex sp., tp. Senecio aquaticus) of hunted animals, in dung from domesticated animals kept in the cave or even in droppings from wild animals which could have been accidentally charred (Vaquer & Ruas 2009).

The plant spectrum highlights the exploitation of the sparse or marginal areas of the typical Atlantic Holocene forest in which hazel (Corylus avellana) and apple-like fruits (Maloideae) thrive. These wild products, together with acorns (Quercus sp.), would have been gathered between summer and autumn and could have been stored, if previously dried, for some months (Cunningham 2005, Riddervold & Ropeid 1988). This spectrum would have been progressively diversified, reaching herbs and shrubs (Umbelliferae, Compositae (tribe Cardueae/Cynareae), tp. Senecio aquaticus, tp. Cruciferae/Ericaceae, Rumex sp.) and other possible fruits (Potentilla sp. and cf. Ficus carica) and the introduction of domesticated species (Triticum sp. and T. “nudum”) and the possible development of crop processing activities, with the presence of potential agricultural weeds (Avena sp., Gramineae tp. Bromus).

9 Portugal

9.1 Cabeço do Pez

For the description of the context, *vid.* 10.2.1 Cabeço do Pez (p. 87).

9.1.1 Plant macroremain assemblages

Samples from Cabeço do Pez (5800-4000 cal BCE) have provided a few identifiable non-woody plant macroremains (*vid.* Table 127 and Figure 101).
9.1.1.1  SU 2

The single sample with non-woody plant macroremains from this stratigraphical unit has provided two *Brassica* sp./*Sinapis* sp. seeds, one whole and one fragmented, two *Medicago* sp. seeds, also one whole and one fragmented and one *Vicia* sp./*Lathyrus* sp. seed embryonal fragment. Indeterminate non-woody plant macroremains are also abundant.

9.1.1.2  SU 1

Two *Brassica* sp./*Sinapis* sp. seeds, four Leguminosae seeds (tp. *Genista* sp./*Lotus* sp.) four *Medicago* sp. seeds and one fragment, and a fragment of pine cone bract scale fragment, probably from *Pinus pinea*, have been recovered in this stratigraphical unit, together with several undetermined non-woody plant macroremains.

9.1.2  Overview

Plant remains from Cabeço do Pez belong to three plant families (*vid.* Table 89); a preliminary list of taxa has been published (López-Dóriga, Diniz & Arias 2015).

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Brassica</em> sp./<em>Sinapis</em> sp.</td>
<td>Seed</td>
</tr>
<tr>
<td>tp. <em>Genista</em> sp./<em>Lotus</em> sp.</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Medicago</em> sp.</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Vicia</em> sp./<em>Lathyrus</em> sp.</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Pinus</em> cf. <em>pinea</em></td>
<td>Bract-scale fragment</td>
</tr>
<tr>
<td>Indeterminates</td>
<td>Tissue</td>
</tr>
</tbody>
</table>

Table 89: Taxonomical adscription of the charred plant macroremain assemblage at Cabeço do Pez.

Only 6 of the samples examined from Cabeço do Pez contained determined plant macroremains other than wood (*vid.* Table 90): a larger number of samples needs to be examined to obtain a significant amount of remains in a context such as this. This is probably a result of the easy erosion of charred plant macroremains in shell-middens, because of the high level of calcium carbonate (Braadbaart, Poole & van Brussel 2009). In addition, charred plant remains assemblages do not represent the entirety of the plant resources exploited in a site but only those which came into contact with fire in such a way that they were carbonised and not destroyed (*vid.* Zapata Peña 2000). Moreover, because of the Mediterranean climate, with its very hot and dry summers, carbonized remains near the surface may have dried out and broken up when exposed to percolating moisture during the wet autumn and winter (Hansen 2001). Probably as a result of this, species richness is higher at the lower layer and more remains have been determined. Although the fragmentation index contrastingly suggests the low
incidence of this destructive phenomenon, the remains studied are so few that caution is needed for the interpretation of an assemblage like this.

<table>
<thead>
<tr>
<th></th>
<th>SU 5</th>
<th>SU 4</th>
<th>SU 3</th>
<th>SU 2</th>
<th>SU 1</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samples</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. with plant macroremains</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>14</td>
<td>26</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>% with non-woody plant macroremains</td>
<td>0 %</td>
<td>0 %</td>
<td>0 %</td>
<td>33 %</td>
<td>36 %</td>
<td>23 %</td>
</tr>
<tr>
<td>NR / NDR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of remains</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>No. of determined remains</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Fragmentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNI (Minimum number of individuals)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Species richness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NT (No. of taxa)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Index (SU MNS = NT / Site MNS = NT)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.75</td>
<td>0.50</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 90: Taphonomical description of the charred plant macroremain assemblage at Cabeço do Pez.

A neat taxonomical distinction exists between charred and uncharred plant remains in the samples: whilst the latter might have been recently introduced either by burrowing animals or ants, the former are most likely by-products of past human activities, although bioturbation effects, such as those caused by worms (Tryon 2006), could be causing horizontal and vertical displacements of the remains within the sequence. Taxonomically, the layers in which plant remains have been recovered are indistinguishable, because the plant spectra and types are similar to one another. In addition, important markers, such as the potential appearance of remains from domesticated plants, which might have occurred in the later occupation phase at the site, are absent. These facts, in addition to the absence of radiocarbon dates for the layers in which the plant remains have been recovered, and the current inability to correlate the newly recognised excavation layers with those from former fieldwork, which do have radiocarbon dates (e.g. Arnaud 1989), makes it impossible to attribute the remains to different occupation phases or events. Given the current archaeobotanical evidence, a Holocene occupation, in which domesticated plants are not known to have been exploited, is suggested.

9.1.3 Discussion

The plant assemblage recovered suggests the exploitation of nuts and abundant wild legumes and crucifers, which could have been gathered from spring to autumn in the open Mediterranean pine woodland environment typical of the Early and Middle Holocene in the region (van der Schriek et al. 2008).

Pines (*Pinus* spp.) probably occupied the free-draining sandy soils adjacent to the valley floor (van der Schriek et al. 2008). In the case of pine nuts, to avoid competition with other nut-eating animals, ethnographical evidence shows that it is most usual to gather the pine cones in spring before they have

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opened due to the heat of the summer; when needed, these cones could have been opened, releasing the nuts, by exposing them to the fire (Badal García 2001). Pine cone bract scales, probably from *Pinus pinea*, would have been gathered and could have become charred when extracting their nuts, or when making pitch to use as glue and impermeable protection, or simply used as fuel. An accidental origin in this case is altogether more unlikely, with the exception of the possibility of cones being buried in the soil above which a hearth might have been made. Drying the nuts without deshelling them would have also extended their storable life for a long period of several months.

The homogeneity of the assemblage, at least of plant types, is noteworthy. It is mostly composed of small seeded but edible products, such as wild legumes (tp. *Genista* sp./*Lotus* sp., *Medicago* sp., *Vicia* sp./*Lathyrus* sp.) and crucifers (*Brassica* sp./*Sinapis* sp.), which could have been intentionally gathered for bromatological purposes. They would have been gathered from open areas during the summer, but as these wild species are mostly dehiscent, the most efficient strategy to consume the seeds and green pods would have been to gather them before the seeds are ripe at the end of the summer. In addition, the rest of the plant could have been consumed as a green vegetable or dried for being used piecemeal as dye or medicine. However, an accidental origin for these remains cannot be discarded, particularly as these taxa are dehiscent and their pods eject their seeds several metres to promote their chances of reproduction: if growing near potential open-air hearths in the site, the seeds from these plants could arrive accidentally near hearths and end up charred. *Medicago* are usually epizoochorous species which might have arrived attached to animal furs or human clothing.

In addition to plant macroremains, other types of remains have been recovered within the flotation samples: charred fungi mycorrhizal sclerotia (tp. *Cenococcum geophilum*, Alonso & López 2008). The relationship between this type of remain and human activities is not well-known, but because they are charred, these remains are likely to be ancient. *Cenococcum geophilum* fungi sclerotia are ectomycorrhizal fungi, this is, fungi which thrive in forest soils in symbiosis with different plant roots, mostly from woody species, and among them, pine. They might have been attached to underground plant parts which could have been cooked and, if charred, have not been preserved (tubers and rhizomes are usually rich in water and are less able to survive charring), or could have been in the soils underneath hearths which have not been preserved (the preservation of recognisable hearths depends on variable circumstances such as the reiteration of use and the form of extinction of the fire, *vid*. Groenendijk 1987) and become accidentally charred during the hearth’s activity.

### 9.2 Poças de São Bento

Samples from Trench 1 of Poças de São Bento chosen at random by the pinch strategy have an alleatory distribution (*vid*. Figure 102).
Part III B: Results: the carpological assemblages

For the description of the context, *vid.* 10.2.2 Poças de São Bento (p. 91).

### 9.2.1 Plant macroremain assemblages

Although not numerically rich, relatively diverse assemblages of plant macroremains have been recovered through the archaeobotanical analysis (*vid.* Table 132, Figure 103, and Figure 104).
Figure 103: Abundance of plant remains per category by phase in Poças de S Bento’s North section of Trench 1. Modified from image by Luis Teira.

Figure 104: Abundance of plant taxa (by NMI of seeds or fruits) by phase at Poças de São Bento.
9.2.1.1 Phase B (1st phase: 6000-5000 cal BCE)

The assemblage from this phase is heterogeneous in preservation, no other pattern than a conspicuous vertical gradient has been observed: the fragmentation decreases as depth increases. In terms of species richness, the assemblage is rich (16 taxa, 65 % of the whole assemblage, have been documented in this phase).

9.2.1.1.1 SUs 3/7

This stratigraphical unit has provided determined plant macroremains from herbs (*Chenopodium album*, Gramineae, *Lolium* sp., cf. *Loli um* sp., *Malva* sp., *Rumex* sp.) and fruit-bearing trees and herbs (cf. *Ficus carica*, *Pinus pinea*, cf. *Pinus pinea*, cf. *Pistacia lentiscus*). Preservation is heterogeneous, particularly conspicuous in *Loli um* grains which have been found from very well to very poorly preserved, and fragmentation is high (only 40 % of the remains are complete). In addition, undetermined remains are also abundant, particularly non-woody plant tissue, but also a few parenchymae, seeds, seed fragments and succulent acicula fragments have been recovered. Termite faecal pellets are very abundant in these samples, together with fungi sclerotia (tp. *Cenococcum geophilum*).

9.2.1.1.2 SU 8

The samples examined from this stratigraphical unit had indeterminate fragments from non woody-plant tissue and thin pericarps, and seeds from herbaceous plants (*Linaria* sp., *Malva* sp./*Lavatera* sp. and tp. *Viola* sp.) and cf. *Pinus pinea* bract scale fragments. Charred faecal pellets from termites and other arthropods and fungi sclerotia (tp. *Cenococcum geophilum*) are also abundant. Fragmentation is relatively low (69 %).

9.2.1.1.3 SU 12

Non-woody charred plant remains from this stratigraphical unit are diverse indeterminate fragments (plant tissue, fruit flesh with seed imprints, seed fragments, stalk or pedicels and thin pericarps), and determined seeds from herbs (cf. *Ficus carica*, cf. *Geranium* sp., *Loli um* sp., cf. *Loli um* sp., Polygonaceae, *Rumex* spp. and *Urtica membranacea*) and fruit remains (*Pinus pinea* and cf. *Pinus pinea* bract scale fragments and nutshell). Fragmentation is relatively low (69 %). In addition, charred fungi sclerotia (tp. *Cenococcum geophilum*) and faecal pellets from termites and other arthropods are also abundant.

9.2.1.2 Phase C (2nd phase, ca. 4600 cal BCE)

This assemblage of stratigraphical units (SUs 2, 9, 14, 18) has provided abundant charred plant macroremains, in addition to charred fungi sclerotia, dry/dead-wood termite and other arthropod faecal
pellets. The fragmentation is relatively low (64 % of the specimens are complete) and species richness is high (65 % of the site taxa are present). Among the non-woody plant macroremains, a miscellaneous assemblage of indeterminate items, such as plant tissue, seeds and seed fragments, stalk or pedicel fragments, thin pericarp fragments, succulent acicula fragments and a tuber, has been recovered. Determined remains are seeds from various herbaceous plants (*Anagallis arvensis*/monelli, *Chenopodium album, Coronilla sp./Galega sp.*, cf. *Coronilla sp./Galega sp.*, tp. *Echium sp.*, cf. *Geranium sp.*, Gramineae, *Lolium sp.*, cf. *Lolium sp.*, *Malea sp.*, *Malea sp.*, *Plantago sp.*) and seeds, bract scale fragments and endocarp fragments from fruits (cf. *Celtis australis*, cf. *Ficus carica, Pinus pinea*, cf. *Pinus pinea*, cf. *Pistacia lentiscus, Quercus sp.*).

### 9.2.2 Overview

A preliminary list of taxa of plant remains from Poças de São Bento has been published (López-Dóriga, Diniz & Arias 2015), some corrections and additions have been made (*vid.* Table 91) to that list.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
<th>Phase B (1st phase: 6000-5000 cal BCE)</th>
<th>Phase C (2nd phase: ca. 4600 cal BCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grasses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lolium sp.</td>
<td>Caryopsis</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Gramineae</td>
<td>Caryopsis</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Legumes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronilla sp. / Galega sp.</td>
<td>Seed</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Other seeds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anagallis arvensis / monelli</td>
<td>Seed</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Chenopodium album</td>
<td>Seed</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Compositae</td>
<td>Seed</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>tp. Echium sp.</td>
<td>Mericarp</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>cf. Geranium sp.</td>
<td>Seed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linaria sp.</td>
<td>Seed</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Malva sp.</td>
<td>Seed</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Malva sp. / Lavatera sp.</td>
<td>Seed</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Plantago sp.</td>
<td>Seed</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td>Nutlet</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Rumex sp.</td>
<td>Nutlet</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Urtica membranacea</td>
<td>Achene</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>tp. Viola sp.</td>
<td>Seed</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Fruits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Celtis australis</td>
<td>Endocarp</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Part III B: Results: the carpological assemblages

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
<th>Phase B (1st phase: 6000-5000 cal BCE)</th>
<th>Phase C (2nd phase: ca. 4600 cal BCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>cf. Ficus carica</em></td>
<td>Seed and mesocarp</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><em>Pinus pinea</em></td>
<td>Bract-scale fragment, nutshell</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>cf. Pistacia lentiscus</em></td>
<td>Nutshell</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><em>Quercus sp.</em></td>
<td>Pericarp fragment</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Indeterminates</td>
<td>Seed, fruit, tissue, etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 91: Taxonomical adscription of the charred plant macroremain assemblage at Poças de São Bento.

The assemblage has been mostly obtained from light flotation fractions: flotation has been very effective at this particular site, as the heavy fractions have not produced new determinable plant remains (*vid.* Table 92). Other types of remains have been recovered within the light flotation fractions: uncharred seeds, mycorrhizal fungi sclerotia (tp. *Cenococcum geophilum*), termite and rodent coprolites and insect parts.

<table>
<thead>
<tr>
<th>Samples</th>
<th></th>
<th>Trench 1</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Phase B (1st phase: 6000-5000 cal BCE)</td>
<td>Phase C (2nd phase: ca. 4600 cal BCE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SU3</td>
<td>SU8</td>
</tr>
<tr>
<td>Samples</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. with plant macromremains</td>
<td></td>
<td>120</td>
<td>13</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td></td>
<td>68</td>
<td>13</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains in both flotation fractions (heavy + light)</td>
<td></td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains in the light flotation fraction</td>
<td></td>
<td>57</td>
<td>13</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains in the heavy flotation fraction</td>
<td></td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>% with non-woody plant macroremains</td>
<td></td>
<td>57 %</td>
<td>100 %</td>
</tr>
<tr>
<td>NDR</td>
<td>No. of determined remains</td>
<td>43</td>
<td>14</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>MN1 (Minimum number of individuals)</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Index (MN1/NDR)</td>
<td>0.43</td>
<td>0.71</td>
</tr>
<tr>
<td>Species richness</td>
<td>NT (No. of taxa)</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>MNS (Minimum number of species)</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Index (SU MNS / Site MNS)</td>
<td>0.35</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>Index (SU NT / Site NT)</td>
<td>0.36</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Table 92: Taphonomical description of the charred plant macroremain assemblage at Poças de São Bento.
Preservation by charring, indispensable for the recovery of ancient plant remains in a dry environment such as this, produces a bias towards certain plants and plant parts (e.g. Zapata Peña 2000). Charred plant macroremains are relatively abundant in terms of quantity and species richness in comparison with other contemporaneous sites with the same preservation. Still, quantities are low and a large number of samples needs to be examined to obtain significant amounts of determined plant macroremains. A high number of plant remains have been recovered in such a fragmentary and eroded state of preservation that their taxonomical determination is impossible by macroscopical observation alone. A single 10 litre sediment sample provides between 0 and 50 pieces of indeterminate plant tissue, and between 0 and 5 determined non-woody plant macroremains (vid. Table 132). Preservation of the determinable plant macroremains is not homogeneous: whilst very fragmentary and eroded remains are present, some seeds are very well preserved. In fact, bad preservation involves more often erosion than fracture, as the indices of fragmentation are relatively average. These heterogeneous states of preservation can be explained by the existence of multiple charring and deposition events being responsible for the assemblage, most likely in tertiary position (vid. p. 132) as is also hinted by other taphonomical proxies.

On the one hand, differential preservation might be partially responsible: shell-middens, because of the high level of calcium carbonate, are far from ideal deposits for the preservation of charred plant macroremains which become easily eroded (Braadbaart, Poole & van Brussel 2009). Furthermore, because of the Mediterranean climate, with its very hot and dry summers, carbonized remains near the surface may have dried out and broken up when exposed to percolating moisture during the wet autumn and winter (Hansen 2001). Indeed, remains in the lower stratigraphical unit (SU 12) are in general better preserved that those in the upper one (SU 2).

Plant macroremains have been recovered distributed through the archaeological stratigraphical units mixed with other archaeological material. The remains are generally small in size, never more than 5 mm and most often less than 2 mm, a fact which supports the brooming hypothesis (Antolín i Tutusaus 2010a): very small remains result dispersed upon regular sweeping of functional areas (McKellar hypothesis, Miksicek 1987). This, however, does not seem to match the character of the site as a midden in which occupation floors have not been identified yet. More likely, this small size of the plant macroremains could also be a result of the climate which promotes charcoal cracking (Hansen 2001), which might also account for the sparseness of the determined finds (but not the undetermined) over all the sequence. These types of dispersed distributions have been proven upon radiocarbon dating to be often subjected to intrusive charred materials (Crombé et al. 2013), particularly in palimpsest-like sites where fertile archaeological stratigraphical units are vertically contiguous with one another: this probably accounts for the lack of taxonomical difference between the different stratigraphical units (ancient plant macroremains have probably been displaced throughout the sequence) and the percolation of uncharred modern specimens to the lower units. Because of the dispersed distribution of plant remains, the difficulties in their taphonomical analysis and the potential multiple uses of each plant taxon, the possible functional origins of the plants can be merely hypothesised.

Whilst bioturbation by plant roots and burrowing animals probably explains the introduction of modern biological remains (among which, the uncharred seeds, mycorrhizal fungi sclerotia and termite and rodent coprolites) in the archaeological stratigraphical units, the recent introduction of charred ones is highly improbable. On the one hand, burrowing animals might intentionally transport uncharred seeds
for their consumption, but not charred ones, unless accidentally. On the other hand, no correlation exists between the uncharred seeds and the charred ones: although some taxa appear in both states of preservation, most uncharred seeds are not preserved in a charred form and vice versa. The existence of natural fires, which could eventually carbonise different plant parts (Scott 2010) and less often seeds (Miksicek 1987), has not been detected in the form of an ash or charcoal layer in the excavated sequence. In addition, radiocarbon dating of non-woody plant macroremains has been tried in several instances: three remains from the studied area, Trench 1 (a *Pinus* sp. bract scale fragment, and two *Setaria* sp. and *Lolium* sp. grains) could not be successfully dated due to insufficient carbon; another grain from another excavation area (Trench 3), with a taxonomical identification which suggested it was intrusive (*Triticum “nudum”*), has proved to contain enough carbon and has been dated to a modern chronology. This could not be used as a proof of the age of the charred plant remains, but together with the previous arguments, it supports their presumed ancientness.

As in the case of carbonised seeds, charred termite faecal pellets and fungi sclerotia are quite likely ancient remains. Termite faecal pellets might have been accidentally charred when deadwood was used as fuel or termites themselves might have been cooked for eating. *Cenococcum geophilum* fungi sclerotia are ectomycorrhizal fungi, this is, fungi which thrive in forest soils in symbiosis with different plant roots, mostly from woody species, and among them, pine. Their preservation by charring might be accounted for by two potential explanations: either they were attached to underground plant parts which could have been cooked and, if charred, have not been preserved (tubers and rhizomes are usually rich in water and are less able to survive charring), or they could have been dispersed in the soil and become accidentally charred by hearths (which might have not been recognisable hearths, *vid.* Groenendijk 1987).

### 9.2.3 Discussion

The plant macroremain assemblage from Poças de São Bento evidences the exploitation of the typical Holocene open Mediterranean pine woodland (van der Schriek *et al.* 2008). Wild grasses from open grassland areas (*Lolium* sp., Gramineae) were exploited in both occupation periods (Phase B and Phase C). Evidence for the intensive exploitation of undomesticated small-grained wild grasses in prehistorical times is well known from other regions (*e.g.* Weiss *et al.* 2004b). The gathering season would be summer but storable life could be prolonged considerably. Spikes and grains from wild grasses (*Lolium* sp., Gramineae) could have been gathered by cutting, uprooting, beating or hand-plucking, depending on the intended use of the plant or plant parts. Seeds might have been used for food; whilst the straw, for which no exploitation evidence has been found in this assemblage, could have been left in the fields or could have been employed for different manufactures, such as building, weaving, bedding, etc. (Mingote-Calderón 1987). In the case of wild grasses, of which the dispersal mode is anemochory (for *Lolium* at least), their potential arrival in a hearth in the site by chance, transported by the wind, cannot be excluded. No grass chaff has been recovered surrounding the grains, and two reasons might be behind this phenomenon: chaff was present but did not survive the charring event or was destroyed upon deposition; or chaff was absent because the grain was already dehusked when charred, such as would happen in the later stages of processing. Grains could have been roasted to help dehusking, for drying and storing or for some sort of culinary preparation. The grains could be stored in above-ground
facilities, in which case they could be easily consumed piecemeal as needed; or in underground storage pits, which would allow for a long-term storage period of at least a year.

Other herbaceous plants have a testimonial presence in the site and their interpretation might be controversial, because the ways in which they might have arrived at the site are various, and their potential uses are also diverse. The low numbers per taxa do not encourage undertaking taphonomical experimentations which could not be successfully tested against such rare archaeological evidence. These are plants from grasslands, potential weeds in cropfields (Anagallis arvensis/monelli, Geranium sp., Linaria sp., Plantago sp.) which would have been ripe by the same time as wild grasses and, if intentionally gathered, could have been prepared for immediate consumption or delayed medicinal use. Even if they were not intentionally gathered, as they are edible, they might have been consumed if accidently gathered together with potential intentionally gathered wild grasses (Hillman, Legge & Rowley-Conwy 1997), as these plants might be eaten as green vegetables and prepared into medicines. These uses would leave few chances for the seeds to be carbonised, so their rarity cannot be used as evidence of their accidental presence.

Several nitrophilous (Anagallis arvensis/monelli, Chenopodium album, Geranium sp., Linaria sp., Malva spp., Polygonaceae, Rumex spp., Urtica membranaceae, Viola sp.) point to the exploitation of rich humid soils such as would be found either in the floodplain of the valley or the immediate environment of the site, favoured by the creation of disturbed habitats by human activities such as garbage disposal, vegetation clearings, etc. Slope-thriving plants, such as Echium sp., Geranium sp. and Plantago sp. might have been gathered on valley slopes. All these plants would fruit between spring and autumn and their vegetative parts could have been consumed raw as green vegetables, or they could have been dried for storage and kept to be used piecemeal for other purposes (medicinal, dyes.).

Urtica membranaceae is one of the ruderal plants recovered which might have been intentionally exploited for its fibres, which have traditionally been used for textile production (Pinto Carvalho 2005). Other known uses of the plant are bromatological and medicinal. Remains of this taxon, however, together with those of other nitrophilous species recovered (Anagallis arvensis/monelli, Chenopodium album, Geranium sp., Linaria sp., Malvaceae and Malva spp., Polygonaceae and Rumex spp.) that, despite being potentially useful, might be accidentally present in the charred assemblage. Either because they were growing near the site (they grow in disturbed habitats rich in nitrogen such as middens) or could have been present either in dung or stomach contents of other animals which might have been exploited or might have left their droppings near the site (Vaquer & Ruas 2009).

The case of Echium sp. might be different. The leaves of plants in this genus might be eaten as green vegetables, the oils in their seeds used for culinary purposes, and the whole plants have a wide series of medicinal applications; their seeds, however, are not usually transported by the wind or by animals, and therefore an accidental arrival is more unlikely.

Some of the plants present have reproductive dispersals consisting of the distant ejection of the seed from the plant (Geranium sp., but contrary to most wild legumes, not Coronilla sp./Galega sp.), which could account for the accidental presence of the seeds in the site, if by chance they had fallen near open-air hearths. Otherwise, they might have been gathered in spring or summer before full maturity: whilst the whole plant might have been eaten as a green vegetable, the oils extracted from the seeds of some legumes have traditionally been exploited. These plants are also appreciated in folk medicine because of their very diverse pharmaceutical properties which might have been known and exploited in the past.
Fruits from different Mediterranean trees would have been gathered between spring and autumn but could have been stored much longer (Riddervold & Ropeid 1988). *Pinus pinea* cones might have been gathered unripe in spring to avoid animal competition for the nuts and could have been opened later in the heat of a hearth (Badal García 2001). Acorns from different oaks (*Quercus* sp.) would have also been available (van der Schriek *et al.* 2008) but evidence for their exploitation is scarce: they would also have been gathered in a particular season, autumn, but their storable life might have been prolonged by drying. Figs (*Ficus carica*) would have been gathered either in spring or summer and autumn, but as they also have excellent storable qualities, they could be the object of delayed consumption, or even exchange.

*Pinus pinea* cones might result charred when exposing them to the fire for opening, to prolong the storable life of the nuts by roasting or for extracting the resin. Cases of owls regurgitating pellets containing pine (*Pinus monophylla*) shells have been reported (Rhode & Madsen 1998) but this does not seem to occur in the Iberian Peninsula; most of the *Pinus* remains recovered are cone bract scale fragments and only a few shell fragments: therefore, the non-anthropic contribution of these remains is very unlikely, limited to the possibility of the deciduous cones being buried in the soil on top of which a hearth might have been made.

Equally, acorns from oaks (*Quercus* sp.) might have been gathered and processed with fire for consumption in foodstuffs or beverages, to prolong their storage life or to produce tans or mordants with which to treat leathers and cloths. Figs (*Ficus carica*), in turn, might become charred when drying (usually dipped in boiling water and then baked) or be transformed into medicines; however, fig seeds are dispersed by many frugivorous animals which might have been hunted and processed in the site, leaving an opportunity for their stomach contents to be exploited (Buck & Stringer 2014) or discarded. The presence of a fragment of fruit flesh with a seed imprint suggests the former explanation in this case.

The case of other fleshy fruits, such as *Celtis australis* and *Pistacia lentiscus*, is more difficult to ascertain. Fragments of the endocarp of these taxa, together with others which have not been identified, have been recovered in relative abundance. The fruits might have been brought either intentionally, perhaps eaten and their endocarps discarded into the fire, or accidentally, within the stomach contents of hunted animals, which might or might not have been exploited (Buck & Stringer 2014). The seeds from both taxa, however, are rich in oils which have traditionally been used for culinary purposes (Fern 1992-2010; Flora iberica 1986+): the extreme fragmentation of the endocarps might have been produced by pressing the uncharred endocarps in order to extract the oils, or perhaps is just a postdepositional result (Hansen 2001).

### 9.3 São Pedro de Canaferrim

For the description of the context, *vid.* 10.2.3 São Pedro de Canaferrim (p. 98).
9.3.1 Plant macroremain assemblages

With the exception of two of the studied samples, which did not contain any provenance information, the assemblages studied have arisen from the infilling of four underground pits (vid. Figure 105, Figure 106, and Figure 107), with chronologies around 5200 cal BCE. Provisional and preliminary reports of this data have been published in several conferences (López-Dóriga & Simões 2012; López-Dóriga & Simões in press), some amendments and additions have since been made to the results (vid. Table 133). The two delocalised samples have provided a few poorly preserved plant remains from several taxa which have a frequent representation in the site: barley (*Hordeum vulgare*), einkorn (*Triticum monococcum*) and herbs (*Brassica* sp./*Sinapis* sp.).
Part III B: Results: the carpological assemblages

9.3.1.1 Pit SU63

SU 63 was a bell-shaped asymmetrical pit with a hearth structure with abundant stones and fire-reddened soil at the bottom. The charred plant remains from the pit are most likely a result of the secondary use of the pit than the result of the cooking process. The assemblage is very heterogeneous, preservation ranges from poor to very poor, fragmentation indices are relatively low (from 50 % to 100 % unfragmented remains) and species richness indices are low within each microstratigraphical unit (with a single exception, SU 49-0), although the whole assemblage represents most of the taxa present in the whole site (75 %). The most abundant and ubiquitous remains in this pit are naked barley grains (*Hordeum vulgare* var. *nudum*), crucifer seeds (*Brassica* sp./*Sinapis* sp.), naked wheat grains (*Triticum nudum*) and legume grains (*Vicia* tp. *cracca*). Other taxa are not so abundant or ubiquitous, such as hulled wheat grains (*Triticum dicoccum* and *Triticum monococcum*) or *Corema album* seeds, or remain indeterminate (the number of undetermined remains, either seeds or plant tissue fragments is very high).

Figure 107: Abundance of plant taxa (by NMI of seeds or fruits) and by pit at S. Pedro de Canaferrim.
Samples from this microstratigraphical unit have provided relatively abundant remains that are rich in species richness (50 %), half of which are undetermined, either seed fragments or other plant tissue (possibly parenchymae). The preservation of the plant remains is in general poor. However those from the upper part of the stratigraphical unit are quite badly preserved in comparison with those underneath. This could be linked to their exposure to environmental agents once deposited, or more likely in this case, to being nearer the fire in the case of the primary use of the pit as a cooking structure.

The taxa recovered are a variety of cereals (from the most to the least abundant: *Hordeum vulgare* var. *nudum*, *Triticum “nudum”*, *Triticum cf. “nudum”*, *Triticum dicoccum* and *Triticum monococcum*), legumes (indeterminate and *Vicia* sp. [*cracca*]), herbs (*Brassica* sp./*Sinapis* sp., *Chenopodium* sp. and *Solanum nigrum*) and a fruit (*Corema album*). Remains of crucifers (*Brassica* sp./*Sinapis* sp.) are particularly abundant in this microstratigraphical unit.

In addition to abundant undetermined non-woody plant remains, the poorly preserved sample from this microstratigraphical unit has produced grains of cereals (*Hordeum vulgare* var. *nudum* and *Triticum* sp.), a legume (*Vicia* sp. [*cracca*]), and seeds from a fruit (*Corema album*), with a relatively low index of fragmentation (78 % are whole specimens).

Several samples from this microstratigraphical unit have been analysed, providing few undetermined remains (mostly parenchymatic tissue) and not very fragmented (67 % are whole specimens) determinate remains belonging to naked cereals (*Hordeum vulgare* var. *nudum* and *Triticum “nudum”*) and seeds from a fruit (*Corema album*).

Non-woody plant remains from this microstratigraphical unit are poorly preserved but not very fragmented (78 % are whole specimens), they have mostly been determined and belong to cereals (*Hordeum vulgare* var. *nudum*, *Triticum “nudum”*, *Triticum* sp., *Triticum monococcum*), and crucifers (*Brassica* sp./*Sinapis* sp.). Undetermined remains are scarce.
Part III B: Results: the carpological assemblages

**SU 49-5**

The single sample studied from this microstratigraphical unit, in a fairly poor state of preservation, has yielded a naked wheat (*Triticum “nudum”*) and crucifer (*Brassica sp./Sinapis sp.*) taxa.

**SU 49-7**

Remains in poor and very poor preservation condition have been recovered in samples from this microstratigraphical unit, which belong to cereal (*Hordeum vulgare var. nudum, Triticum “nudum”*) and legume (*Vicia tp. cracca*) taxa. Fragmentation is relatively low (67 % are whole specimens). A few indeterminate remains have also been found.

**SU 49-8**

Two samples of very poor preservation have been studied from this microstratigraphical unit, coming from the two recovery techniques employed in the site. Determined remains belong to two cereal taxa (*Hordeum vulgare var. nudum, Triticum sp.*). Some indeterminate remains have also been recovered.

**9.3.1.1.2 SU 64**

The one sample from this stratigraphical unit has yielded very scarce remains from very poorly preserved naked barley (*Hordeum vulgare var. nudum*). Fragmentation is relatively high (50 %) in comparison with other microstratigraphical units in the same pit. It is difficult to evaluate the reasons accounting for the preservation of this assemblage, as it could either represent both a depositional event in which plant remains were scarce or it might be just a result of the sampling strategy (this is the only SU in this pit which has been wet-sieved and sorted without magnification).

**9.3.1.1.3 SU 68**

The two samples from this stratigraphical unit have provided abundant remains, poorly preserved but not too fragmented (88 % whole specimens), from a variety of taxa (Triticeae, *Hordeum vulgare var. nudum, Vicia tp. cracca, Brassica sp./Sinapis sp.*, Malvaceae, cf. *Atropa bella-donna* and *Chamaerops humilis*).

**9.3.1.2 Pit SU 58**

This pit was though to have initially had a storage function, on the basis of its capacity (volume 1,356 l). The assemblage of charred plant remains recovered does not appear to have resulted from this hypothetical primary use. Preservation is heterogeneous but in general poor or very poor; fragmentation
is relatively low high (between 50 and 100 % of the specimens are not fragmented) and species richness relatively high (about 75 % of the taxa in the site are present in the whole assemblage and between 25 and 50 % in every microstratigraphical unit).

9.3.1.2.1 SU 70

SU 70-0

Determined non-woody plant remains from this microstratigraphical unit are diverse (about 50 %) and belong to cereals (Triticeae, Hordeum vulgare var. nudum, Triticum “nudum”, Triticum cf. “nudum”, Triticum monococcum and Triticum monococcum from a double-grained spikelet and Avena sp.), legumes (Pisum sativum, Vicia tp. cracca), and other herbs (Malvaceae), in poor or very poor state of preservation, with average fragmentation (50 %). Indeterminate seeds and plant tissue fragments are also abundant.

SU 70-1

The preservation of non-woody plant macroremains from this microstratigraphical unit is very heterogeneous but considerably good for the general condition in the site: three of the samples have the typically poor preservation, but another is regular and another is very well preserved, although indeterminate seeds and plant tissue fragments are also abundant. Fragmentation is relatively high (only 63 % are whole specimens). Taxonomically, the remains are relatively rich (44 % of the species from the whole site are present) and belong to different cereals and grasses (Triticeae, Hordeum vulgare var. nudum, Triticum “nudum”, Triticum monococcum, Avena sp.), legumes (Vicia faba, Vicia tp. cracca) and crucifers (Brassica sp./Sinapis sp.).

SU 70-2

Non-woody plant macroremains from this microstratigraphical unit display poor preservation, relatively low fragmentation (78 % are whole specimens) and belong to different taxa (species richness indices about 40 %) from cereals (Triticeae, Hordeum vulgare var. vulgare, Hordeum vulgare var. nudum, Triticum “nudum”, Triticum monococcum from a single-grained spikelet and Triticum sp.), legumes (Trifolieae, Vicia tp. cracca), crucifers (Brassica sp./Sinapis sp.) and indeterminate taxa.

SU 70-4

In addition to a few indeterminate seeds and plant tissue fragments, this microstratigraphical unit has provided poorly preserved and rarely fragmented (83 % are whole specimens) determined remains from cereals, one of them puffed (Hordeum vulgare, Hordeum vulgare var. nudum, Triticum “nudum”),
Part III B: Results: the carpological assemblages

crucifers (*Brassica* sp./*Sinapis* sp.) and a fruit fragment (cf. *Corema album*). In addition, abundant indeterminate seeds and plant tissue fragments have been recovered.

### 9.3.1.2.2 SU 57

All the studied samples from this microstratigraphical unit have been wet-sieved and have yielded very few indeterminate remains. Determined remains are poorly or very poorly preserved, but not fragmented (100 % are whole specimens) and belong to different barley varieties (*Hordeum vulgare*, *Hordeum vulgare* var. *vulgare*, *Hordeum vulgare* var. *nudum*) and wheats (*Triticum* sp.), both naked (*Triticum “nudum”*) and hulled (*Triticum dicoccum*, *Triticum monococcum*), in addition to a few legumes (*Vicia* tp. *cracca*) and crucifers (*Brassica* sp./*Sinapis* sp.).

### 9.3.1.3 Pit SU 67

This bell-shaped pit was reported to contain scarce archaeological remains from a scarcely diverse spectrum of plants (between 35 and 40 % of the whole site). The non-woody plant macroremain assemblages are poor, but it is difficult to know whether the recovery strategy (mostly wet-sieving rather than the combination of wet-sieving a flotation as in other pits) could have had an influence in this. Fragmentation is heterogeneous but never exceeds 50 %. Indeterminate plant tissue fragments are scarce.

### 9.3.1.3.1 SU 62

**SU 62-0**

The preservation of the remains in this microstratigraphical unit in general varies between poor and very poor and fragmentation is high (about 50 %). However, in one of the samples, conspicuous differences have been observed in the preservation of the plant remains according to their type: pulses are well preserved whilst cereals are not. The following cereal (Triticeae, *Hordeum vulgare* var. *nudum*, *Triticum “nudum”*, *Triticum cf. “nudum”* and *Triticum sp.*) and legume (indeterminate, *Vicia faba* and *Vicia* tp. *cracca*) taxa have been recovered. It is the richest microstratigraphical unit in the pit, in terms of quantity and species richness of plant remains.

**SU 62-1**

The only sample from this microstratigraphical unit has provided a few poorly preserved naked barley (*Hordeum vulgare* var. *nudum*) remains.
SU 62-2

The few samples studied from this microstratigraphical unit have yielded a few poorly preserved remains of cereals (Triticeae, *Hordeum vulgare* var. *nudum*, *Triticum* “*nudum*”, *Triticum* sp.) and a seed from a multiple-seeded fruit (*Corema album*).

9.3.1.3.2 SU 72

This stratigraphical unit has provided remains from naked cereals (*Hordeum vulgare* var. *nudum*, *Triticum* “*nudum*”) and crucifers (*Brassica* sp./*Sinapis* sp.), with a high fragmentation index (nearly 50 %).

9.3.1.4 Pit SU 66 / SU 65

This shallow pit with scarce archaeological remains was also poor in charred non-woody plant macroremains, limited to a few remains from naked barley (*Hordeum vulgare* var. *nudum*) and *Vicia* tp. *cracca*.

9.3.2 Overview

Plant macroremains from São Pedro de Canaferrim belong to diverse plant taxa (*cfid* Table 93). Provisional and preliminary reports spread in conferences have been improved since (López-Dóriga & Simões 2012; López-Dóriga & Simões in press).

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wet-sieve</td>
</tr>
<tr>
<td>Grasses</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Avena</em> sp.</td>
<td>Caryopsis, awn</td>
<td>✓</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. <em>nudum</em></td>
<td>Caryopsis</td>
<td>✓</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. <em>vulgare</em></td>
<td>Caryopsis</td>
<td>✓</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em></td>
<td>Caryopsis</td>
<td>✓</td>
</tr>
<tr>
<td><em>Triticum</em> “<em>nudum</em>”</td>
<td>Caryopsis</td>
<td>✓</td>
</tr>
<tr>
<td>*Triticum cf. “<em>nudum</em>”</td>
<td>Caryopsis</td>
<td>✓</td>
</tr>
<tr>
<td><em>Triticum dicoccum</em></td>
<td>Caryopsis</td>
<td>✓</td>
</tr>
<tr>
<td><em>Triticum monotococcum</em></td>
<td>Caryopsis</td>
<td>✓</td>
</tr>
<tr>
<td><em>Triticum</em> sp.</td>
<td>Caryopsis</td>
<td>✓</td>
</tr>
<tr>
<td>Triticeae</td>
<td>Caryopsis</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Legumes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Medicago</em> sp. / <em>Melilotus</em> sp. / <em>Trifolium</em> sp.</td>
<td>Seed</td>
<td>✓</td>
</tr>
</tbody>
</table>
One of the taxa in this assemblage (Pisum cf. sativum) could belong either to a domesticated cultivar from the Neolithic package (Pisum sativum) or be a wild part of the exploited natural resources autochthonous in the environment (Pisum elatius, Pinto da Silva 1989). If it was domesticated, it could be among the earliest cultivars found in the Iberian Peninsula so far. Unfortunately, its domesticated/wild status is simply indeterminable from solely the morphological point of view, as is often the case with most legume seeds (Weiss & Zohary 2011). Precisely because it appears together with clearly domesticated specimens, wheat and barley, these legumes might be considered as domesticated. Apart from this circular argument, however, no reliable evidence exists to support this idea; it has often been demonstrated that the existence of agriculture is always complemented by the exploitation of natural resources and the Neolithic domesticate package is not such an indissoluble package.

According to the current plant catalogue of the local environment (Pinto da Silva 1989), some of the plants listed, such as Atropa bella-donna, Vicia cracca, Chamaerops humilis or Corema album, are not currently present in the immediate environment of the site and must have been transported from elsewhere; the Chenopodium sp. specimens determined would be most likely Chenopodium album.

Abundant plant remains have been recovered in this assemblage (vid. Table 94). Charred plant remains assemblages are essentially biased towards plants and plant parts which, because of their uses and structural properties, are likely to become carbonised as a result of human activities (vid. Zapata Peña 2000). Although the conditions of burial (in underground pits instead of on the surface of a soil layer) are not particularly aggressive for the preservation of charred plant remains, the non-woody plant macroremains from São Pedro de Canaferrim are in general poorly preserved: on the one hand, the fragmentation rate is very heterogeneous, ranging between high (nearly 50%) and very low (100%); on
the other hand, the epidermis of most cereal and legumes grains is fragmentary or absent as they have abundant soil concretions attached. Preliminary experimental evidence shows that this latter phenomenon seems to be correlated with an exposure of the charred remains to environmental agents before burial (Antolín i Tutusaus 2012). The important differences which exist in the preservation conditions of the plant remains from each microstratigraphical unit point to the heterogeneity of the assemblages, as a result of their having originated in different charring events (vid. p. 132), not necessarily related to each other. In addition, the number of crop items per litre of sediment is heterogeneous but relatively low (vid. Table 95) and points to a slow but repeated deposition rather than a single large conflagration event (van der Veen 2007), although the deposition rate has not been daily.

An important bias has been introduced by the adoption of different recovery strategies which have not been uniformly applied through the different stratigraphical units, and has resulted in pits having striking differences in the composition of their charred assemblages. These differences can, in some cases, be identified as having a probable direct cause-effect relationship with the two recovery strategies employed (wet-sieving and flotation) (vid. Table 94):

- light flotation fractions have high numbers of fragile indeterminate plant tissue fragments, whilst in the other type of samples undetermined remains are scarce, probably because they have been either destroyed upon wet-sieving or not picked up upon sorting;
- the number of taxa is higher in wet-sieved samples than the minimum number of species, as a result of the friction exerted on the plant remains upon sieving, which tends to make them lose characteristic traits: for example, cereal remains which cannot be determined (Triticeae) are more abundantly recovered in wet-sieving samples, this is, cereal remains reach the analysis stage in a better condition which allows determination at least to genus level when they have undergone flotation. Large and dense grained legumes such as Pisum sativum and Vicia faba more likely to sink and appear in wet-sieved samples (Hubbard 1975).

However, and most unfortunately, in others cases it is difficult to ascertain whether the differences are recovery-induced or real depositional differences related to past human activities: for example, are Brassica sp./Sinapis sp. more prone to be recovered in flotation samples than wet-sieved ones.
Inés L. López-Dóriga

<table>
<thead>
<tr>
<th>N.D.</th>
<th>Pit SU 63</th>
<th>Pit SU 58</th>
<th>Pit 66</th>
<th>Pit SU 67</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.D.</td>
<td>SU 49-0</td>
<td>SU 49-1</td>
<td>SU 49-3</td>
<td>SU 49-4</td>
<td>SU 49-7</td>
</tr>
<tr>
<td>Samples</td>
<td>No. / No. with non-woody plant macroremains</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>NR / NDR</td>
<td>No. of remains</td>
<td>29</td>
<td>202</td>
<td>24</td>
<td>17</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>MNI (Minimum number of individuals)</td>
<td>10</td>
<td>100</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Species richness</td>
<td>NT (No. of taxa)</td>
<td>9</td>
<td>74</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>MNS (Minimum number of species)</td>
<td>0.9</td>
<td>0.74</td>
<td>0.78</td>
<td>0.67</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>No. of determined remains</td>
<td>10</td>
<td>100</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
<td>0.19</td>
<td>0.56</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Index (SU NT / Site NT)</td>
<td>0.14</td>
<td>0.5</td>
<td>0.18</td>
<td>0.18</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Table 94: Taphonomical description of the charred plant macroremain assemblage at São Pedro de Canaferrim.

<table>
<thead>
<tr>
<th>SU 49-0</th>
<th>SU 49-1</th>
<th>SU 49-3</th>
<th>SU 49-4</th>
<th>SU 49-7</th>
<th>SU 49-8</th>
<th>SU 64</th>
<th>SU 68</th>
<th>SU 70-0</th>
<th>SU 70-1</th>
<th>SU 70-2</th>
<th>SU 70-4</th>
<th>SU 57</th>
<th>SU 62-0</th>
<th>SU 62-1</th>
<th>SU 62-2</th>
<th>SU 72</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hordeum vulgare var. nudum MNI</td>
<td>19</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>10</td>
<td>26</td>
<td>14</td>
<td>9</td>
<td>5</td>
<td>1</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum FI</td>
<td>0.49</td>
<td>0.8</td>
<td>0.83</td>
<td>0.5</td>
<td>-</td>
<td>0.6</td>
<td>1</td>
<td>0.5</td>
<td>0.67</td>
<td>0.46</td>
<td>0.36</td>
<td>0.57</td>
<td>0.5</td>
<td>0.5</td>
<td>0.43</td>
<td>0.67</td>
</tr>
<tr>
<td>Triticum “nudum” MNI</td>
<td>14</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>15</td>
<td>4</td>
<td>9</td>
<td>9</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Triticum “nudum” FI</td>
<td>0.93</td>
<td>-</td>
<td>0.67</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>0.67</td>
<td>0.79</td>
<td>1</td>
<td>1</td>
<td>0.9</td>
<td>0.75</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Density (No. of crop items/litres of sediment)</td>
<td>6.6</td>
<td>0.8</td>
<td>1.4</td>
<td>1.4</td>
<td>0.6</td>
<td>1</td>
<td>0.8</td>
<td>0.2</td>
<td>2</td>
<td>8.8</td>
<td>5.8</td>
<td>2.6</td>
<td>2.8</td>
<td>2</td>
<td>2.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Table 95: Fragmentation index per crop taxa and crop density (deposition rate) at São Pedro de Canaferrim.
9.3.3 Discussion

The assemblage recovered at São Pedro de Canaferrim evidences the potential exploitation of several milieux. On the one hand, a cultivated grassland or cropfield in which domesticated cereals were grown. It is difficult to tell whether the cropfield was located near the site or if only final products arrived there for the final preparation for consumption, as both possibilities are equally plausible and the macroremain evidence does not allow a taphonomical analysis in that way. It can only be asserted that no evidence for local cultivation has been gathered (which does not mean there was no local cultivation). In any case, a wide range of domesticated crops of cereals, and potentially legumes, was available, which would have sustained the needs of a human group over the year, as cereals are easily storable and might even be preserved for several years in long-term storage structures, such as underground pits.

Naked barley (*Hordeum vulgare var. nudum*) and naked wheats (*Triticum nudum*) are the most abundant plant remains in the studied structures from Locus 2 at São Pedro de Canaferrim. The abundance of charred naked wheat and barley remains, with a few others of hulled wheats and barley, suggests that possibly the naked varieties were domesticated crops and the hulled ones merely weedy companions which would have lasted until the latter stages of crop processing. However, these divergent proportions could also be a result of taphonomy: if, for example, hulled varieties were also intentionally cultivated, they could have been intended for animal fodder, and in that case, would have few chances of becoming charred, as they would not need to be either cooked or dehusked. Another element to be pondered is the possibility of a maslin (mixed cultivation) of wheat and naked barley, their potential joint processing (as they are both naked varieties, they would need to undergo the same processing stages and would present similar fragmentation rates) or merely being discarded together, with other domestic by-products. Most cereal fractured edges have shown to have a typical postcharring appearance (Valamoti 2002), but in a high number of cases the pre- or post-charring character of the fractures has not been safely established. The fragmentation index analysis per naked cereal taxa which has been carried out to ascertain whether they could have been processed together shows that, although numbers are low and the confidence in the analysis is therefore low, the fragmentation indices are very different (*vid* Table 95) and thus point to the cereals being processed differently, if the high incidence of postdepositional fragmentation is not blurring this panorama.

The immediate environment of the site would have propitiated the appearance of nitrophilous species which usually thrive in disturbed habitats: *Chenopodium* sp., Malvaeeae, *Solanum* cf. *nigrum*. These taxa could, as well, have accompanied the cereal crops as agricultural weeds, or might have been intentionally gathered in their original habitats near water-courses and other dark humid areas, for the exploitation of their different properties. The same may be true of crucifers (*Brassica* sp./*Sinapis* sp.), legumes (*Vicia cracca*) and grasses (*Avena* sp.): they might serve as evidence both of weeds and of naturally available and exploitable resources. *Vicia cracca* does not, however, currently grow in the area: if indeed an agricultural weed, it might prove that the cropfield was elsewhere. It might, however, have been transported in the crop of a pigeon (*vid*. Vaquer & Ruas 2009).

The specific determination of weeds typical of particular crops could help infer if different crops were cultivated; however, plant remains that could have possibly belonged to crop weeds in São Pedro de Canaferrim are scarce and in many cases determinations have not reached the crucial specific level. On
the one hand, if preservation had been better, the specific determination of herbaceous plants that could
be weeds might have allowed for their interpretation as such, always tentative because not all potential
weeds in charred assemblages need necessarily to have been crop weeds, they could have also been
spontaneous herbs! On the other hand, weeds might have been truly absent from the crop product. This
could either be a result of the crops being already clean when charred (e.g. when cooking or in some
forms of storage) or due to the gathering of the cereal ears by hand-plucking or ear-stripping or due to
intensive cropfield weeding efforts. The absence of chaff could be interpreted as an evidence of the
former. In that case, the identified structures would have been the rubbish bins for discarding cooking
by-products and the crop processing stages, which would have produced different assemblages of plant
remains, would be located elsewhere (either in another part of the settlement which has not been
properly sampled for plant macroremains, or which has not been preserved or identified; or in another
complementary site, perhaps in the lower plains, as is suggested by Simões 1999). However, given the
present preservation circumstances (most charred macroremains are badly preserved), the absence of
chaff could also be a result of taphonomical bias, as chaff is much more fragile than grains and is earlier
destroyed (Boardman & Jones 1990). Under the present circumstances, it is likely that a cereal crop
store would have been available for piecemeal preparation and consumption, accounting for the
progressive deposition of domestic rubbish remains in regular quantities.

Several explanations between two poles might account for the assemblages in which cereals and
potential weeds arise; the case of SU 68 is given next as an example. The most restrictive hypothesis
suggests the existence of at least two charring events or processing activities: the cereals (Triticeae,
Hordeum vulgare var. nudum) and the legume (Vicia tp. cracea), crucifers (Brassica sp./Sinapis sp.)
and mallow (Malvaceae) are a processing by-product of the cereal crop; the fruits (Atropa bella-donna
and Chamaerops humilis) might have been present in the stomach of a large frugivorous bird that had
been hunted. The least restrictive hypothesis allows for each type of remain having been charred
accidentally and independently whilst processing the plant from which they come.

The second group of plant remains, according to their abundance in the carbonised assemblages at
São Pedro de Canaferrim, are grains of the crucifer(s) Brassica sp./Sinapis sp. These have been
recovered in particularly conspicuous numbers from Pit SU63 (44 grains, from SUs68 and 49). Their
abundance could be pointing to their intentional gathering or even cultivation, as they serve the same
purpose as legumes: they can be used as human food or animal fodder and contribute to enrich
agricultural soils by fixing nutrients. However, crucifers also have perennial weedy forms; in that case,
one of the origins of SU 68 and 49 assemblages could be the discard of the by-products of a particular
crop processing stage, sieving or screening, in which small grains of weeds are separated from the larger
cereal grains by weight or size. In addition, they are indehiscent and might have arrived by accident if
open-air hearths were lit in the site.

Vicia cracca seeds are also very abundant, but similarly to crucifers, they could be the remains of
crop weeds as well as an intentionally gathered product, cultivated or not. Both taxa have a dehiscent
reproductive mechanism which ejects the seeds when the pods ripen and open; however unlikely, this
event could account for the accidental presence of these seeds in the site, if the plants were growing
nearby and open-air hearths were kept. However, Vicia cracca does not currently grow in the area:
either its distribution has changed over time, or it was intentionally or accidentally transported from
elsewhere. These, together with other legumes present, such as Pisum sativum and Vicia faba, were
probably charred before having any previous treatment for consumption, as they are either complete (but often without testa) or irregularly broken (*vid.* Table 58, and Valamoti, Moniaki & Karathanou 2011).

Possible evidence of, either accidentally or intentionally, relative large-distance transportation of fruits, if current distributions are taken into account, has been gathered. Three plants (*Atropa bella-donna*, *Corema album* and *Chamaerops humilis*) whose natural habitat is not in the immediate environment of the site, but between dozens and hundreds of kilometres away, have arrived at the site. It is possible that these plants might have arrived within hunted animals’ contents, or been transported or traded/exchanged between human groups. Although these fruits ripen between summer and autumn, their storable life is longer with a previous drying treatment, and can thus be subjected to delayed consumption. They might have even been appreciated resources: berries of *C. album* have traditionally been highly valued for their taste, *Ch. humilis* dates might have been valued because of being exotic food-stuffs possibly difficult to obtain; *A. bella-donna* because of some of its powerful pharmaceutical properties; in addition to being an interesting poison which could be used against enemies, the plant possesses some medicinal attributes which few other plants possess, such as analgesic and mushroom poisoning antidotes, as well as psychoactive properties. In contrast, many other diuretic, anti-inflammatory and digestive plants could have been gathered locally.

The specimen of *Chamaerops humilis* from São Pedro de Canaferrim is the first and only archaeobotanical record in the Iberian Peninsula (with the exception of possible Palmae phytoliths in Can Sadurní, Blasco et al. 1999). The only other archaeobotanical record of the fruit of this plant comes from another Early Neolithic site in North Africa (Morales et al. 2013): does this evidence point to the existence of cultural links between those regions or is it just a result of a research or taphonomical bias? The tree is not present nowadays in the area from which it has been recovered, but it is found a little south (at least 50 kilometres). Has the past distribution been substantially modified? Past pollen and charcoal diagrams from the region are silent about this taxon, but this is probably a taphonomical bias: palm trees have a particular type of wood which is difficult to determine as charcoal in archaeological sites (Bouchaud, Thomas & Tengberg 2012), and their pollen, although it has sometimes been recorded at other Holocene sites in the Mediterranean, is infrequent because it is mostly dispersed by a weevil rather than the wind and difficult to determine morphologically (it can be easily mistaken with Liliaceae pollen; Núñez de la Fuente, pers. comm.). Probably for these reasons, the taxon does not appear in the pollen record of the other only site in which the fruit stones have been recovered abundantly (Zapata et al. 2013). If it is finally agreed that *Ch. humilis* was not present in the area, the mode of arrival of the fruit to the sites may be debated: is it a result of endozoochory (and was contained within the digestive tract of a hunted animal) or is it a result of human exchange? If so, an exchange between whom? Was it a luxury food? Dried fruits are preserved for a long time, several months, as is well known for palm dates, and can be the object of trade or exchange. Frugivorous mammals of medium and large size (carnivores and ungulates) are often long-distance seed transporters (Fedriani & Delibes 2009a).

The presence of *Atropa bella-donna* is probably a result of an intentional activity, probably related to the exploitation of its pharmaceutical properties. This is so because the whole plant contains toxic alkaloids, which can be used in a wide range of medicinal applications, and its effects are stronger when bearing fruits (Fern 1992-2010). Other uses for the plants are not known and endozoochory (animal ingestion and excretion) is only possible by birds, which might have been hunted (Vaquer & Ruas 2009).
Despite its current absence in the immediate environment (Pinto da Silva 1989), the plant might have been available in the area, as it is often a ruderal of disturbed habitats (Flora iberica 1986+). The case for Solanum nigrum is not as simple, because despite being toxic and having been the object of an intense medicinal exploitation, many animals disperse the seeds from this species after eating the berries (Debusche & Isenmann 1989) and it might act as a weed of some crops.

Corema album is a fruity taxa that seems to be the object of a thorough exploitation in the site, as different fruit parts appear constantly cross-stratigraphically (the same phenomenon occurs also at Lapiás das Lameiras): this plant is known to have been intensively exploited, both as food and as medicine, from the Roman era up to the most current times (e.g. Bugalhão & Queiroz 2005, Queiroz & Mateus 2011, van Leeuwaarden et al. 1999). However, an endozoochoric explanation (its being part of the stomach contents of hunted animals) for its presence in the site cannot be altogether rejected. It is very frequent on the sand dunes of the region’s coastal area, some 10km away.

9.4 Lapiás das Lameiras

For the description of the context, vid. 10.2.4 Lapiás das Lameiras (p. 104).

9.4.1 Plant macroremain assemblages

Very rich and relatively diverse assemblages have been obtained through the archaeobotanical analysis of the infilling of the pits of this site (vid. Error: Reference source not found, Figure 108, Figure 109, and Figure 110), with chronologies around 5400 cal BCE. Some amendments and additions have been made to the provisional and preliminary results published in conferences (López-Dóriga & Simões in press; López-Dóriga & Simões 2012).
Figure 108: Abundance of plant taxa (by NMI of seeds or fruits) by pit at Lapiás das Lameiras.
Part III B: Results: the carpological assemblages

Figure 109: Abundance of plant remains per category and SU in Lapiás das Lameiras.

Figure 110: Abundance of plant remains per category by SU in Lapiás das Lameiras. With the exception of the sections of SUs 38 and 28, provided by Teresa Simões, pit sections are ideal representations.
9.4.1.1 Pit SU 42

Plant remains from this pit come from four microstratigraphical units with very different quantities of remains but which belong exclusively to cereals and to a very limited number of taxa and species (vid. Table 96), mostly naked barley (*Hordeum vulgare var. nudum*) and wheat (*Triticum “nudum”*), and a few other indeterminate cereals (Triticeae and *Triticum* sp.) and a single hulled barley grain (*Hordeum vulgare var. vulgare*). Fragmentation rates in the two naked cereals, barley and wheat (vid. Table 97), possibly point to their similar processing in different events, represented in the varying deposition rates.

<table>
<thead>
<tr>
<th>SU 42</th>
<th>41-0</th>
<th>41-1</th>
<th>41-3</th>
<th>41-4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hordeum vulgare var. nudum MNI</td>
<td>149</td>
<td>19</td>
<td>28</td>
<td>1</td>
<td>197</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum NDR</td>
<td>298</td>
<td>34</td>
<td>53</td>
<td>2</td>
<td>387</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum FI</td>
<td>0.50</td>
<td>0.56</td>
<td>0.52</td>
<td>0.50</td>
<td>0.51</td>
</tr>
<tr>
<td>Triticum “nudum” MNI</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Triticum “nudum” NDR</td>
<td>18</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Triticum “nudum” FI</td>
<td>0.40</td>
<td>0.50</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Density (crop NMI/litre of sediment)</td>
<td>31.27</td>
<td>3.90</td>
<td>6.00</td>
<td>0.20</td>
<td>41.37</td>
</tr>
</tbody>
</table>

Table 96: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 42.

<table>
<thead>
<tr>
<th>SU 42</th>
<th>41-0</th>
<th>41-1</th>
<th>41-3</th>
<th>41-4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hordeum vulgare var. nudum MNI</td>
<td>149</td>
<td>19</td>
<td>28</td>
<td>1</td>
<td>197</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum NDR</td>
<td>298</td>
<td>34</td>
<td>53</td>
<td>2</td>
<td>387</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum FI</td>
<td>0.50</td>
<td>0.56</td>
<td>0.52</td>
<td>0.50</td>
<td>0.51</td>
</tr>
<tr>
<td>Triticum “nudum” MNI</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Triticum “nudum” NDR</td>
<td>18</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Triticum “nudum” FI</td>
<td>0.40</td>
<td>0.50</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Density (crop NMI/litre of sediment)</td>
<td>31.27</td>
<td>3.90</td>
<td>6.00</td>
<td>0.20</td>
<td>41.37</td>
</tr>
</tbody>
</table>

Table 97: Fragmentation index per crop taxa and crop density (deposition rate) at Lapiás das Lameiras: SU 42.
9.4.1.1.1 SU 41-0

Preservation of plant remains in this microstratigraphical unit is quite good, many grains are puffed. One remain has not been determined, the remainder belong to different cereal taxa (Triticeae, *Hordeum vulgare* var. *vulgare*, *Hordeum vulgare* var. *nudum*, *Triticum* sp., *Triticum "nudum"*).

9.4.1.1.2 SU 41-1

A few remains of indeterminate cereals (Triticeae), barley (*Hordeum vulgare* var. *nudum*) and wheats (*Triticum* sp., *Triticum "nudum"*, *Triticum dicoccum*) have been recovered in the sample from this microstratigraphical unit.

9.4.1.1.3 SU 41-3

An indeterminate remain, together with some determined ones from cereals (Triticeae), barley (*Hordeum vulgare* var. *nudum*) and wheats (*Triticum* sp., *Triticum "nudum"*, *Triticum dicoccum*) characterise the poor assemblage from this microstratigraphical unit. The grains of naked barley (*Hordeum vulgare* var. *nudum*) are puffed.

9.4.1.1.4 SU 43-4

Only a few naked barley (*Hordeum vulgare* var. *nudum*) fragments have been found in the sample from this microstratigraphical unit.

9.4.1.2 Pit SU 40

The assemblage infilling this pit is very heterogeneous, in terms of quantity, species richness, quality, degree of fragmentation and density (rate of deposition) of plant remains (*vid*. Table 98 and Table 99).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Samples No.</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>25</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>No. with plant macromacremains</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>25</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>No. with non-woody plant macromacremains</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>25</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>No. with determined non-woody plant macromacremains</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>25</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>NR / NR (No. of remains)</td>
<td>12</td>
<td>335</td>
<td>11</td>
<td>324</td>
<td>14</td>
<td>15</td>
<td>1</td>
<td>61</td>
<td>10</td>
<td>50</td>
<td>8</td>
<td>1</td>
<td>842</td>
</tr>
</tbody>
</table>
Table 98: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 40.

<table>
<thead>
<tr>
<th></th>
<th>SU 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDR</td>
<td>NDR (No. of determined remains)</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>MNI (Minimum number of individuals)</td>
</tr>
<tr>
<td></td>
<td>Index (MNI/NDR)</td>
</tr>
<tr>
<td>Species richness</td>
<td>NT (No. of taxa)</td>
</tr>
<tr>
<td></td>
<td>MNS (Minimum number of species)</td>
</tr>
<tr>
<td></td>
<td>Index (SU MNS / Site MNS)</td>
</tr>
<tr>
<td></td>
<td>Index (SU NT / Site NT)</td>
</tr>
</tbody>
</table>

Table 99: Fragmentation index per crop taxa and crop density (deposition rate) at Lapiás das Lameiras: SU 40.

<table>
<thead>
<tr>
<th></th>
<th>SU 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hordeum vulgare var. nudum MNI</td>
<td>5</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum NDR</td>
<td>7</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum FI</td>
<td>0.6</td>
</tr>
<tr>
<td>Triticum “nudum” MNI</td>
<td>1</td>
</tr>
<tr>
<td>Triticum “nudum” NDR</td>
<td>2</td>
</tr>
<tr>
<td>Triticum “nudum” FI</td>
<td>0.6</td>
</tr>
<tr>
<td>Density (crop NMI/litre of sediment)</td>
<td>1.1</td>
</tr>
</tbody>
</table>

9.4.1.2.1 SU 39-0

Scarce remains of barley (Hordeum vulgare, Hordeum vulgare var. nudum) and wheat (Triticum sp.) are present in the samples from this microstratigraphical unit.

9.4.1.2.2 SU 39-1

A moderate amount of plant remains have been found in samples from this microstratigraphical unit, belonging to a fruit (Corema album), a grass (Avena sp.), some legumes (Leguminosae, Lathyrus sp.,
Vicia cf. faba, Vicia tp. sativa), but mostly cereals (Triticeae, Hordeum vulgare, Hordeum vulgare var. nudum, Triticum sp. Triticum “nudum”, Triticum cf. dicoccum). Preservation is heterogeneous, ranging from good to poor, and varying between different taxa. Several naked barley grains have glumes preserved, one of them has been radiocarbon dated. Indeterminate remains are also relatively abundant.

9.4.1.2.3 SU 39-1/2

A very poorly preserved assemblage of plant macroremains has been recovered in the single sample from this interfacies between microstratigraphical units. It contains fragmentary indeterminate remains, indeterminate cereals (Triticeae), barley (Hordeum vulgare var. nudum) and indeterminate wheat (Triticum sp.).

9.4.1.2.4 SU 39-2

Remains in this microstratigraphical unit are heterogeneously preserved, either well or very poorly. The determined remains are abundant but not as much as could be expected from the high number of samples analysed. Indeterminate remains are scarce. Among the determined ones, some remains come from indeterminate cereals (Triticeae), barley (Hordeum vulgare) and wheat (Triticum sp.), but most belong to well determined naked cereal taxa (Hordeum vulgare var. nudum, Triticum “nudum”, Triticum cf. “nudum”). Some hulled wheats (Triticum dicoccum, Triticum cf. monococcum and Triticum monococcum from a single-grained spikelet), legumes (Leguminosae, Pisum sativum, Vicia tp. sativa and Vicia sp./Lathyrus sp.) are also present. Additionally, an awn of oats (Avena sp.) and a seed from a fruit (Corema album) have been recovered.

9.4.1.2.5 SU 39-2/3

A few plant macroremains have been recovered in the sample from this microstratigraphical unit interfacies, a possible pea (cf. Pisum sativum), some wheats (Triticum sp., Triticum “nudum”, Triticum monococcum from a single-grained spikelet), barley (Hordeum vulgare var. nudum), indeterminate cereals (Triticeae) and an indeterminate remain. Einkorn displays a remarkably good preservation.

9.4.1.2.6 SU 39-3

The six samples from this microstratigraphical unit have provided very fragmentary and poorly preserved remains from different cereal taxa (Triticeae, Hordeum vulgare var. nudum, Triticum sp., Triticum “nudum” and Triticum dicoccum/monococcum/nn).
9.4.1.2.7 SU 30-4

Only one plant macroremain has been recovered in the sample from this microstratigraphical unit, a whole bitter vetch seed (*Vicia* *tp. sativa*).

9.4.1.2.8 SU 39-5

Preservation of plant remains in this microstratigraphical unit is good and all remains have been determined. Naked cereals are the most abundant (*Hordeum vulgare* var. *nudum*, *Triticum* “*nudum*”) but others might also be present (*Triticeae*, *Triticum* sp.). A well-preserved *Triticum monococcum* grain from a single-grained spikelet has been radiocarbon dated. Remains of legumes (*Leguminosae*, *Vicia* cf. *faba* and *Vicia* *tp. sativa*) have also been recovered.

9.4.1.2.9 SU 39-6

This microstratigraphical unit is poor in plant remains in both quantity and quality. Less than a dozen fragments from indeterminate cereals (*Triticeae*) have been recovered.

9.4.1.2.10 SU 39-7

Samples from this microstratigraphical unit have yielded a few cereal (*Triticeae*, *Hordeum vulgare*, *Hordeum vulgare* var. *nudum*, *Triticum* sp., *Triticum “nudum*” and *Triticum dicoccum*), grasses (*Avena* sp.) and legume (*Leguminosae*) grain and grain fragments. In addition, a fruit endocarp fragment from a sloe (*Prunus spinosa*) has been identified.

9.4.1.2.11 SU 39-8

A very scarce quantity of fragmentary remains of cereal grains from several taxa (*Triticeae*, *Hordeum vulgare* var. *nudum*, *Triticum* sp. and *Triticum “nudum”*) have been recovered in samples from this microstratigraphical unit.

9.4.1.2.12 SU 40

A single grain of *Triticum* cf. “*nudum*” has been recovered in this sample.
9.4.1.3 Pit SU 38

This assemblage is very rich in the quantity of plant remains, but the distribution by microstratigraphical units and taxa is heterogeneous (vid. Table 100). Preservation is generally good, although the degree of fragmentation is high and uniform (abut 50 %) through the sequence. Whilst the deposition rate is fairly uniform and points to a periodical deposition of similar quantities of by-products, fragmentation indices between the two cereal crops (naked barley and naked wheat) are conspicuously different between the two taxa and the different depositional events (vid. Table 101), evidencing heterogeneous processing activities, particularly among the naked wheats.

<table>
<thead>
<tr>
<th></th>
<th>SU 38</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>37-1</td>
</tr>
<tr>
<td>Samples</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>1</td>
</tr>
<tr>
<td>No. with plant macroremains</td>
<td>1</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>1</td>
</tr>
<tr>
<td>No. with determined non-woody plant macroremains</td>
<td>1</td>
</tr>
<tr>
<td>NR / NDR</td>
<td></td>
</tr>
<tr>
<td>NR (No. of remains)</td>
<td>154</td>
</tr>
<tr>
<td>NDR (No. of determined remains)</td>
<td>154</td>
</tr>
<tr>
<td>Fragmentation</td>
<td></td>
</tr>
<tr>
<td>MNI (Minimum number of individuals)</td>
<td>77</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>0.50</td>
</tr>
<tr>
<td>Species richness</td>
<td></td>
</tr>
<tr>
<td>NT (No. of taxa)</td>
<td>7</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>4</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
<td>0.20</td>
</tr>
<tr>
<td>Index (SU NT / Site NT)</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Table 100: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 38.

<table>
<thead>
<tr>
<th></th>
<th>SU 38</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>37-1</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum MNI</td>
<td>33</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum NDR</td>
<td>76</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum FI</td>
<td>0.44</td>
</tr>
<tr>
<td>Triticum “nudum” MNI</td>
<td>5</td>
</tr>
<tr>
<td>Triticum “nudum” NDR</td>
<td>6</td>
</tr>
<tr>
<td>Triticum “nudum” FI</td>
<td>0.83</td>
</tr>
<tr>
<td>Density (crop NMI/litre of sediment)</td>
<td>7.68</td>
</tr>
</tbody>
</table>

Table 101: Fragmentation index per crop taxa and crop density (deposition rate) at Lapiás das Lameiras: SU 38.
9.4.1.3.1 SU 37-1

The sample from this microstratigraphical unit has produced abundant remains of cereals (Triticeae, *Hordeum vulgare* var. *nudum*, *Hordeum vulgare* var. *vulgare*, *Triticum* sp., *Triticum* “*nudum*” and *Triticum dicoccum*). Also, a remain of a fruit (*Corema album*) has been recovered. Preservation is heterogeneous, good in some barley grains but puffed wheat and barley grains are also abundant.

9.4.1.3.2 SU 37-2

Very abundant remains, on average with good preservation, have been recovered in samples from this microstratigraphical unit. One of the remains is undetermined. Most determined remains belong to cereals (Triticeae, *Hordeum vulgare* var. *nudum*, *Triticum* sp., *Triticum* “*nudum*”, *Triticum dicoccum* and *Triticum monococcum*). Other grasses (*Avena* sp., *Lolium* sp.) also have a testimonial presence, together with legumes (Leguminosae, *Lathyrus* sp., *Vicia* sp./*Lathyrus* sp., *Vicia* tp. *sativa*) and a fruit (*Corema album*).

9.4.1.3.3 SU 37-3

Remains of indeterminate cereals (Triticeae), barley (*Hordeum vulgare*, *Hordeum vulgare* var. *nudum*), wheats (*Triticum* sp., *Triticum* “*nudum*” and *Triticum dicoccum*) and a small legume (*Coronilla* sp./*Galega* sp.) have been recovered in moderate quantities and a relatively homogeneous good state of preservation. Some grains preserve their glumes, others are puffed.

9.4.1.4 Pit SU 32

Plant remains in this assemblage are preserved quite well, despite the high fragmentation (around 50%) (*vid. Table 102*). With the exception of one rich microstratigraphical unit (31-1), in both quantity and species richness, the assemblage is in general poor with very low deposition rates. Cereal crops were probably processed separately, as shown by the different quantities and fragmentation indices of naked barley and naked wheat (*vid. Table 103*).

<table>
<thead>
<tr>
<th></th>
<th>SU 32</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31-0</td>
</tr>
<tr>
<td>Samples</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>2</td>
</tr>
<tr>
<td>No. with plant macroremains</td>
<td>2</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>2</td>
</tr>
<tr>
<td>No. with determined non-woody plant macroremains</td>
<td>2</td>
</tr>
<tr>
<td>NR / NDR</td>
<td></td>
</tr>
<tr>
<td>NR (No. of remains)</td>
<td>32</td>
</tr>
<tr>
<td>NDR (No. of determined remains)</td>
<td>32</td>
</tr>
</tbody>
</table>
### Part III B: Results: the carpological assemblages

#### SU 32

<table>
<thead>
<tr>
<th>Fragmentation</th>
<th>SU 32</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31-0</td>
</tr>
<tr>
<td>MNI (Minimum number of individuals)</td>
<td>17</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>0.53</td>
</tr>
<tr>
<td>Species richness</td>
<td></td>
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<tr>
<td>NT (No. of taxa)</td>
<td>5</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>3</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
<td>0.15</td>
</tr>
<tr>
<td>Index (SU NT / Site NT)</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Table 102: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 32.

<table>
<thead>
<tr>
<th>Hordeum vulgare var. nudum MNI</th>
<th>SU 32</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31-0</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum NDR</td>
<td>6</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum FI</td>
<td>11</td>
</tr>
<tr>
<td>Triticum “nudum” MNI</td>
<td>0.55</td>
</tr>
<tr>
<td>Triticum “nudum” NDR</td>
<td>1</td>
</tr>
<tr>
<td>Triticum “nudum” FI</td>
<td>1</td>
</tr>
<tr>
<td>Density (crop NMI/litre of sediment)</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 103: Fragmentation index per crop taxa and crop density (deposition rate) at Lapiás das Lameiras: SU 32.

#### 9.4.1.4.1 SU 31-0

All plant macroremains in this microstratigraphical unit have been determined. Because of the poor preservation, it has been possible to ascertain that a few belong to Triticaceae, indeterminate barley (Hordeum vulgare), wheat (Triticum sp.) and legume (Leguminosae). Naked cereals (Hordeum vulgare var. nudum and Triticum “nudum”) are little more abundant.

#### 9.4.1.4.2 SU 31-1

Samples from this microstratigraphical unit have provided abundant determined remains. Diverse legumes (Leguminosae, Vicia sp./Lathyrus sp., Lathyrus sativus/Vicia ervilia, Vicia sp., Vicia sp. sativa and Lens cf. culinaris), a grass (Gramineae), hulled cereals (Triticum dicoccum, Triticum monococcum from a 1-grained spikelet and Hordeum vulgare var. vulgare) and less diverse but more numerous naked cereals (Hordeum vulgare var. nudum, Triticum “nudum” and Triticum cf. “nudum”) and indeterminate wheat (Triticum sp.) and cereal (Triticaceae) characterise the assemblage. The state of preservation is heterogeneous among the different remains, ranging from poor to good, with differences per taxa. Some barley and naked wheat grains are notably well preserved, a barley grain preserves the
glumes, but others are puffed, particularly the Triticeae (reducing the possibility of identifying them more precisely).

### 9.4.1.4.3 SU 31-3

This microstratigraphical unit has yielded an undetermined remain, together with several determined ones, mostly from naked cereals (*Hordeum vulgare* var. *nudum* and *Triticum* “*nudum*”) but also from other possible cereals (Triticeae, *Hordeum vulgare*, *Triticum* cf. *monococcum*), and legumes (*Lathyrus* sp. and cf. *Pisum sativum*).

### 9.4.1.4.4 SU 31-4

The single sample from this microstratigraphical unit has produced a few fragmentary remains of bitter vetch (*Vicia* tp. *sativa*), naked barley (*Hordeum vulgare* var. *nudum*) and possibly naked wheat (*Triticum* cf. “*nudum*”).

### 9.4.1.5 Pit SU 28

This pit has provided one of the richest assemblages at the site, with very abundant plant macrobotanical remains belonging to diverse plants. Differences between microstratigraphical units are conspicuous, in the quality, quantity, species richness and deposition rates of the remains (*vid.* Table 104). Fragmentation is also variable but fairly high (around 50 %) and in some cases is similar for the two naked cereal crops (*vid.* Table 105), which were possibly processed together or in a similar way.

<table>
<thead>
<tr>
<th></th>
<th>SU 28</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27-0</td>
</tr>
<tr>
<td><strong>Samples</strong></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>3</td>
</tr>
<tr>
<td>No. with plant macroremains</td>
<td>3</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>3</td>
</tr>
<tr>
<td>No. with determined non-woody plant macroremains</td>
<td>3</td>
</tr>
<tr>
<td><strong>NR / NDR</strong></td>
<td></td>
</tr>
<tr>
<td>NR (No. of remains)</td>
<td>118</td>
</tr>
<tr>
<td>NDR (No. of determined remains)</td>
<td>118</td>
</tr>
<tr>
<td><strong>Fragmentation</strong></td>
<td></td>
</tr>
<tr>
<td>MNI (Minimum number of individuals)</td>
<td>64</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>0.54</td>
</tr>
<tr>
<td><strong>Species richness</strong></td>
<td></td>
</tr>
<tr>
<td>NT (No. of taxa)</td>
<td>4</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>2</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Table 104: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 28.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Index (SU NT / Site NT)</td>
<td>0.11</td>
<td>0.34</td>
<td>0.23</td>
<td>0.14</td>
<td>0.11</td>
<td>0.29</td>
<td>0.23</td>
<td>0.11</td>
<td>0.17</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Table 105: Fragmentation index per crop taxa and crop density (deposition rate) at Lapiás das Lameiras: SU 28.

9.4.1.5.1 SU 27-0

Preservation of plant macroremains in this microstratigraphical unit is poor on average, but some grains stand out due to their good preservation. Only cereals have been recovered, mostly naked barley (*Hordeum vulgare* var. *nudum*) and naked wheat (*Triticum* “*nudum*”), but also indeterminate wheat (*Triticum* sp.) and barley (*Hordeum vulgare*).

9.4.1.5.2 SU 27-2

A few indeterminate remains, together with very abundant determined ones characterise the assemblage from this microstratigraphical unit. The most abundant taxa are naked barleys (*Hordeum vulgare* var. *nudum*), followed by naked wheats (*Triticum* “*nudum*”). Less abundant are other cereal taxa (*Triticaceae*, *Triticum* sp., *Triticum* cf. “*nudum*”, *Triticum dicoccum* and *Triticum monococcum* from both single and double-grained spikelets), legumes (*Leguminosae*, *Vicia* cf. *faba*, *Vicia* sp./*Lathyrus* sp.) and a fruit (*Corema album*). The state of preservation is very heterogeneous but there seems to be a slight tendency to find better preserved specimens at greater depths than in the uppermost part of the microstratigraphical unit. An emmer grain (*Triticum dicoccum*) has been radiocarbon dated.
The average state of preservation of the assemblage recovered in this microstratigraphical unit is poor. A few remains of legumes (*Vicia* spp.), grasses (*Avena* sp.), wheats (*Triticum* spp., *Triticum* “nudum”, *Triticum* monococcum from a single grained spikelet) and indeterminate cereals (Triticeae) accompany abundant grains and grain fragments of naked barley (*Hordeum vulgare* var. *nudum*).

Remains from cereals (Triticeae, *Hordeum vulgare* var. *nudum*, *Triticum* sp., *Triticum* “nudum”, *Triticum* cf. “nudum”) and an indeterminate legume (Leguminosae) have been identified in samples from this microstratigraphical unit. An undetermined remain is also present. Preservation is bad, ranging from poor to very poor.

A single sample from this microstratigraphical unit has provided a limited assemblage with poor preservation, in which only cereal remains have been recovered, from naked wheats (*Triticum* “nudum”), hulled wheats (*Triticum* dicoccum/monococcum/nn), hulled barley (*Hordeum vulgare* var. *vulgare*) and an indeterminate wheat (*Triticum* sp.).

In this microstratigraphical unit, samples have yielded plentiful grains and grain fragments from naked cereals (mostly *Hordeum vulgare* var. *nudum* but also *Triticum* “nudum”), a few remains from other cereals (*Hordeum vulgare* var. *vulgare*, *Triticum* sp., *Triticum* dicoccum/monococcum/nn and *Triticum* monococcum from a single grained spikelet), grasses (*Avena* sp., Gramineae) and legumes (*Medicago* sp./*Melilotus* sp./*Trifolium* sp. and *Vicia* cf. *faba*). Preservation ranges from poor to quite good.

An indeterminate remain has been recovered in this microstratigraphical unit. Determined remains are grains and grain fragments that belong mostly to cereals, which are in some cases forming crusts or have hollows in their surface. The identified taxa are naked cereals (*Hordeum vulgare* var. *nudum* and *Triticum* “nudum”) and wheat (*Triticum* sp.). Other less numerous remains are einkorn (*Triticum monococcum* from a single grained spikelet), oats (*Avena* sp.) and legumes (Leguminosae, *Vicia* tp. *sativa*, *Vicia* sp./*Lathyrus* sp.).
9.4.1.5.8 SU 27-8

Abundant remains of cereals (*Hordeum vulgare* var. *nudum, Triticum* sp. and *Triticum “nudum”*) and a legume (*Vicia* tp. *sativa*) and an indeterminate remain have been recovered in this microstratigraphical unit, preservation varies from to poor to quite good, with some grains with hollows.

9.4.1.5.9 SU 27-9

Cereals (*Hordeum vulgare* var. *nudum, Triticum* sp. and *Triticum “nudum”*) and legumes (*Lathyrus* sp., *Vicia* tp. *sativa* and an indeterminate *Leguminosae*) have been recovered in small numbers in the sample from this microstratigraphical unit.

9.4.1.6 Pit SU 29

The assemblage from this pit is the richest in species richness and quantity of plant macroremains at the whole site. Conspicuous differences are seen between the microstratigraphical units, with varying amounts of plant remains of several plants, in heterogeneous states of preservation, degrees of fragmentation and density (deposition rates) (*vid. Table 106*). Fragmentation rates of the two naked cereal crops are similar in some cases, possibly pointing to their joint processing (*vid. Table 107*).

<table>
<thead>
<tr>
<th>Samples</th>
<th>SU 29</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26-0</td>
</tr>
<tr>
<td>No.</td>
<td>3</td>
</tr>
<tr>
<td>No. with plant macroremains</td>
<td>3</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>3</td>
</tr>
<tr>
<td>No. with determined non-woody plant macroremains</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NR / NDR</th>
<th>SU 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR (No. of remains)</td>
<td>281</td>
</tr>
<tr>
<td>NDR (No. of determined remains)</td>
<td>273</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fragmentation</th>
<th>SU 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN (Minimum number of individuals)</td>
<td>141</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>0.52</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species richness</th>
<th>SU 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>NT (No. of taxa)</td>
<td>8</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>5</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
<td>0.25</td>
</tr>
<tr>
<td>Index (SU NT / Site NT)</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Table 106: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 29.
Table 107: Fragmentation index per crop taxa and crop density (deposition rate) at Lapiás das Lameiras: SU 29.

<table>
<thead>
<tr>
<th></th>
<th>SU 29</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26-0</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum MNI</td>
<td>62</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum NDR</td>
<td>128</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum FI</td>
<td>0.48</td>
</tr>
<tr>
<td>Triticum “nudum” MNI</td>
<td>4</td>
</tr>
<tr>
<td>Triticum “nudum” NDR</td>
<td>8</td>
</tr>
<tr>
<td>Triticum “nudum” FI</td>
<td>0.47</td>
</tr>
<tr>
<td>Density (crop NMI/litre of sediment)</td>
<td>13.13</td>
</tr>
</tbody>
</table>

9.4.1.6.1 SU 26-0

Plant remains from this microstratigraphical unit are very abundant but in a poor state of preservation, and belong to undetermined taxa, legumes (Lathyrus sp.), herbs (Salsola sp.) and cereals: grains of Triticeae, Hordeum vulgare var. nudum, Triticum sp., Triticum “nudum”, Triticum dicoccum and a spikelet fork of a hulled wheat (T. dicoccum/T. monococcum/T. nn).

9.4.1.6.2 SU 26-1

Relatively few and poorly preserved remains have been recovered from this microstratigraphical unit, belonging to naked barley (Hordeum vulgare var. nudum), wheats (Triticum sp., Triticum “nudum”) and undetermined remains.

9.4.1.6.3 SU 26-2

Naked barley (Hordeum vulgare var. nudum), wheat (Triticum sp., Triticum “nudum”, Triticum dicoccum) and indeterminate legumes (Leguminosae) grains and grain fragments have been recovered in the single sample from this microstratigraphical unit.

9.4.1.6.4 SU 26-3

The plentiful plant macroremains in the samples from this microstratigraphical unit are in a very heterogeneous state of preservation, ranging from very good to poor, although for most and on average it is relatively good. Half a dozen remains are undetermined. Determined remains are mostly grains that belong to cereals (Triticeae, Hordeum vulgare var. vulgare, Hordeum vulgare var. nudum, Triticum sp., Triticum “nudum”, Triticum dicoccum, Triticum monococcum from a single-grained spikelet, Triticum cf. monococcum), a wild grass (Gramineae) and legumes (Leguminosae, Vicia tp. sativa, Vicia
Part III B: Results: the carpological assemblages

sp./Lathyrus sp.). A probable rachis segment from a naked tetraploid wheat \((T. durum/T. turgidum)\) has also been recovered. In addition, this microstratigraphical unit has provided a Rosaceae/Ericaceae pome fragment and a crust of three Corema album seeds in anatomical connexion, which is interpreted as a smashed fruit.

9.4.1.6.5 SU 26-4

One sample has been obtained from this microstratigraphical unit, which has provided very abundant seeds from diverse cereals (Hordeum vulgare var. nudum, Triticum sp., Triticum “nudum”, Triticum dicoccum), a spikelet fork of a hulled wheat \((T. dicoccum/T. monococcum/T. nn)\) and a few legume grains (cf. Pisum sativum, Vicia tp. cracca, Vicia tp. sativa, Vicia sp./Lathyrus sp., Lathyrus sp.).

9.4.1.6.6 SU 26-5

The preservation of plant macroremains in this microstratigraphical unit is heterogeneous, from good to poor, without allowing for the detection of a trend. A single remain has remained undetermined. Determined remains are diverse cereal grains and grains fragments (Triticeae, Hordeum vulgare var. nudum, Triticum sp., Triticum “nudum”, Triticum cf. “nudum”, Triticum dicoccum, Triticum monococcum from single-grained spikelets and Triticum cf. monococcum), herbs (Avena sp., Galium sp./Asperula sp. and Malva sp.), pulses (Leguminosae, Lathyrus sp., Vicia sp./Lathyrus sp., Vicia tp. sativa and Vicia cf. faba) and fruits (Corema album).

9.4.1.6.7 SU 26-5/6

A sample from the interfacies between microstratigraphical units 26-5 and 26-6 has yielded few plant macroremains, restricted to a legume fragment (Leguminosae indet.) and 3 cereal grains and 1 cereal grain fragment (Hordeum vulgare var. nudum and Triticum “nudum”). A naked wheat grain (Triticum “nudum”) from this sample has been radiocarbon dated.

9.4.1.6.8 SU 26-7/8

The interfacies between these microstratigraphical units has provided a sample with several grains and grain fragments from cereals (Hordeum vulgare var. nudum, Triticum sp. and Triticum “nudum”) and legumes (Leguminosae indet. and Vicia tp. cracca), in a poor state of preservation.

9.4.1.6.9 SU 26-8

Preservation of plant macroremains in this microstratigraphical unit is good, some cereal grains even preserve their glumes but others are puffed. The assemblage is very rich in numbers, but restricted to
certain cereal taxa (*Hordeum vulgare* var. *nudum*, *Triticum* sp. and *Triticum* “*nudum*”), and much less of others (*Triticeae, Hordeum vulgare* var. *vulgare*, *Triticum dicoccum*, *T. cf. dicoccum*, *Triticum monococcum* from single and double-grained spikelets, *T. cf. monococcum*), grasses (Gramineae indet. and *Avena* sp.) and legumes (Leguminosae indet., *Vicia* tp. *sativa*).

**9.4.1.6.10 Pit SU 25**

This pit is one of the poorest at the site, both in quantity and species richness of plant remains. Notably, fragmentation is in general low (vid. Table 108). Only remains from one of the crops, naked barley, is present, and in such low quantities that the different fragmentation indices between microstratigraphical units (vid. Table 109), which might be a result of different processing activities, are unreliable.

<table>
<thead>
<tr>
<th></th>
<th>SU 25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21-0</td>
</tr>
<tr>
<td><strong>Samples</strong></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>1</td>
</tr>
<tr>
<td>No. with plant macroremains</td>
<td>1</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>1</td>
</tr>
<tr>
<td>No. with determined non-woody plant macroremains</td>
<td>1</td>
</tr>
<tr>
<td><strong>NR / NDR</strong></td>
<td></td>
</tr>
<tr>
<td>NR (No. of remains)</td>
<td>1</td>
</tr>
<tr>
<td>NDR (No. of determined remains)</td>
<td>1</td>
</tr>
<tr>
<td><strong>Fragmentation</strong></td>
<td></td>
</tr>
<tr>
<td>MNI (Minimum number of individuals)</td>
<td>1</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Species richness</strong></td>
<td></td>
</tr>
<tr>
<td>NT (No. of taxa)</td>
<td>1</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>1</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
<td>0.05</td>
</tr>
<tr>
<td>Index (SU NT / Site NT)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 108: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 25.

<table>
<thead>
<tr>
<th></th>
<th>SU 25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21-0</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. <em>nudum</em> MNI</td>
<td>1</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. <em>nudum</em> NDR</td>
<td>1</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. <em>nudum</em> FI</td>
<td>1.00</td>
</tr>
<tr>
<td>Density (crop NMI/litre of sediment)</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Table 109: Fragmentation index per crop taxa and crop density (deposition rate) at Lapiás das Lameiras: SU 25.
9.4.1.6.11 SU 21-0

A naked barley grain (*Hordeum vulgare* var. *nudum*) has been recovered from the sample from this microstratigraphical unit.

9.4.1.6.12 SU 21-2

A single fragment of Triticeae has been recovered in the sample examined from this microstratigraphical unit; its state of preservation is very poor.

9.4.1.6.13 SU 21-3

The sample from this microstratigraphical unit has provided an indeterminate remain, a grain and a grain fragment from naked barley (*Hordeum vulgare* var. *nudum*), and an indeterminate legume (*Leguminosae*).

9.4.1.7 Pit SU 34

Plant remains in this assemblage are quantitatively abundant, but poor in preservation quality, and with heterogeneous degrees of fragmentation and species richness (*vid*. Table 110). Deposition rates (densities) are also heterogeneous. Fragmentation indices among the cereal crops are interspecifically and interstratigraphically heterogeneous (*vid*. Table 111), pointing to differences in preparation between the two products and between the different depositional events.

<table>
<thead>
<tr>
<th>Samples</th>
<th>SU 34</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10-0</td>
</tr>
<tr>
<td>No.</td>
<td>4</td>
</tr>
<tr>
<td>No. with plant macroremains</td>
<td>4</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>4</td>
</tr>
<tr>
<td>No. with determined non-woody plant macroremains</td>
<td>4</td>
</tr>
<tr>
<td>NR / NDR</td>
<td>147</td>
</tr>
<tr>
<td>NR (No. of remains)</td>
<td>144</td>
</tr>
<tr>
<td>NDR (No. of determined remains)</td>
<td>80</td>
</tr>
<tr>
<td>Fragmentation</td>
<td></td>
</tr>
<tr>
<td>MNI (Minimum number of individuals)</td>
<td>0.56</td>
</tr>
<tr>
<td>Species richness</td>
<td></td>
</tr>
<tr>
<td>NT (No. of taxa)</td>
<td>9</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>7</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
<td>0.35</td>
</tr>
<tr>
<td>Index (SU NT / Site NT)</td>
<td>0.26</td>
</tr>
</tbody>
</table>

431
Table 110: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 34.

<table>
<thead>
<tr>
<th></th>
<th>SU 34</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10.0 10.1 10.2 10.6 Total</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. <em>nudum</em> MNI</td>
<td>44 1 42 38 124</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. <em>nudum</em> NDR</td>
<td>90 3 96 69 258</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. <em>nudum</em> FI</td>
<td>0.48 0.28 0.44 0.55 0.48</td>
</tr>
<tr>
<td><em>Triticum</em> “nudum” MNI</td>
<td>7 2 6 1 15</td>
</tr>
<tr>
<td><em>Triticum</em> “nudum” NDR</td>
<td>12 4 12 2 30</td>
</tr>
<tr>
<td><em>Triticum</em> “nudum” FI</td>
<td>0.56 0.44 0.46 0.25 0.48</td>
</tr>
<tr>
<td>Density (crop NMI/litre of sediment)</td>
<td>10.05 0.52 9.58 7.63 27.78</td>
</tr>
</tbody>
</table>

Table 111: Fragmentation index per crop taxa and crop density (deposition rate) at Lapiás das Lameiras: SU 34.

9.4.1.7.1 SU 10-0

Indeterminate remains (plant tissue and a fruit fragment), together with abundant determined remains from different cereal (*Hordeum vulgare* var. *nudum*, *Triticum* sp., *Triticum“nudum”, *Triticum dicoccum*,) and legume taxa (Leguminosae, *Lathyrus* sp., *Lens culinaris*, *Vicia* tp. *cracca* and *Vicia* tp. *sativa*), have been recovered in this microstratigraphical unit, with poor or very poor preservation.

9.4.1.7.2 SU 10-1

A single sample from this microstratigraphical unit has provided abundant but very fragmentary Triticeae remains, together with a few poorly preserved barley (*Hordeum vulgare* var. *nudum*) fragments and several wheat fragments and grains (*Triticum* sp., *Triticum “nudum”*, *Triticum dicoccum* and *Triticum monococcum* from a single-grained spikelet), legume cotyledons and grains (*Lathyrus* sp., *Vicia* tp. *sativa*, *Vicia* sp., Leguminosae indet.) and a pome fruit fragment (Rosaceae/Ericaceae).

9.4.1.7.3 SU 10-2


432
9.4.1.7.4 SU 10-6

Diverse cereals (*Hordeum vulgare* var. *vulgare* and *Hordeum vulgare* var. *nudum*, *Triticum* sp., *Triticum “nudum”, Triticum dicoccum and Triticum monococcum* from a single-grained spikelet) and legumes (*Leguminosae*, *Lathyrus* sp., *Vicia* tp. *sativa*) have been found in the sample from this microstratigraphical unit, in heterogeneous states of preservation: whilst some remains are well preserved, others (notably glume wheats) are poorly preserved. Undetermined remains are also present. A radiocarbon date has been obtained for a seed from *Hordeum vulgare* var. *vulgare*.

9.4.1.8 Pits SUs 34/36 / SUs10/35

A few remains of cereals (*Hordeum vulgare*, *Triticum “nudum”, Triticum sp.) and undetermined remains have been provided by the two samples from the interface between these two features (*vid. Table 112*). Due to the character of the stratigraphical unit, no attempt has been made to compare the different depositional rates and fragmentation indices of crops.

<table>
<thead>
<tr>
<th>Samples</th>
<th>SU 34-36</th>
<th>10-35</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>No. with plant macroremains</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No. with determined non-woody plant macroremains</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>NR / NDR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NR (No. of remains)</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>NDR (No. of determined remains)</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Fragmentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNI (Minimum number of individuals)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>index (MNI/NDR)</td>
<td></td>
<td>0.58</td>
</tr>
<tr>
<td>Species richness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NT (No. of taxa)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
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<td>0.10</td>
</tr>
<tr>
<td>Index (SU NT / Site NT)</td>
<td></td>
<td>0.09</td>
</tr>
</tbody>
</table>

Table 112: Taphonomical description of the charred plant macroremain assemblage at Lapias das Lameiras: SUs 34-36.

9.4.1.9 Pit SU 36 / SU 35-1

The three samples from this microstratigraphical unit have yielded poorly preserved plant macroremains from legumes (*Vicia* sp./*Lathyrus* sp., *Leguminosae*) and cereals (*Hordeum vulgare* var. *nudum*, *Triticum “nudum”, Triticum sp.*), together with an indeterminate remain (*vid. Table 113*). Fragmentation indices among the two cereal crops are very different (*vid. Table 114*), so they have probably undergone different processing actions.
### Table 113: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 36.

<table>
<thead>
<tr>
<th>Samples</th>
<th>SU 36</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
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</tr>
<tr>
<td>No. with plant macroremains</td>
<td>3</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>3</td>
</tr>
<tr>
<td>No. with determined non-woody plant macroremains</td>
<td>3</td>
</tr>
<tr>
<td>NR / NDR</td>
<td></td>
</tr>
<tr>
<td>NR (No. of remains)</td>
<td>61</td>
</tr>
<tr>
<td>NDR (No. of determined remains)</td>
<td>60</td>
</tr>
<tr>
<td>Fragmentation</td>
<td></td>
</tr>
<tr>
<td>MNI (Minimum number of individuals)</td>
<td>30</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>0.50</td>
</tr>
<tr>
<td>Species richness</td>
<td></td>
</tr>
<tr>
<td>NT (No. of taxa)</td>
<td>5</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>4</td>
</tr>
<tr>
<td>Index (SU MNS / Site MNS)</td>
<td>0.20</td>
</tr>
<tr>
<td>Index (SU NT / Site NT)</td>
<td>0.14</td>
</tr>
</tbody>
</table>

### Table 114: Fragmentation index per crop taxa and crop density (deposition rate) at Lapiás das Lameiras: SU 36.

<table>
<thead>
<tr>
<th>Crop</th>
<th>SU 36</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Hordeum vulgare</em> var. <em>nudum</em> MNI</td>
<td>16</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. <em>nudum</em> NDR</td>
<td>43</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> var. <em>nudum</em> FI</td>
<td>0.37</td>
</tr>
<tr>
<td><em>Triticum</em> “<em>nudum</em>” MNI</td>
<td>7</td>
</tr>
<tr>
<td><em>Triticum</em> “<em>nudum</em>” NDR</td>
<td>8</td>
</tr>
<tr>
<td><em>Triticum</em> “<em>nudum</em>” FI</td>
<td>0.88</td>
</tr>
<tr>
<td>Density (crop NMI/litre of sediment)</td>
<td>4.62</td>
</tr>
</tbody>
</table>

### 9.4.1.10 Pit SU 48 / SU 47

A few and very fragmentary plant macroremains have been recovered from this microstratigraphical unit (*vid.* Table 115), from different cereals (*Triticeae*, *Hordeum vulgare* var. *nudum*, *Triticum* sp., *Triticum* “*nudum*”) and legumes (*Leguminosae*). No attempt has been made to analyse the existence of potentially different processing activities for the different crops, as their abundance is very restricted.
Table 115: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 48.

9.4.1.11 Pit SU 122

This pit has provided a poor assemblage of plant remains, in preservation, quantity and species richness (vid. Table 116).

Table 116: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SU 122.
9.4.1.11.1 SU 118-0

Plant remains from this microstratigraphical unit are very scarce and are poorly preserved, limited to two Triticeae fragments.

9.4.1.11.2 SU 118-4

A dozen Triticeae fragments have been recovered from this microstratigraphical unit.

9.4.2 Overview

The complete list of taxa identified at Lapiás das Lameiras is presented next (Table 117).

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grasses</strong></td>
<td></td>
</tr>
<tr>
<td><em>Avena</em> sp.</td>
<td>Caryopsis, awn</td>
</tr>
<tr>
<td><em>Lolium</em> sp.</td>
<td>Caryopsis</td>
</tr>
<tr>
<td><em>Hordeum vulgare var. nudum</em></td>
<td>Caryopsis</td>
</tr>
<tr>
<td><em>Hordeum vulgare var. vulgare</em></td>
<td>Caryopsis</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em></td>
<td>Caryopsis</td>
</tr>
<tr>
<td><em>Triticum &quot;nudum&quot;</em></td>
<td>Caryopsis</td>
</tr>
<tr>
<td><em>Triticum &quot;nudum&quot;</em> cf. tetraploid</td>
<td>Rachis segment</td>
</tr>
<tr>
<td><em>Triticum dicoccum</em></td>
<td>Caryopsis</td>
</tr>
<tr>
<td><em>Triticum monococcum</em></td>
<td>Caryopsis</td>
</tr>
<tr>
<td><em>Triticum &quot;vestitum&quot;</em></td>
<td>Spikelet fork</td>
</tr>
<tr>
<td><em>Triticum sp.</em></td>
<td>Caryopsis</td>
</tr>
<tr>
<td>Triticeae</td>
<td>Caryopsis</td>
</tr>
<tr>
<td><strong>Legumes</strong></td>
<td></td>
</tr>
<tr>
<td><em>Coronilla</em> sp. / <em>Galega</em> sp.</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Lathyrus cicera / sativus</em></td>
<td>Seed</td>
</tr>
<tr>
<td><em>Lathyrus</em> sp.</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Lens cf. culinaris</em></td>
<td>Seed</td>
</tr>
<tr>
<td><em>Medicago / Melilotus / Trifolium</em></td>
<td>Seed</td>
</tr>
<tr>
<td><em>Pisum cf. sativum</em></td>
<td>Seed</td>
</tr>
<tr>
<td><em>Vicia</em> sp. cracca</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Vicia</em> cf. faba</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Vicia</em> sp. sativa</td>
<td>Seed</td>
</tr>
</tbody>
</table>
Several specimens in the assemblage (*Lathyrus cicera/sativus, Lens cf. culinaris, Pisum cf. sativum, Vicia sativa, Vicia ervilia/Lathyrus cicera/sativus*) could either belong to domesticated plants in the Neolithic package or be simply part of the exploited autochthonous wild resources in the region (*Lens nigricans, Pisum elatius*, etc); taxa that are similar to those of Neolithic domesticate agriculture. Should they have been domesticated, they could be the earliest cultivars found in the Iberian Peninsula so far. Unfortunately, the specimens are simply indeterminable from solely the morphological point of view, as is often the case with most legume seeds (Weiss & Zohary 2011). Some authors would argue that just because they appear together with clearly domesticated specimens, wheat and barley, these legumes would be domesticated. However, no reliable evidence, apart from this circular argument, supports this idea: the existence of domestic agriculture has been often perceived to complement by the exploitation of natural resources, and the Neolithic domesticate package is not such an indissoluble package.

All examined samples contained charred plant macroremains and almost all contained non-woody plant macroremains; determined remains have been found to be predominant and undetermined are scarcer (*vid* Table 118 and Table 119). It is uncertain how this rarity of undetermined remains might be a result of a bias caused by sorting with the naked eye.

Most pits have provided charred plant macroremains in very heterogeneous qualities of preservation, very divergent quantities and species richness indices, thus pointing to different original deposition activities (*vid* p. 132); the exceptions to this phenomenon are SUs 38 and 42, whose infillings are quite homogeneous from both the sedimentary and archaeobotanical point of view. Two types of pits can be recognised from the archaeobotanical point of view: on the one hand, pits whose fill has probably come from a range of domestic activities in which plant processing activities player a major role (SUs 42, 40, 38, 34, 32, 29, and 28, but with differences between their microstratigraphical units!); on the other hand, a hearth (SU 43) and pits (SUs 12, 25, 36, 48, and 122) whose fill came from activities in which plant processing activities had a minor role. Fragmentation rates are quite uniform and high (around 50

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Plant part</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Vicia</em> sp.</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Vicia ervilia</em> / <em>Lathyrus cicera</em> / <em>sativus</em></td>
<td>Seed</td>
</tr>
<tr>
<td><em>Vicia</em> sp. / <em>Lathyrus</em> sp.</td>
<td>Seed</td>
</tr>
<tr>
<td>Leguminosae</td>
<td>Seed</td>
</tr>
<tr>
<td>Other seeds</td>
<td></td>
</tr>
<tr>
<td><em>Galium</em> sp. / <em>Asperula</em> sp.</td>
<td>Achene</td>
</tr>
<tr>
<td><em>Maclea</em> sp.</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Salsola</em> sp.</td>
<td>Seed</td>
</tr>
<tr>
<td>Fruits</td>
<td></td>
</tr>
<tr>
<td><em>Corema album</em></td>
<td>Seed, fruit</td>
</tr>
<tr>
<td><em>Prunus spinosa</em></td>
<td>Endocarp</td>
</tr>
<tr>
<td><em>Rosaceae</em> / <em>Ericaceae</em></td>
<td>Pome</td>
</tr>
<tr>
<td>Indeterminates</td>
<td>Seed, fruit, tissue</td>
</tr>
</tbody>
</table>

Table 117: Taxonomical adscription of the charred plant macroremain assemblage at Lapiás das Lameiras.
Inés L. López-Dóriga

and mostly belong to the postdepositional type, very probably induced by the retrieval technique (wet sieving).

<table>
<thead>
<tr>
<th>Samples</th>
<th>SU 12</th>
<th>SU 43</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. with plant macroremains</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No. with non-woody plant macroremains</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NR / NDR</th>
<th>SU 12</th>
<th>SU 43</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR (No. of remains)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NDR (No. of determined remains)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fragmentation</th>
<th>SU 12</th>
<th>SU 43</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNI (Minimum number of individuals)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Index (MNI/NDR)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species richness</th>
<th>SU 12</th>
<th>SU 43</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>NT (No. of taxa)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MNS (Minimum number of species)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Index (MNS)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Index (NT)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 118: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SUs without non-woody plant macroremains.
Part III B: Results: the carpological assemblages

Table 119: Taphonomical description of the charred plant macroremain assemblage at Lapiás das Lameiras: SUAs with plant macroremains.

<table>
<thead>
<tr>
<th>Index (SU NT / Site NT)</th>
<th>SU 42</th>
<th>SU 40</th>
<th>SU 38</th>
<th>SU 32</th>
<th>SU 28</th>
<th>SU 29</th>
<th>SU 25</th>
<th>SU 34</th>
<th>SU 34-36</th>
<th>SU 36</th>
<th>SU 48</th>
<th>SU 122</th>
<th>Whole sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>41</td>
<td>39</td>
<td>37</td>
<td>31</td>
<td>27</td>
<td>26</td>
<td>21</td>
<td>10</td>
<td>10-35</td>
<td>35</td>
<td>47</td>
<td>118</td>
<td>0.17 0.57 0.46 0.51 0.54 0.69 0.09 0.51 0.09 0.14 0.14 0.03 1</td>
</tr>
</tbody>
</table>

9.4.3 Discussion

Because hulled cereals for human consumption usually have more chances of becoming charred than naked cereals due to the need of dehusking them (which is helped by roasting), it is likely that they are represented in such low numbers because they were cultivated for animal foddering (and therefore not dehusked) or because they were not cultivated but just weeds of the other crops. In the case of naked cereals, the different crop deposition rates (densities) and different fragmentation indices show variations in crop processing activities, probably due to the practice of heterogeneous forms of cereal consumption and quantities. Whilst the former might be a matter of choice, the different quantities could have been related to variations in the availability of other foodstuffs or the number of people taking part in the meals (which might vary if guests are present or if part of the group is on a trip). No attempt has been made to relate fragmentation proportions with particular culinary preparations, as the indices obtained are most probably distorted by the importance of postdepositional fragmentation.

Few plants that could be interpreted as weeds have been recovered (Avena sp., Galium sp./Asperula sp., Gramineae, Lolium sp., Malva sp. and Salsola sp.), together with very few chaff remains. However, two factors complicate the interpretation of potential agricultural weeds: firstly, the imprecise determination only to genus level; secondly, herbs which might be considered potential weeds are spontaneous plants which might be gathered from other habitats and intentionally exploited for several reasons (medicinal, green leaves, etc.). For example, Salsola sp. is at the same time a potential agricultural weed and a plant whose leaves are edible green and cooked, whose seeds have been traditionally cooked and baked with cereal flour, and which green and burnt has several medicinal and cosmetic applications (Fern 1992-2010). Oats (Avena sp.) and other wild grasses (Lolium sp., Gramineae) might have been intentionally gathered for the consumption of their grains, as a winter dietary complement for domesticated animals or for the exploitation of their straw (Harlan 1992). Malva plants are also eaten green (leaves) and have a wide range of other applications (Fern 1992-2010). Most herbaceous wild plants (Avena sp., Gramineae, Lolium sp., Malva sp.), legumes (Coronilla sp./Galega sp., Lathyrus spp., Vicia spp.) and domesticated crops (Hordeum vulgare var. nudum and Triticum “nudum”) would have been gathered from grasslands or cropfields in summer when fruiting, but their different plant parts might be consumed at different times: green leaves, shortly after gathering; dry plant parts and seeds throughout the year as needed.

Whilst the absence of chaff could be a result of taphonomy (chaff is less able to survive fire and erosion than grains), it is less likely that this might be the case for weeds. Several explanations might be
Inés L. López-Dóriga

responsible for this scarcity of weeds, which, if present, could be very informative about the agricultural techniques and processes developed. On the one hand, the assemblages recovered might have been part of the crop end products (van der Veen 2007), which resulted charred when ready for consumption, either whilst cooking or upon storage. Weeds and chaff, the crop by-products, could have been fed to domesticated animals instead of being thrown into the fire and this could be the explanation for so few charred crop by-products having been found. Grains accidentally charred whilst being roasted would be unpalatable and therefore discarded; stored grains could have been accidentally charred if a fire affected the storage structure; some of the grains could even be in situ and had been charred when disinfecting the storage pit with fire. On the other hand, weeds could have been present in very low numbers form the beginning if a large labour input had been dedicated to weeding the crop field prior to gathering or if the crops had been gathered by hand-plucking.

Legumes, from wild stands and also possibly domesticated crops, are important in the site and diverse taxa have been tentatively recognised (vid. Table 117) despite their determination difficulties. Their reduced numbers in comparison with cereals might be due to their potential consumption in a raw state (e.g. Pisum sativum) and to their requirements for higher temperatures for becoming charred (vid. p. 268). Wild legumes, however, are usually indehiscent and some of them (Coronilla/Galega, Trifoliaz) might have fallen into open-air hearths if growing in the immediate environment. Conspicuously, the assemblages of Vicia tp. sativa and Lathyrus, potentially domesticated taxa which need being detoxified for human consumption, are the more numerous and show diagnostic characteristics which, in other closely related species, result of having been treated before becoming charred (vid. Table 58 and Valamoti, Moniaki & Karathanou 2011): most of the Vicia tp. sativa specimens are split in halves (the cotyledons are neatly separated) and show a concavity in the inner surface of the cotyledon (vid. Figure 70), which indicate they were probably charred after being boiled; some Lathyrus specimens are shiny and would easily split neatly into cotyledons (vid. Figure 63, top right), indicating that they were soaked before becoming charred. In addition, many of the specimens which have been left determined as Fabae/Vicieae (vid. Figure 62, with concave inner cotyledon surface and fragmented testa) might have belonged to some of these taxa and have been so transformed, so as to impede determination to species or genus level, by treatments undergone before becoming charred. Indeterminate legumes, on the contrary, show an irregular breakage pattern into fragments which do not correspond to cotyledons, showing they were probably untreated upon carbonisation (vid. infra Table 58 and Valamoti, Moniaki & Karathanou 2011).

Prunus spinosa is a shrub with fleshy berries which might have reached the site accidentally (transported by endozoochory) or intentionally, for the exploitation of some of its properties. A single fragment from the endocarp of the fruit has been recovered but the fragmentation edge points to its postcharring fragmentation, possibly postdepositional, therefore no evidence of processing is offered by it. Prunus spinosa is an Atlantic shrub of which a coastal subspecies also exists; it might have also been gathered on the coast or in other shrublands in the environment, in autumn when the berry would be ripe.

Because of the indetermination of the Rosaceae/Ericaceae fruit remain, it is difficult to infer the environment from which it was gathered, most probably a shrubland or open forest, also between summer and autumn. Its carbonisation is most probably the result of an accident whilst roasting to
improve its eating or storing qualities, which could have been extended for several months if carried out in a proper (cool and dry) place.

*Corema album* is a fruit taxa that seems to have been the object of thorough exploitation, and together with *Salsola* sp., suggests the exploitation of the coast, which was several kilometres from the settlement. Both fruiting plants could have been gathered between summer and autumn (unripe berries from *Corema* from spring) and consumed fresh. Whilst no evidence is known for the storage of whole *C. album* berries other than in liquors, *Salsola* seeds might be dried and stored for addition to cereal flour. *Corema album* is a coastal shrub which provides an edible berry highly appreciated for human consumption. The size of the seeds, similar to the smaller varieties of grape pips, allows the whole ingestion of the fruit by humans. The presence of a smashed fruit with seeds in anatomical connexion might be pointing to some sort of processing, such as pressing for extraction of the flesh. However, the fruit is notably dispersed by frugivores and the remains in anatomical connection might have been excreted by birds (Calviño Cancela, pers. comm.; Vaquer & Ruas 2009). This makes possible an accidental arrival to the site, within the gut contents of a hunted animal or a dropping. In any case, being consumed by humans or by animals, it is likely that the remains deposited belonged to whole fruits.
Part IV: Discussion and conclusions

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10 Discussion

The enrichment of current knowledge about past plant exploitation activities in Atlantic Iberia between 8000 and 3000 cal BCE has been the main aim of this thesis and, therefore, the state of the art for this aspect will be reappraised in light of the new data obtained (vid. Table 120, Figure 119, Table 121, and Table 122). Some considerations regarding representativity and taphonomy (vid. infra) have an important role in the obtained representation of past plant exploitation.

10.1 Evaluation of the available information

10.1.1 Representativity of the studied contexts and archaeobotanical sampling strategies

Several limitations that reduce the interpretative potential of the obtained information regarding the exploitation of plant resources by past human groups in both the Cantabrian region and Portugal have been encountered in this thesis. Some of these limitations are inherent to the method of analysis and the particular preservation of organic matter at the studied contexts (vid. p. 130), and were thereby expected. Methodological improvements to try to overcome some of these limitations have been suggested (vid. p. 450 and 452).

The most conspicuous limitation is the rarity of sites in which strategies for the appropriate recovery of plant macroremains have been employed (vid. p. 47). For example, of the Early Neolithic archaeological contexts (contexts showing signs of Neolithisation and with chronology confirmed by radiocarbon dates) in the Cantabrian region (Fano, Cubas & Wood 2015), less than a forth has provided non-woody plant macroremain evidence (vid. Figure 112) and, as a general rule, the quality of the dates is rather poor (Fano, Cubas & Wood 2015). The same phenomenon occurs when the assessment of the radiocarbon dates (vid. Table 3) is taken to Mesolithic and Neolithic sites in both the Cantabrian region and Portugal: of the 42 contexts with plant non-woody macroremain evidence, only 39 contexts have radiocarbon dates that confirm their chronological ascription (vid. Figure 115), and within these dates...
(n=51), high quality ones are scarce, optimal are entirely inexistent, and low quality ones predominate (vid. Table 120 and Figure 112).

In addition, the unsystematical publication of archaeobotanical related data, which can be easily appreciated in the existence of many blanks (identified with question marks in Table 121), hinders the assessment of the appropriateness of the sampling strategies and recovery techniques employed in each of the contexts the and the consequent representativity of the data. An appropriate sampling strategy is essential for the successful recovery and analysis of plant macroremains and the achievement of meaningful results: although the size and the intensity of the sampling strategy must have an influence which is not possibly evaluated with the available data, there is a moderate positive correlation between the number of samples analysed and the species richness of the assemblage (vid. Figure 113). But

![Figure 113: Correlation between number of samples and species richness of the assemblages.](image)

A Pearson’s product-moment correlation has been estimated between the no. of samples analysed and the diversity index of each archaeobotanical assemblage: cor 0.504684, t = 2.4802, df = 18, p-value = 0.02324. The diversity index has been
appropriate recovery techniques (from retrieval from the soil to sorting of the flots) are also positively correlated (although less strongly) to the species richness of the assemblages (vid. Figure 114).  

Although the recovery techniques need to be adapted to the specific circumstances of each archaeological context, sampling the different features of an archaeological site homogeneously to avoid as many biases as possible; in practice it is best to sample as extensively as time, facilities, personnel and budget allow.  

calculated taking into account the number of taxa in each assemblage and the number of taxa in all the assemblages of the same region (vid. Table 121).

A Pearson’s product-moment correlation has been estimated between the rank of the techniques employed and the diversity index of each archaeobotanical assemblage: cor 0.491206, t = 3.5666, df = 40, p-value = 0.9995. The rank value has been obtained as a median of retrieval (vid., p. 121) and sorting (with or without magnification, vid. p.123) techniques, which in turn have been ranked from 1 (pessimal or unknown) to 3 (optimal). The diversity index has been calculated taking into account the number of taxa in each assemblage and the number of taxa in all the assemblages of the same region (vid. Table 121).
As has often been remarked, no retrieval technique is perfect, inexorably some loss of information occurs upon excavation and recovery in any archaeological context (vid. p. 121) but sorting with magnification is probably the most significant stage of the retrieval process.

Other limitations which this thesis has encountered are not inherent to the archaeobotanical method but to more general archaeological (mostly historiographical) issues: the rarity of sites of different types, the rarity of contexts with radiocarbon dates, the rarity of contexts with radiocarbon dates and in which archaeobotanical recovery strategies have been applied, and even further, the rarity of archaeobotanical assemblages directly dated (vid. Table 120 and Figure 115). Residuality and intrusion issues are relatively common within certain archaeological deposits (e.g. Zilhão 2011) and, more particularly, archaeobotanical assemblages (e.g. Pelling et al. 2015). Therefore, a generalised effort to radiocarbon date the non-woody plant macroremains themselves must be undertaken to overcome this problem. In the Cantabrian region, although four dates have been directly obtained from non-woody macrobotanical assemblages (Pico Ramos IV, El Mirón and Kobadeerra II), only the site of Xestido III possess a highly valued (vid. Table 3 and López-Dóriga 2014) radiocarbon date on a non-woody plant macroremain (a hazelnut shell from a hearth) (vid. Table 120). In Portugal, previous to this work, only the site of Ameal VI, and possibly Prazo (the literature is rather imprecise), had dates from non-woody plant macroremains from earths and pits (vid. Table 120). Owing to the effort of radiocarbon dating undertook in the framework of this thesis36, intrusion has been proven at the sites of Arangas (vid. p. 358) and Poças de São Bento (p. 397) but has been ruled out at Lapiás das Lameiras (vid. Table 32) and São Pedro de Canaferrim (vid. Table 29); residuality probably occurs at El Carabión (vid. p. 66); whilst many open questions still remain after unsuccessful dating experiences (Poças de São Bento, vid. p. 397) or not yet undertook (Los Gitanos, El Toral III, El Mazo). Still, an important gap between contexts with non-woody macrobotanical evidence and evidence directly dated exists (vid. Figure 115).

36 Funded by COASTTRAN, vid. p. 5.
The concentration of prehistoric archaeological research at caves in the Cantabrian region (vid. p. 39 and 118), which might have not been the main habitational areas during the Holocene (Arias et al. 2015; Fano, Cubas & Wood 2015; Zapata Peña 2005-2006) is a limiting factor in our understanding of late Mesolithic and Early Neolithic societies. Unfortunately, the circumstances of current archaeological practice in the Cantabrian region have not allowed the study of archaeobotanical assemblages from open-air sites in this thesis (vid. Table 120). Given the present circumstances, the available information for understanding past plant exploitation activities in the Cantabrian region is much more complete for wild resources than for the domesticates of early agricultural practices. This is partly a result of the rarity of Early Neolithic contexts (Cubas & Fano 2011), and particularly so of contexts with plant macroremains (vid. Figure 112). On the contrary, thanks to recent sampling efforts in a diversity of (cave) contexts, Mesolithic plant exploitation activities are better known: in addition to the relatively abundant low quality information provided by some old-excavated sites in which less appropriate sampling and recovery strategies had been carried out, new well-sampled sites have provided very promising plant evidence (vid. El Mazo, p. 362 and El Toral III, p. 372).

The research panorama has been substantially changed in Portugal, where no Mesolithic archaeobotanical assemblages had been recovered and studied before (vid. p. 41) and where Early Neolithic agricultural practices have been unprecedentedly proven for the 6th millennium cal BCE (vid. p. 87 and 387). Still, the information obtained might be greatly improved in the future, as many of the assemblages are biased due to their character as shell-middens (Poças de São Bento and Cabeço do Pez), where charred plant remains encounter detrimental conditions for being preserved (vid. p. 155 and 396) or come from sites whose occupation floors have been eroded (Lapiás das Lameiras and São Pedro de Canaferrim, vid. p. 99 and 104). In addition, although most of the sampled sites are in the open-air, only a partial portion of Early and Middle Holocene sites are suspected to have been properly recognised, possibly due to geomorphological alterations: although new sites have been identified, previously known sites have not been found again in recent surveys (Cerrillo-Cuenca & Rocha 2013) and sites seem to be located where dense vegetation now exists, a fact that might be pointing to an artificial representation of sites in which the less protected have been probably destroyed (Cerrillo-Cuenca & Rocha 2013).

Despite the lower number of Portuguese sites with analyses of non-woody plant macroremain evidence, in comparison with the Cantabrian region, the number of species documented is larger in the former than in the latter (vid. Figure 116). Whilst a natural explanation might be behind this phenomenon (Central-South Portugal is richer in floral species for climatical reasons: it has a Mediterranean climate with Atlantic influence, vid. p. 21), other potential factors such as the development of particular resource exploitation strategies (specialisation vs. diversification) might also be concurring. Until more evidence is obtained from appropriately sampled sites and functionally similar contexts no further light can be thrown upon this mater.
10.1.2 Used plants or “background noise”?

Whilst the presence of morphologically domesticated plants in the archaeological record must be somehow (even if distantly) related to the existence of anthropic activities somewhere, many of the plant species analysed in this thesis belong to wild plants or to plants in which domestication is not recognisable from a mere morphological analysis of the reproductive parts (vid. p. 13). Agricultural practices of different complexity (i.e. sowing, harvesting, transplanting, coppicing, etc...) could have been practised with both wild and domesticated taxa (vid. p. 12), independently from their morphological reproductive status, and pass unrecognised in the archaeobotanical record due to the lack of taphonomical criteria to recognise use-wear in plant remains (vid. p. 144). This fact might induce either to reject their consideration as intentionally exploited resources, biasing the understanding of past plant exploitation activities to reductionist definitions of what is domesticated and what is wild (vid. p. 15), or to assume the intentional exploitation of certain plant resources without real proof, based merely on their presence in the archaeobotanical record. If, as done here, a decision is taken to consider both possibilities, and as the potential uses of many plants are diverse (vid. p. 139), the actual purpose for the exploitation of particular plant taxa might be only hypothesised about.

One of the main issues in the interpretation of archaeobotanical data is the mode of arrival of plant remains to archaeological sites. First, considerations regarding preservation are met: if plant remains are uncharred or they have not been subject to mineralisation, desiccation, waterlogging or freezing, then they are most probably modern intrusions in archaeological contexts. However, even when plant remains are charred and charring is most often a result of an anthropic activity (Miksicek 1987 but Scott 2010), they might have several pathways of introduction into archaeological contexts. Several cases, just because plants or plant parts are edible or have been traditionally exploited by humans, are sometimes straightforwardly thought as intentionally exploited. Nevertheless, because other possibilities might account for their presence in archaeological sites, their actual exploitation should not be considered proven in the absence of further arguments (e.g. Behre 2008).

The case of seeds from herbs which grow as weeds in fieldcrops together with cultivated cereals (e.g. Bogaard, Jones & Charles 2005) is exemplary of the better studied cases in which certain taxa arrive accidentally due to human activities. The consideration of the ecological preferences of plants, such as their annual, biennial or perennial character or their preferred growth habitats, is a key element in the functional characterisation of charred plant assemblages and their original environments (vid. p. 158). In this thesis, several problems in this respect have had to be overcome (or ignored). On the one hand, the tertiary character of most of the studied assemblages, in which plant remains probably come from more than one event and are forming artificial assemblages which do not represent either a single environment or a single processing activity (vid. p. 132). On the other hand, the bad preservation state in which most remains have been recovered has not allowed for the specific determination of many of the plant taxa and, consequently, of the assemblage in terms of ecological and phytosociological variables. Their potential role as weeds, without forgetting that current weeds need always have been weeds (vid. p. 16), has been duly considered for a few of the plant remains from herbs recovered in the agricultural contexts studied in this thesis (Avena sp., Galium sp./Asperula sp., Linaria sp., Plantago sp., etc., vid. Table 76). Even if the difficulty of safely connecting them with cereal crops could be overcome, the scarcity of potential weeds in the samples of this work does not allow statistical approaches for
reconstructing past crop growing conditions, as has also happened in other well preserved contexts in the Iberian Peninsula (Antolín & Buxó 2012; Antolín, Jacomet & Buxó 2015).

The case of seedlings dispersed by the wind (anemochory) or attached to animal furs (exozoochory, e.g. Ronel & Lev-Yadun 2009), two potential pathways of introduction into archaeological contexts, is also well-known: remains of these types of plants might be ancient, but their carbonisation might have been accidental. Some plant remains studied in this work have been also considered in this light (Galium sp./Asperula sp.), together with dehiscent plants whose reproductive mechanism consists of ejecting their seeds several metres away (Geranium sp., Leguminosae, e.g.).

The endozoochory of grasses, crop by-products and small seeds from herbs has been prominently brought forward in the case of dung fuels since the discovery of their potential (Miller 1996) but little attention has been paid so far to the dispersal of fruit seeds and endocarps by frugivorous animals. The only known references discuss the presence of wild legumes in pigeon’s crops and of fleshy berry seeds in corvid’s dejections (vid. Vaquer & Ruas 2009) and pine nutshells in owl regurgitated pellets (Rhode & Madsen 1998). Fruits and fruit remains, in turn, are usually interpreted as resulting from intentional anthropic gathering activities, without taking into account the potential role of fruit-eating animals (vid. p. 152). With the exception of large fruits surrounded by inedible plant parts such as thick woody pericarps, as in the case of hazelnuts (Corylus avellana), or cones in the case of pine nuts (Pinus pinea), many taxa studied in this work (Celtis australis, Chamaerops humilis, Corema album, Ficus carica, Solanum nigrum, etc.) might have been eaten by diverse frugivorous animals. In the absence of human intervention, these types of animals could act as important dispersers crucial for the reproduction of these plants. However, should these animals have been hunted, their stomach contents, including those undamaged endocarps and seeds, might reach archaeological assemblages upon processing. The ingestion of herbivores’ stomach contents has been recently brought forward to possibly account for the presence of plant remains in Neanderthals dental calculus (Buck & Stringer 2014) and this possibility should be considered for the case of fruit remains. In addition, another possibility exists: the stomach contents being discarded in the site after the separation of the “edible” and “inedible” parts of a hunted animal; whilst a whole deer, bear or wild aurochs might not be brought to the site for this task, smaller fruit dispersers such as rabbits, foxes, lizards, crows or pigeons might and probably would. Both of these activities could result in the accidental charring of a fruit endocarp or seed, completely unrelated to the human consumption of its fruit flesh.

To approach this issue during the development of this research, animal droppings with fruit remains have been gathered from different environments. Unfortunately, due to the random character of the finds, only one of the potential animal-dispersed fruit remains (Ficus carica) has been cross-examined. Macroscopical differences in the surfaces of digested and undigested remains have been ineffectively sought with the aid of a binocular macroscope. These disappointing results have been confirmed by observations of other studied taxa (Corema album, Calviño Cancela, pers. comm.). These, however, should only be considered preliminary results for several reasons. On the one hand, the identity of the dropping-producer animal has not always been successfully established, but it is likely that differences in the preservation of seeds or endocarps exist depending on the species or, at least, animal type according to feeding habits. In addition, more samples of animal droppings are needed, covering more plant taxa. On the other hand, it remains to be explored whether the digestion process might leave subtler traces observable with a deeper magnification than that provided by binocular macroscopes, and other seed
characteristics than their surfaces, such as their thickness and permeability (vid. Torroba Valmori 2013), must be examined.

10.1.3 “Invisible” plant resources

The existence of “invisible” plant resources in the archaeobotanical record, particularly in the charred one, has been a well-known issue in the study of plant macroremains for a long time (Dennell 1976). This invisibility is partially given by the particularities of preservation by charring, which subrepresent certain plant part types (vid. p. 154) or produce remains hardy to identify (vid. p. 163). Non-woody plant macroremains of several potentially exploited available plant taxa (vid. p. 21) have been found to be absent from the archaeobotanical assemblages studied in this thesis. However, there is insufficient information (due to a combination of limited sampling strategies and rarity of analyses of complementary archaeobotanical proxies, vid. p. 160) to prove the absence satisfactorily to be true or false.

*Quercus* spp. acorns have long been supposed to form an important part of hunter-gatherer subsistence in the Iberian Peninsula, and particularly in the Cantabrian region (e.g. González Morales et al. 2004; Straus 2008), partly due to their ubiquity in the environment, the abundance of *Quercus* spp. wood charcoal in the archaeological record and to acorn bread being part of the “immemorial” traditional native diet observed by the Romans (e.g. García Gómez & Pereira Sieso 2002). The data obtained in this work does not confirm this prejudiced idea about past consumption (but neither does it have the power to deny it): *Quercus* spp. acorns are not abundant nor as ubiquitous as expected in the archaeobotanical record (Figure 120). Despite the good general overview given by the diverse recovery strategies applied, in the Cantabrian region acorn remains are apparently absent from Mesolithic shell-middens (El Mazo, El Toral III, Mazaculos II and El Carabión) although they are present in small quantities in later contexts (Arangas and Los Gitanos); and they are also apparently absent from all contexts studied in Portugal in this thesis (with the exception of a single cupule from Poças de São Bento). This apparent absence could be for several reasons:

- a true absence in the repertoire or plants exploited, in which case this would be a matter of cultural choice, as environmental availability would have been high in both regions through the Holocene, and might be explained by taste choices (avoidance of bitter products), cultural beliefs (food taboos), preference for easily prepared products, among other possible factors,

- to the development of particular preparation procedures which do not involve the use of fire and which do not facilitate the charring of some of the products, such as boiling instead of roasting, or which are carried out in specific locations outside the excavated areas,

- or to a taphonomical bias, in the impossibility to taxonomically determine at low power magnification the abundant non-woody plant tissue, possibly parenchymatic fruit flesh which could possibly belong to (among other fruits or nuts) acorn cotyledons, and which have been recovered in all contexts where sampling strategies have been systematical and recovery methods unbiased by sight with the naked eye (El Toral III and El Mazo). The reason why in these sites acorn cotyledons were not preserved whole or in recognisable fragments as occurs in Arangas or Los Gitanos could be due to erosion in an alkaline depositional environment such as that of shell-middens, which is detrimental for the survival of charred plant matter (Braadbaart, Poole & van Brussel 2009).
A similar situation occurs in the Cantabrian region with other wild fruits, such as *Prunus avium*, or edible plants, such as *Triglochin maritima*, *Salicornia* ssp. *maritima*, *Salsola* ssp. *Eryngium maritimum* or *Daucus carota* which appear prominently in anthracological or pollen analyses for the same period and which have not been identified as non-woody plant macroremains (Zapata Peña 1999b). Portuguese sites, in turn, have a notable absence of potential wild plant resources such as olives (*Olea europaea* subsp. *sylvestris*), strawberry tree fruits (*Arbutus unedo*), wild vines (*Vitis vinifera* subsp. *sylvestris*) or hawthorns (*Crataegus* spp.) which are known to have been available and also appear in the anthracological record (e.g. Carrión Marco, García & Figueiral 2012; Queiroz & Mateus 2001). As the case of *Quercus* acorns, it is difficult to tell whether this absence is the result of a combination of taphonomical biases, or of the existence of a powerful cultural avoidance or choice.

*Corylus avellana* nutshell are prominent in the archaeobotanical record of the Cantabrian region. However, many open questions exist about their significance (vid. p. 473). Undetermined carbonised fragments of parenchymatic tissue, which could possibly be the remains of charred nut kernels have been recovered in most sites with proper recovery (Table 121). However, they could also be remains of other fruits or nuts which have also been recovered in the sites, such as Maleae (or others for which no hint has been identified, such as acorns); unfortunately, a distinction of fruit parenchymatic tissue based on purely morphological criteria is even more difficult than that of underground storage organs composed of parenchymae (e.g. Kubiak-Martens 2002). Undetermined carbonised fragments of parenchymatic tissue are often retrieved from the same deposits in which nutshells are recovered through temperate Europe (e.g. Stevens 2009) but it is difficult to know the extent of this co-appearance, and if it matches only sites with *Corylus avellana* remains or also other potential sources of fruit parenchymatic tissue, since recovery of plant remains is not always unbiased and not all archaeobotanical site reports include plant remains that are left undetermined.

Several plant species, important in Early Neolithic agriculture in the Iberian Peninsula, such as *Papaver somniferum* (Peña-Chocarro 2007), *Linum usitatissimum*, *Olea europaea* subsp. *europaea* or *Vitis vinifera* subsp. *vinifera*, are absent from the studied contexts, in both the Cantabrian region and Portugal. It is again impossible to ascertain if the absence is due to cultural, ecological or taphonomical factors. Cereals and legumes are the most important domesticated crops in Early Neolithic agriculture in the Iberian Peninsula, but with the exception of the possible ancient *Vicia* at Peña Oviedo, legumes are absent from Neolithic sites in the Cantabrian region. In Portugal, legumes have been identified in low numbers in comparison with cereals in Lapiás das Lameiras and São Pedro de Canaferrim, but ratios between cereal and legumes do not reveal differences in importance or value for prehistorical communities, but rather taphonomical biases (namely, among others, differential preservation, e.g. Mikić *et al.* 2014). Therefore, given the present evidence, it is difficult to establish whether the incompleteness of the Neolithic crop package in certain areas is a result of preservation and depositional differences, or rather the introduction of foreign domesticated species in different stages, possibly as a result of evolving cultural choices.

Three types of remains, which might provide insights into the exploitation of usually “invisible” plant resources, have been recovered amidst plant macroremains in many of the samples studied in this thesis: on the one hand, charred items such as oblong featureless items and spherical fungi sclerotia (tp. *Cenococcum geophilum*); on the other hand, microfossils such as foraminifera and ostracoda.
Firstly, the presence of oblong featureless charred items, which are quite likely arthropod faecal pellets (Scott et al. 2010), in relation with plant macroremains from flotation samples needs further research: it is quite possible that their co-occurrence is not a matter of chance but a result of past co-occurrence. It has been here suggested that a particular type of arthropod faecal pellets which have been identified as arising from termites (Adams 1984, abundantly and frequently appearing in Poças de São Bento, *vid.* Figure 117) might be interpreted as evidence for the development of specific resource exploitation strategies, such as the gathering of deadwood or a previously invisible food source (termites). A hypothesis, which needs further testing, is that some of these pellets from other arthropods (which have not yet been thoroughly identified, but larvae from *Balaninus*-type insects have been observed to produce very similar pellets within hazelnuts and acorns) might have been present in plant products, such as nuts and fruits, at the time of charring. These pellets would have been produced within nuts and fruit flesh by fruit and nut-kernel-eating insects and infested nuts would have been accidentally collected for human consumption. Their charring could have been an entirely accidental matter when roasting nuts or a result of sorting nuts after gathering and discarding infested ones into the fire.

Secondly, the presence of charred fungi (*tp.* *Cenococcum geophilum*) sclerotia has long been noticed in flotation plant macroremains assemblages, but their relationship with human activities has not yet been established (*e.g.* Alonso & López 2008). *Cenococcum geophilum* are either a heterogeneous species or a species complex (Douhan, Huryn & Douhan 2007), ubiquitous ectomycorrhizal fungi which live in forest soils in a symbiotic relationship with plant, mostly woody, roots. Some plants depend on the ectomycorrhizal fungi attached to neighbouring tree roots for photosynthesis or germination. Although about 80 % of the plants in the world have mycorrhizal relationships with fungi, only about 2 % are ectomycorrhizal (Wang & Qiu 2006). These fungi do not penetrate their host but form a highly branched filamentous external structure, known as hyphae, extending up to several centimetres into the surrounding soil (Smith & Read 2010). Many ectomycorrhizal fungal fruiting bodies are well known, such as the edible truffle (*Tuber* spp.) and the deadly death caps and destroying angels (*Amanita* spp.). Ectomycorrhizal fungi thrive particularly in symbiosis with temperate forest taxa such as pines (*Pinus* spp.), birches (*Betula* spp.), willows (*Salix* spp.), beeches (*Fagus* spp.), strawberry trees (*Arbutus* spp.) and oaks (*Quercus* spp.) (Tedersoo, May & Smith 2010); *Cenococcum geophilum* has a host range of more than 200 tree species from 40 genera of both angiosperms and gymnosperms (Douhan, Huryn & Douhan 2007). Possible explanations that might account for their presence in charred archaeological assemblages are potentially anthropic and might evidence the exploitation of otherwise usually unrecorded resources: these fungi sclerotia might have been attached to underground plant parts which could have been gathered and processed (Alonso & López 2008) and, if charred, have not been preserved (tubers and rhizomes are usually rich in water and are less able to survive charring, *e.g.* Kubiak-Martens 2002), or could have been in the soils underneath hearths which might have or might not have been identified (the preservation of recognisable hearths depends on variable circumstances such as the reiteration of use and the form of extinction of the fire, *vid.* Groenendijk 1987) and become accidentally
Part IV: Discussion and conclusions

charred during the hearth’s activity. Additionally, the possibility of these sclerotia as indicators of good conditions for the preservation of charred organic matter (Perry 1999b) needs further exploration.

Thirdly, the presence of foraminifera and ostracoda in Cantabrian shell-middens, attested both in flotation samples (vid. p. 355) and in petrographic thin sections for micromorphological analyses (Duarte 2015), in such low numbers as to indicate an anthropic rather than natural origin (Rosendahl, Ulm & Weisler 2007), but in a constant way, needs an explanation. They have been identified as clearly not fossil (vid. Figure 118), therefore their presence due to the dissolution of the surrounding limestone can be ruled out. They are mostly typical species of the current infralittoral coastal association (internal platform / estuarine entrance) although also planctonic ones are also present (Fratela & Freitas, pers. comm.). Although their occurrence in archaeological sites is understudied and several explanations might be possible (Kenward 2009), they might be important archaeobotanical proxies for otherwise invisible plant resources such as algae (as gastropods have recently hinted to be, Ainis et al. 2014): many foraminifera might be found attached to seaweed and would end up deposited in archaeological deposits should the algae be transported there for consumption. Foraminifera have been found in light flotation fractions from all sites, not exclusively shell-middens, in the Cantabrian region (El Mazo, El Toral III and Los Gitanos) and in petrographic thin sections from El Alloru (Duarte 2015) but not in the Portuguese contexts where the same sampling strategies have been applied (nor in Poças de São Bento or Cabeço do Pez, studied here; nor in the Muge shell-middens, Wollstonecroft, pers. comm.). It is difficult to tell whether these abundance in the Cantabrian region and absence in Portugal are related to the existence of different cultural practices among the Atlantic populations, or just due to a taphonomic bias: foraminifera and ostracoda have detrimental preservation in acid soils (Campbell, Moffett & Straker 2011) such as those in which the portuguese sites are located (Fulgêncio & Bettencourt 2011), although their acidity is partially counteracted by the alkalinity inherent to the shell-midden so as to allow for the preservation of bones, even though in a frail condition.

10.1.4 How does direct evidence match the isotopic evidence?

One of the concerns of current archaeology is the reconstruction of past diets; however, the identification of palaeodiets is a very problematical issue in archaeology, as well as in archaeobotany (vid. p. 140). Great hopes have been placed in dietary inferences based on stable isotope analyses, although they are necessarily based on assumptions (vid. p. 166). Many of these assumptions tend to undervalue the role of plants (Fraser et al. 2013b) and plant variability in the environment, giving more importance to variations due to geolocalisation, meat-based dietary changes, etc. For example, it has been generally assumed that high δ¹³C values (which drop with the Mesolithic–Neolithic transition in Mediterranean Europe, vid. p. 53) are unrelated to the consumption of C₄, as those are scarce in temperate Europe and are considered unlikely candidates for an important dietary role. However, C₄ plants are scarcer but not so much as to make it impossible for the high values to be the result either of the consumption of some of the wild native relatives of the domesticated millets (Sage & Monson 1999), widely distributed around central and south Europe (e.g. Panicum repens, Setaria viridis, Setaria verticillata), or other C₄-C₃-C₄ or CAM plants within or outside the family Gramineae (grasses), because
these types of photosynthesis also proliferate within the Cyperaceae, and numerous families of Eudicots (Magnoliopsidae), including the Compositae, Euphorbiaceae, but especially the Orchidaceae, Chenopodiaceae and Amaranthaceae (Gowik & Westhoff 2011), a C₃ and C₄ intermediate photosyntheses in Cruciferae and, additionally, both C₃ and C₄-type photosyntheses coexist within some algae (Xu et al. 2012). In this work, remains from several C₄ and CAM plants have been identified and could have been part of the food by-products of past populations (e.g. tp. Senecio aquaticus, Fioretto & Alfani 1988). Additionally, algae consumption would also contribute to high δ¹³C values; although algae remains have not been found in the contexts studied this thesis, the presence of foraminifera (vid. p. 452) could be indicating their consumption (Kenward 2009).
### Context\(^{37}\)

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<th>Type</th>
<th>Location</th>
<th>Ascription</th>
<th>Method</th>
<th>Material</th>
<th>Origin</th>
<th>(\Delta^{13}C) (AMS)</th>
<th>(\Delta^{13}C) (IRMS)</th>
<th>(\Delta^{15}N)</th>
<th>Lab. ref.</th>
<th>Age BP cal BCE</th>
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<th>Confidence(^{39})</th>
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<td>Novoa Fonseca 2014</td>
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<td>Arangas – 3 &amp; 4</td>
<td>C</td>
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<td>Meso</td>
<td>C(^{40})</td>
<td>B</td>
<td>D</td>
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<td>0xA-24163</td>
<td>5540 ± 29</td>
<td>1551-1770</td>
<td>Intrusive</td>
<td>Arias et al. 2014</td>
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<td>El Mazo(^{41})</td>
<td>R</td>
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<td>Meso</td>
<td>C(^{40})</td>
<td>B (Cereus)</td>
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<td>C(^{40})</td>
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<td>Meso</td>
<td>C(^{40})</td>
<td>B (Bos taurus)</td>
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<td>-</td>
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<td>5540 ± 29</td>
<td>1551-1770</td>
<td>Intrusive</td>
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\(^{37}\) Key to Context abbreviations: types of sites: C = cave, O = Open-air, M = megalithic, R = rock-shelter; locations: C = Cantabrian region, P = Portugal; ascription: Meso = Mesolithic, Neo = Neolithic.

\(^{38}\) Key to age abbreviations: material: B = Bone (BA = Bone bioapatite, BC = Bone collagen), C = Non-woody plant macroremain, E = Earth, R = Carbonate, S = Shell, W = Wood charcoal; origin: B = Burial, D = Dispersed in soil matrix, H = Hearth, P = Pit.

\(^{39}\) Dates have been calibrated with the online version of OxCal 4.2 (updated on 6 March 2014 / 24 May 2014; Bronk Ramsey 2009), with the curve IntCal13 for samples of terrestrial origin and Marine13 for samples in which the marine reservoir effect is relevant (marine samples and consumers) (Reimer et al. 2013). In the case of the Sado Valley, two different existing \(\Delta R\) values have been used (Vale de Romeiras), \(\Delta R = -170 \pm 60\) yr, (Soares & Dias 2006) and \(\Delta R = 100 \pm 155\) (Martins, Carvalho & Soares 2008); for the Cantabrian region, \(\Delta R = 210\) (Arias 2005).

\(^{40}\) The value of confidence is a reflection of the identification precision of the material dated and its contextual provenance (vid. Table 3; López-Dóriga 2014).

\(^{41}\) Amino-acid racemisation dates have also been obtained for samples from this site (vid. p. 72).
### Radiocarbon dates from old research programmes are available for this site (vid. p. 95), only those of the current research project and studied trench have been listed here.

<table>
<thead>
<tr>
<th>Context</th>
<th>Age</th>
<th>Site &amp; Intrasite</th>
<th>Reference</th>
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<td>Tapia Sagarna et al. 2008</td>
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## Context

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<th>Method</th>
<th>Material</th>
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<th>31IC (BRMS)</th>
<th>Δ13N</th>
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<td>S &amp; W</td>
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<td>C&lt;sup&gt;14&lt;/sup&gt; AMS</td>
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<td>P</td>
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# Reference

Inés L. López-Dóriga
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Inês L. López-Dóriga
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Table 120: Archaeological contexts in Atlantic Iberia with plant macroremain evidence between 8000-3000 cal BCE, ordered by average age.

\(^{42}\) The chronology of A Fontenla is far from clear: the reference for this radiocarbon date, based on charcoal (Fábregas-Valcarce & Vilaseco-Vázquez 2003), quotes another one (Peña Santos & Rey García 1993) which refers back to the original publication, in which the radiocarbon date is conspicuously different (2460 ± 50) and obtained on acorns.
Figure 119: Distribution of archaeological sites in the Iberian Peninsula with non-woody plant macroremain evidence between 8000 and 3000 cal BCE. Sites with names in red have been studied in this work. Modified from image by Luis Teira.
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<td>Pocas de Sáo Bento – phase B</td>
<td>6000-5500</td>
<td>This work (vid. p. 390)</td>
<td>D &amp; B</td>
<td>Yes</td>
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<td>F (250 μm)</td>
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<td>Los Cañes-2-6</td>
<td>6000-5000</td>
<td>Ramil-Rego, Dopazo Martínez &amp; Fernández Rodríguez 1996</td>
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<td>Mazaculos II-Interior</td>
<td>6000-4000</td>
<td>This work (vid. p. 380)</td>
<td>D</td>
<td>Yes</td>
<td>100 %</td>
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<td>0.02</td>
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44 The bibliographic references do not always contain all the information displayed in the table: some unpublished data have been obtained by personal communication with the authors. Key to Retrieval abbreviations: F = Flotation, I = In situ, S = Sieving (DS = Dry-sieving; WS = Wet-sieving). The size in parentheses reflects the mesh size used for the recovery of remains. The column Sorting, reflects the use of magnification in preliminary sorting (“With +”) or sorting by the naked eye (“Without +”).

45 The column % positive refers to the percentage of samples with non-woody plant macroremains. Key to abbreviations: NDR = Number of determined remains; MNI = Minimum number of individuals (the original is given when available, a new one is otherwise calculated whenever possible); NT = number of taxa; MNS = Minimum number of species (vid. p. Error: Reference source not found). The diversity index has been calculated by taking into account the whole number of species determined in non-woody macroremain analyses from the same region.

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<table>
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<tr>
<th>Context</th>
<th>Age (cal BCE)</th>
<th>Archaeobotanical reference</th>
<th>Archaeobotanical context</th>
<th>Strategy</th>
<th>Results</th>
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<td>Cabeço do Pez</td>
<td>5800-4000</td>
<td>This work (vid. p.387)</td>
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<td>No</td>
<td>100 % F (250 μm) With +</td>
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<td>Vale Pincel I</td>
<td>5700-5200</td>
<td>Carrón Mareo, García &amp; Figuerial 2012</td>
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<td>El Tural – Área B</td>
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<td>This work (vid. p. 372)</td>
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<td>ca. 11.5 %, n=28 F (250 μm) &amp; WS (4 mm) With &amp; Without</td>
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<td>Peña Oviedo – La Calvera</td>
<td>8000-3300</td>
<td>Díez Castillo 1996a, Díez Castillo 1996b, Díez Castillo 2005, Díez Castillo 2008a</td>
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<td>100 % F &amp; WS (250 μm) With</td>
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<td>-</td>
<td>100 % (only sieve results available) D3 (3 mm) &amp; F 250 μm Without + &amp; With</td>
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<td>Lapús das Lamosiras</td>
<td>ca. 5400</td>
<td>This work (vid. p.113)</td>
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<td>ca. 90 %, n=177 WS (300 μm) Without</td>
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<td>São Pedro de Casaferrín</td>
<td>ca. 5200</td>
<td>This work (vid. p. 399)</td>
<td>P</td>
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<td>ca. 90 %, n=68 F (250 μm) &amp; WS (350 μm) With &amp; Without</td>
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<td>Los Gitanos – A4 &amp; A3</td>
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<td>This work (vid. p. 382)</td>
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<td>Yes</td>
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<td>Buraco da Pala IV</td>
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<td>5 l soil per SU, n=4 F &amp; WS (2 mm) With</td>
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<td>Zapata-Peña 1999a</td>
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<td>3500-3000</td>
<td>Serna-Martínez 1995</td>
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<td>Mendigana</td>
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<td>Ruiz-Alonso et al. 2010</td>
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<td>100 % &amp; n=12 D3 (3 mm) &amp; F (250 μm) Without &amp; With</td>
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46 MNI in Aira’s study has been performed by weight in the case of cereals and by counting anatomical parts in acorns and legumes.
Inés L. López-Dóriga

Table 121: Archaeobotanical sampling and recovery strategies carried out at Atlantic Iberia archaeological contexts between 8000 and 3000 cal BCE. 47

<table>
<thead>
<tr>
<th>Context</th>
<th>Age (cal BCE)</th>
<th>Archaeobotanical reference</th>
<th>Archaeobotanical context</th>
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<td>Abrigo XXIX</td>
<td>ca. 3100</td>
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<td>La Riera-27</td>
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<td>ca. 3000</td>
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<td>Xestido III</td>
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<td>Arias et al. 2014; this work (vid. p. 355)</td>
<td>D</td>
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<td>100 %, n=50</td>
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<td>Yes</td>
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<td>Arias et al. 2014; this work (vid. p. 355)</td>
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</table>

Note that this does not represent the extent of past plant use but only the sites in which plant remains have been recovered, analysed and published. Please note that the contexts have been ordered by age so it can be seen that the abundance of plant macroremains is not affected by age but rather by techniques.
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Inés L. López-Dóriga
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Inés L. López-Dóriga
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<td>Malus sylvestris</td>
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<td>Salix alba</td>
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<td>Ulmus glabra</td>
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Table 122: Taxonomical determinations of plant macroremains per context in Atlantic Iberia between 8000 and 3000 cal BCE.

Figure 120: Ubiquity of plant taxa as evidenced by plant macroremains in archaeological contexts of Atlantic Iberia between 8000 and 3000 cal BCE.
10.2 Plant-resource exploitation during the Mesolithic and Neolithic

The continued exploitation of wild plants, particularly fruits, during the Mesolithic and Neolithic has been documented in the contexts studied in this thesis, an unsurprising fact as it has also been highlighted for other regions (e.g. Mason, Hather & Hillman 2002; Antolín & Jacomet 2015), despite the probable subrepresentation of fruits in the charred archaeobotanical record (e.g. Zapata 2000) and despite being often suggested that the introduction of domesticates brings radical changes in the strategies of plant exploitation developed by human societies (e.g. Zapata & Peña-Chocarro 2005).

From the elements of the “Neolithic package” only a few of them had been previously identified in contexts of Atlantic Iberia between up to 3000 cal BCE (vid. Table 2 and Table 122), and this thesis has contributed to its increase: einkorn (*Triticum monococcum*), emmer (*Triticum dicoccum*), macaroni wheat (*Triticum durum*) [and possibly bread or common wheat (*T. aestivum*) and club wheat (*T. compactum*)], barley (*Hordeum vulgare*), pea (*Pisum sativum*), lentil (*Lens culinaris*), bitter vetch (*Vicia ervilia*), faba bean or broad bean (*Vicia faba*) and grass pea (*Lathyrus sativus*). Still, most other elements of the “package” are missing from the archaeological record, together with those of the subsequent “crop packages”: other cereals, such as spelt (*Triticum spelta*), rye (*Secale cereale*), oats (*Avena sativa*), common or broomcorn millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica*); legumes, such as chick pea (*Cicer arietinum*), lupin (*Lupinus albus, L. luteus and L. angustifolius*) and Spanish vetchling (*Lathyrus clymenum*); and oil plants, such as flax (*Linum usitatissimum*), opium poppy (*Papaver somniferum*) and gold of pleasure (*Camelina sativa*). Whilst some taphonomical filters might undervalue some plant taxa with respect to others, this evidence speaks by itself regarding the concept of “Neolithic package”, and it will be seen next that this is even clearer region by region.

10.2.1 A regional overview

Despite the expressed reticence against studying past human societies in a reductionist way (vid. p. 28), a diachronic snapshot of past plant exploitation activities in Atlantic Iberia can only be precariously obtained with the current data available (vid. Table 122). This is so because contexts sampled for plant macroremain evidence are scarce, unrepresentative and, with a few exceptions, imprecisely dated (vid. Table 120), so it is only possible to safely distinguish between contexts with and without plant domesticates.

10.2.1.1 Cantabrian region

The studied sites have provided abundant information about past exploited plant resources. Some of these plants are well-known components of the spectrum of the probable palaeodiet (Zapata Peña 2000); others, sometimes considered exploited without direct evidence, have been attested for the first time in the Cantabrian region in non-woody plant macroremains.
**10.2.1.1 Plant exploitation activities**

Many of the plants exploited in the Cantabrian region are wild fruits, most usually from Rosaceae but also Ericaceae, and nuts, such as hazelnuts and acorns. These products have very particular seasons of gathering: pomes towards the end of the summer and nuts during autumn (with small variations from year to year). If eaten fresh, plant remains from these taxa might be used as indicators of seasonal occupation activities in certain sites. They are, however, products with good storage qualities, whose storage-life can be prolonged to about a year in ideal humidity and darkness circumstances (Cunningham 2005; Riddervold & Ropeid 1988).

A particularity of all the sites in the Cantabrian region, studied both in this work and in previous research (vid. Table 1 and Table 122), is a ubiquitous species and plant part: *Corylus avellana* shell fragments (Figure 120). These are also almost ubiquitous in Holocene sites in all temperate Europe, particularly in the Early and Middle Holocene (vid. Holst 2010). Hazel trees are present only in the North of Portugal and the Sintra mountains (Aedo & Castroviejo 2012; Pinto da Silva 1989), the latter possibly being the result of recent introductions, and hazelnut remains are absent from the record in Portugal, with the exception of a few isolated finds which have been found to be misidentifications of *Quercus* spp. acorns (e.g. Queiroz 2003). This hazelnut ubiquity in the archaeobotanical record of the Cantabrian region has been previously noticed (Zapata Peña 2000) but its interpretation remains controversial. Hazelnut shells are sometimes considered over-represented in the archaeological record due to their abundance and frequent exploitation (Zapata Peña 2000), their supposed high resistance to carbonisation and erosion (Scaife 1992), and their likelihood of being thrown onto fires, as fuel or as a way of disposing of domestic waste (vid. Jones 2000; Scaife 1992). Sites with palimpsest-like stratigraphies might show evidence of incidental consumption of hazelnuts, rather than intensive exploitation (Mithen & Score 2000). However, they are also considered under-represented in the record due to their slight chance of becoming carbonized, instead of burnt, and thus surviving (McComb 2009).

The relative abundance of hazelnuts cannot always be compared with that of other resources, as their shells are more likely to become carbonised and recovered than other types of remains. Furthermore, some recovery techniques might select and over-represent specific remains, such as nutshell, due to their high resistance to carbonisation and erosion (Scaife 1992) and their size being big enough, so as to be easily retrieved without flotation or screening with small-sized meshes and seen without magnification (Zapata Peña 2000). Even so, the abundance and ubiquity of hazelnuts is undeniable and needs to be better understood. Nuts are sometimes considered accidental by-products of fuel gathering and only intentional when nutshell remains from certain taxa, particularly hazel and hazelnuts (*Corylus avellana*), appear in isolation in archaeobotanical assemblages without wood remains from the same taxa (Antolín et al. 2010; Zapata Peña, Baldellou Martínez & Utrilla Miranda 2008). However, the use of hazel wood need not exclude the possibility of eating the hazelnuts; in fact, the gathering effort would be maximised if two different products could be obtained from the same primary source. Nevertheless, what is usually gathered as fuel is dry wood but hazelnuts fall naturally from the branches when they ripen, thus dry hazel branches are rarely loaded with ripe hazelnuts, and unripe hazelnuts are unlikely to be preserved in archaeological sites (vid. Mason & Hather 2000). The only explanation for the accidental charring of hazelnut shells would be their gathering from the wood floor together with small dry twigs and leaves, to be used as fire starters, but in that case, nutshell purposely burnt would disappear quickly (McComb 2009).
Thus, carbonised hazelnut shells in archaeological sites are usually most probably by-products of domestic activities, independently of the fact that the deposition might be primary, secondary or tertiary (vid. p. 132). Only a few possible actions result in charred nutshells within the context of domestic activities: hazelnut shells must have been discarded into the fire after eating the kernel (Jones 2000; Legge 1989; Scaife 1992) or whole hazelnuts must have accidentally fallen into a hearth whilst roasting (Zapata Peña 2000), or upon being stored. Reasons for roasting hazelnuts are well-known and range from cultural culinary choice (taste preferences) to functional explanations, such as killing insects, improving storage and digestibility (Mason 1996a; Zapata Peña 2000). The identification of nutshell disposal, or whole nut roasting and storage practices is no easy matter, because the detection of deposits of charred whole nuts can easily go unnoticed (vid. p. 452). Numerically, charred hazelnut shells would only be abundant in particular storage accidents, because if stored underground only a small portion of them would result charred unless very lengthy fires occurred (Mithen & Score 2000) and if stored aboveground most hazelnuts would be burnt out (McComb 2009). This latter argument is also useful for understanding shell disposal: carbonisation would be an exception to the intentional burning. The numbers of charred nutshells should neither be high in the case of roasting accidents, as it would be inefficient to roast hazelnuts if a large portion of their kernels were rendered inedible by carbonisation. Fortunately, other proxies might be detected, such as the high proportion of infested nuts within a reduced assemblage of hazelnut shells (vid. El Toral III, p. 379) which are most likely pointing to a potential preparation for storage.

For the case of pomes, more conclusive evidence related to their processing has been found: some clear hints precisely point to the existence of particular preparations (clear-cut sliced fruit halves, Wiltshire 1995) in at least three of the studied contexts (Arangas, El Mazo and El Toral III). This same type of evidence, fruit halves, has been previously obtained at other sites in the region for Maleae taxa (Zapata Peña 2000) but this is the first record for *Arbutus unedo* (vid. El Mazo, p. 371). Roasting sliced fruits in halves would greatly improve their preservation potential and could also represent culinary preparations: roasted whitebeam, wild service tree or rowan fruits (*Sorbus* sp.) and tannin-rich fruits in general have a reduced bitterness and are more agreeable in comparison with fresh ones (Zapata Peña 2000; Wiltshire 1995). The strawberry tree (*Arbutus unedo*) is a Mediterranean tree, currently not very abundant, but which spreads through the calcareous soils of the region, and is relatively frequently mentioned in palaeoenvironmental proxies such as charcoal analyses (Uzquiano 1992; Zapata Peña 2002). It is possible that, contrary to hazelnuts, acorns and Maloideae pomes which would be much more abundant, the strawberry tree was deliberately sought after, perhaps for the exploitation of its medicinal properties.

Potential evidence for the exploitation of common figs (*Ficus carica*) has also been gathered (vid. El Toral III, p. 379 and Los Gitanos, p. 386), although their provenance from wild stands or domesticated ones is impossible to tell from the seeds. Should the presence of fig seeds be safely established, either a reconsideration of wild fig-tree distribution prior to domestication (Zohary, Hopf & Weiss 2012) might be needed (Khadari *et al.* 2005); or the development of food preservation practices to allow large-distance mobility and exchange (Bakels & Jacomet 2003) from the Mesolithic should be considered.

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48 Determinations are not completely secure due to the natural polymorphism of fig seeds and the reduced number of possible specimens.
Spring would be the best season for the collection of broad-leaved herbs for their consumption as green vegetables, such as nettle (*Urtica* sp.), docks (*Rumex* sp.), cinquefoils (*Potentilla* sp.) or plants in the primrose family (*Primulaceae*) and umbellifers (*Umbelliferae*). However, these herbs might have been employed for a variety of other uses, ranging from medicinal to technological, and also eaten in other different food preparations. Due to the fact that the presence of seeds indicates gathering in summer, another explanation than the consumption as greens must be considered. If gathered for medicinal uses, these plants would have been best gathered at the time of flowering (Fern 1992-2010), in spring, when their effects are generally more powerful. But because they could be dried and stored as pharmaceutical raw-materials, to prepare, mix and use piecemeal, their seeds could have been charred at any period. Whilst *Rumex* spp. seeds might be ground to powder and used as flour, *Urtica* spp. seeds are rich in oil and might be pressed for its extraction (Fern 1992-2010). Both of these activities could account for the intentional gathering of their seeds whilst the plants could have also been used for technological activities, such as dyeing (*Rumex* roots) and weaving (*Urtica* fibres) and the seeds could have only arrived accidentally.

Wild grasses have been also attested (*Avena* sp.? and Gramineae tp. *Bromus*), but their interpretation is difficult because, although they could have been intentionally exploited for food (grain), medicines (leaves) and technological uses (straw), they appear in agricultural contexts and might be crop weeds accidentally gathered. The new cereals of the early agriculture would probably serve as food and technological uses as well. The absence of sickles in the archaeological record suggest gathering by up-rooting or ear-plucking by hand or with mesorias, possibly due to the existence of small fields (Zapata Peña 2007).

The year-round organisation of labour for processing plant resources would be the following: spring: gathering of green herbs and possible drying for storage; summer: gathering of dry herbs, grass seeds and fruits and potential preparation for storage; autumn: gathering of nuts and potential storage preparations; winter: piecemeal use of stores for different purposes (food, medicinal, etc.). The introduction of cereal cultivation would introduce agricultural tasks through the year, precluding gathering: preparing the fields, sowing, weeding, manuring.

### 10.2.1.1.2 The mode of arrival of domesticates: demic diffusion or cultural transmission?

The trajectory of arrival of domesticated plants is a key element in the debate about the Neolithisation process in the Cantabrian region, and one which cannot be currently addressed properly given the fragmentary archaeobotanical record. None of the sites studied here has provided evidence for the exploitation of domesticated plants for the chronology in which plant domesticates first appear in the region, about 4500 cal BCE (Peña-Chocarro et al. 2005b). In fact, none of the contexts studied here has had a confident radiocarbon date from that precise age, they are either older or younger (*civ.* Table 120). Given the present archaeobotanical data, plant domesticates are thought to have been progressively (and timidly) adopted by local populations, although the arrival of foreign populations with them or the existence of specialised or seasonal sites without plant domesticates processing activities cannot be ruled out (Zapata Peña 1999b). Among the contexts studied here, only El Carabión (Layer 1) has been dated around 4500 cal BCE, but these dates have been obtained from low-confidence samples (undetermined wood charcoal with a dispersed distribution) which could be “artificially” old. The
scarcity of late 6th and early 5th millennia contexts in the Cantabrian region is a well-known fact (e.g. Fano & Cubas 2012) which might be explained by having so far failed to locate the right habitational sites (e.g. probably the case of Los Gitanos, Cubas & Ontañón 2009).

<table>
<thead>
<tr>
<th></th>
<th>Early (Pre-megalithic) Neolithic (4500-4000 cal BCE)</th>
<th>Megalithic Neolithic (4th millennium cal BCE)</th>
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<tr>
<td></td>
<td>Pico Ramos IV El Mirón Kobaederra II-V Lumentxa</td>
<td>Arangas-D Los Gitanos–A1</td>
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<tr>
<td>Triticum “nudum”</td>
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<td>Triticum dicoccum</td>
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<td>Triticum monococcum</td>
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<td>Hordeum vulgare</td>
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<td>Hordeum vulgare var. vulgare</td>
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<td>Hordeum vulgare var. nudum</td>
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Table 123: Evidence for the introduction of plant domesticated species in the Cantabrian region during the Neolithic.

Early Neolithic agriculture in the Cantabrian region was initially thought to be characterised as a hulled wheat and barley agriculture, possibly due to climatical reasons (adaptation to high humidity) (Zapata Peña 2007), but recent evidence suggest the existence of naked wheats since the beginning of the local cereal cultivation (Peña-Chocarro 2012) (Table 123 and Figure 121). The main contribution of this work to the understanding of the Neolithisation process is the determination of hulled and naked barley varieties at the site of Arangas by the second half of the 4th millennium cal BCE (vid. Table 123). The introduction of barley in the Cantabrian region had been earlier attested, from the end of the 5th millennium and beginnings of the 4th cal BCE (Zapata Peña 2005-2006). The assemblage from Arangas is, however, the oldest determination of the naked variety in the region, as other determinations did not specify the variety, probably due to preservation issues (Pico Ramos and Kobaederra, Zapata Peña 1999b), or did specify the hulled variety (Lumenxta, Zapata Peña 1999b). The other context which has provided domesticate remains is Los Gitanos (Sublayer A1), with testimonial presence of Triticum sp. and Triticum “nudum” and absence of hulled-wheats, which were already known in the region (e.g. Peña-Chocarro et al. 2005b).

By the time domesticates arrived in the Cantabrian region, both the immediate East and South possessed domesticates as well (e.g. Peña-Chocarro 2007). In addition to the possible Mediterranean introduction of the Neolithic crop assemblage to the Iberian Peninsula, the Western Pyrenees have been suggested as another
possible way of introduction which still needs to be tested (Zapata Peña 1999b; Zapata Peña 2007). Data from Atlantic France, particularly from Early Neolithic contexts, are however very limited (Zapata & Peña-Chocarro 2005). Current evidence suggests the improbability of the introduction of domesticates to the Cantabrian region by populations travelling by sea from the Mediterranean along the Portuguese coast, creating “Neolithic enclaves” (e.g. Zilhão 2003), which could account for the spread of domesticates in faraway coastal sites in a very short lapse of time (vid. p. 480). No particular similarities between the Cantabrian region and other Iberian contexts can be seen in order to be able to suggest that the domesticated crop “package” might have arrived from there, other than the absence or rarity of other domesticates (legumes, flax and opium poppy) which also occurs in the central area (Stika 2005). However, these other domesticates have less chances of surviving in charred assemblages and therefore the absence of pulses in the Cantabrian region could be a combination of their unfavourable differential preservation with respect to cereals and the general fragmentary and reduced carpological evidence in the region. The Bayesian analysis of radiocarbon dates obtained from Early Neolithic contexts (those including plant and animal domesticates) has shown an East to West chronological gradient in the introduction of domesticated species in the region (Fano, Cubas & Wood 2015) which is apparently supported (or, rather, not contradicted) by the scanty information available regarding the first plant domesticates. More contexts from this period and more plant macroremain evidence are needed to shed light upon that matter.

10.2.1.2 Portugal

Most hypotheses about plant use by human groups in Portugal have relied on indirect proxies: stable isotope evidence show a relatively high importance of terrestrial foods, probably plants (Umbelino et al. 2007), and anthropological remains show a high degree of dental wear and a high level of caries (Arnaud 2000), which could point to a significant consumption of plant foods.

10.2.1.2.1 Plant exploitation activities

Several sugar-rich fruits (Corema album and Ficus carica) and carbohydrate-rich grains (Lolium sp.) which could account for the high levels of caries detected in anthropological samples have been found.

Portuguese crowberries show prominently in the archaeological record from sites in Estremadura, Corema album is a fruit taxon that seems to be the object of a thorough exploitation in São Pedro de Canaferrim and Lapiás das Lameiras (different fruit parts appear constantly cross-stratigraphically): this plant is known to have been intensively exploited, both as food and medicine, from the Roman era up to recent times (e.g. Bugalhão & Queiroz 2005, Queiroz & Mateus 2011, van Leeuwaarden et al. 1999). The taxon has been present in the Iberian Peninsula throughout the Holocene, as is attested in diverse core samples from at least the 8th millennium (e.g. Freitas, Andrade & Cruces 2002; Mateus & Queiroz 1993). Its exploitation has traditionally surpassed the range of its very limited natural habitat, being the object of commercial exportation towards other regions (e.g. Carruthers 2014; Gil-López 2011) and due to overexploitation and the reduction of its potential habitats it is now in risk of disappearance. Its
Inés L. López-Díriga

prehistorical archaeological record is expanding: a Pleistocene British mention exists (Parfitt et al. 2005, which should be regarded somewhat sceptically for palaeoclimatological reasons and which might be the result of endozoochoric transportation, Proctor 1968) and a further two records have recently been cited (Peña-Chocarro, unpublished; Stika, unpublished). It is unknown whether cultural reasons are behind this discontinuous pattern of exploitation or it is rather a matter of lack of identification, despite the fact that analyses of plant macroremains have been appropriately conducted at several archaeological sites from different periods in the distribution range. Perhaps there were times when it was the object of luxury consumption due to its scarcity and seasonality (Curet & Pestle 2010) and carbonisation accidents were carefully avoided. What is clear is that *Corema album* is a plant which has played an important part in human culture for at least 7000 years but unfortunately it is now in danger of disappearing and should be a great concern in biodiversity conservation programmes.

Evidence for fig (*Ficus carica*) exploitation is sparse but very promising: it consists of a few seeds and a possible fruit flesh fragment with the imprint of a seed. Whilst figs can be eaten raw, they have excellent storage properties once dry (Bakels & Jacomet 2003): the find from Poças de São Bento strongly suggests the practice of exposing whole figs to fire, most probably for drying (Pinto Carvalho 2005). Other fruits very likely exploited for potential diverse purposes are *Celtis australis* and *Pistacia lentiscus*. Seeds from this both of them, very rich in an appreciated oil (Fern 1992-2010; Flora iberica 1986+), might have been pressed for its extraction at Poças de São Bento, as is suggested by the high fragmentation of the endocarps.

Nuts like *Pinus pinea* appear prominently in the archaeobotanical record of the Sado area (Poças de São Bento and Cabeço do Pez). Whilst the seeds ripen in summer, the cones are best gathered in spring to avoid competition with animals such as squirrels, and need then to be exposed to fire to be opened. In addition, the pine cones themselves are very useful sources of tar which can be extracted for impermeabilisation of containers and the elaboration of glues. The noteworthy scarcity of charred acorn remains in both the Mesolithic and Early Neolithic sites studied has been observed previously, although several species of *Quercus* trees were available and even abundant in the environment, and acorns have been appreciated foodstuffs cross-culturally and cross-regionally from ancient times. Whether this absence in the macroremain assemblages is a result of a taphonomical bias, a cultural choice or a combination of them remains to be determined. Among the factors involved in the taphonomical bias, it is possible that acorns could have been consumed, but they had specific processing areas which have not been identified in the archaeological record (this would account for the absence in the Mesolithic shell-midden sites but not the Early Neolithic sites, which are composed of pits with detritus from very different processing activities, in which it would be difficult to explain the absence of acorns should they have been indeed processed). Another explanation, half taphonomical and half cultural, would be that acorns were prepared in such a way that they would hardly ever become charred. Most acorns need quite intensive processing to extract their tannin contents and many of the techniques involve the use of fire, with the exception of leaching. A completely cultural explanation would be that acorns were not chosen to be exploited for some reason or other. Is a seasonal explanation also possible? Acorns mature in autumn whilst most of the seeds at the sites do ripen in spring or summer.

Various herbs in the studied sites might have been exploited for diverse uses. The leaves of many (*Anagallis arvensis*/monelli, *Brassica* sp./*Sinapis* sp., *Chenopodium* spp., *Echium* sp., *Geranium* sp., *Leguminosae*, *Linaria* sp., *Malvaceae*, *Plantago* sp., *Rumex* sp., *Salsola* sp., *Urtica membranacea*, *478*
Part IV: Discussion and conclusions

*Viola* sp.) could have been used as green vegetables, or together with other vegetative parts, exploited for their medicinal properties (Fern 1992-2010). Diverse types of wild edible legumes (*Coronilla* sp./*Galega* sp., *Genista* sp./*Lotus* sp., *Lathyrus* spp., *Trifolieae*, *Vicia* spp.) are also conspicuous in all studied contexts, and as they usually grow together in dense turfs and as they might be processed in a similar way, they might have been gathered conjointly for consumption (Hillman, Legge & Rowley-Conwy 1997). The best season for gathering plants for both of these activities would be the spring and more particularly the flowering time, when leaves are green and tender and when phytochemical properties are generally strongest (Fern 1992-2010). Particularly regarding medicinal uses, vegetative plant parts can be dried and stored, sometimes ground, for piece-meal use over the year as needed. *Atrapa bella-donna* and *Solanum nigrum* might be, in contrast, more properly considered as potentially exploited pharmaceutically, because their fruits are rich in toxic alkaloids, which can be used in a wide range of medicinal applications, and their effects are stronger when bearing fruits (Fern 1992-2010). However, because all the remaining listed herbs usually fruit in summer or autumn, their most likely suggested functional exploitation is for alternative purposes, such as the consumption of the seeds as cereals and legumes (*Avena* sp., *Lolium* sp., *Leguminosae*), for their oils (*Brassica* sp./*Sinapis* sp., *Echium* sp., *Malvaceae*, *Plantago* sp.) or flour (*Avena* sp., *Lolium* sp., *Chenopodium* spp., *Rumex* spp.), or the exploitation of their vegetative parts for dyeing (*Linaria* sp., *Rumex* spp.), fibre extraction (*Urtica membranaceae*, *Viola* sp.), thatching (*Lolium* sp.), etc.

In the case of agricultural contexts, some of these plants might have acted as crop weeds (*e.g.* *Malvaceae*, *Chenopodium* sp., *Solanum* cf. *nigrum*), but being edible and usable in other ways, they might have been considered “useful weeds”. Regarding domesticated crops, comparison between the sites of São Pedro de Canaferrim and Lapiás das Lameiras is unavoidable, as the archaeobotanical contexts and chronologies are similar, despite the relatively larger differences in the climate and environments of the sites. In both of them, naked cereals (wheat and barley) are the most abundant remains, and other domesticated crops much less represented in the charred assemblages. These differences could be due to several taphonomical biases, depending on the purpose of cultivation (*e.g.* processing would be less intense if the crops were destined for animal fodder than for human consumption) and the way of preparation (different preferences for different plants, *e.g.* some eaten raw and other roasted or boiled). Conspicuous differences exist between the legumes, both from wild and potentially domesticated species, and possibly both cultivated, present in the sites. It is difficult to tell whether these taxonomical and quantitative differences correspond to different appreciations of them or simply to different preparation techniques. The case of legume cultivation and the presence of domesticated legumes is difficult to approach, because wild and domesticated legume grains are morphologically indistinguishable in the absence of characteristic features such as the testa, and even then, differences are very subtle (Butler 1990). In comparison with cereals, legumes have less chances of becoming carbonised because they might be eaten green (with the exception of those species which need detoxifying). It is possible that the great variety of domesticated crops would have been a way to minimise risks (Halstead 1996 apud Zapata Peña 1999b). The possibility, as suggested for the North-East (Antolín, Jacomet & Buxó 2015), for crop rotation between naked barley, which quickly depletes soils, and pea, which fixes nitrogen, might be placed as an interesting hypothesis.

Although most plant processing activities would have been carried out from spring to autumn (gathering, preparation, consumption/storage), their actual use could have taken place at any time, as at least some parts of most of them might be stored dry for delayed consumption. Gathering of both wild
and domesticated legumes and grasses would concentrate labour in summer; whilst fruit collection would be primarily carried out in autumn. Hints about fruit gathering at several kilometres distance have been gathered for several resources (namely, *Corema album* and *Chamaerops humilis*, considering the lesser likelihood of their endozochoeric transport, *vid.* p. 248 and 217). Preparation for storage of most resources would follow immediately after gathering, as all these resources are easily storable once dried. The “exotic” products would have been dried before being transported (and eventually exchanged).

Given the present circumstances, it is impossible to ascertain if the domesticated crops were cultivated in the neighbourhood of the studied sites or were imported from elsewhere; what is for sure, is that they were available to the inhabitants, who made a thorough use of them. Most of the evidence from cereals comes in the form of grains, representing the final stages of processing, when the product was already clean (van der Veen 2007). Therefore, it is unknown how cereals were stored, but the existence of storage must have been inherent to the agricultural system. If cultivation was local, a portion of the crop would have been eaten throughout the year, another portion would have been stored as seed for next’s year sowing and another portion would have been saved for risk buffering (bad seasons). It is possible that some of the underground negative structures were initially used as silos, before being just the recipients of domestic detritus. If cultivation was not carried out at the sites, then the cereals must have arrived incompletely processed (probably in spikes or at least spikelets) and stored in mobile containers (Sigaut 1988). The very few remains from straw from grasses might indicate that they were part of an intensive system of exploitation of all crop by-products: the straw would be rarely discarded into the fire, as it could be used for repairing roof thatchings and walls for the oncoming winter season or for animal foddering.

If locally cultivated, the innovation brought about by the introduction of domesticated species would be the addition of potentially new agricultural activities, such as tending the fields (sowing, weeding, manuring, etc.) which would be carried out casually during the rest of the year. The scarcity of weeds recovered in our samples suggests as a possibility that, if cultivation and crop processing was carried out at the sites, then there was an intense exploitation of these crop by-products as well, probable for animal foddering: either just after weeding the cropfields or after cleaning (winnowing and screening) the grains. These activities, however, could also have been carried out with morphologically wild plants, such as legumes and grasses (Hillman, Legge & Rowley-Conwy 1997).

10.2.1.2.2 The mode of arrival of domesticates: demic diffusion or cultural transmission?

The introduction of domesticated species, at least cereals, to the Atlantic Iberian Peninsula is first attested in two of the sites studied in this work, São Pedro de Canaferrim and Lapiás das Lameiras (*vid.* Table 124). The first domesticated plants were known to appear almost simultaneously in different western Mediterranean regions (central, south and eastern Iberia and Northern Africa) from around 5600-5500 BCE, whilst the Atlantic regions only had data from relatively posterior northern sites, which pointed to the presence of domesticates since the early 5th millennium cal BCE (Peña-Chocarro *et al.* 2013). The new data obtained in this work fill a very important gap regarding the process of Neolithisation in the Iberian Peninsula (*vid.* Figure 119), showing that agricultural innovations reached Atlantic Iberia at about the same time as the Mediterranean regions.
### Table 124: Evidence for the introduction of plant domesticates during the Neolithic in Portugal (Phases according to Carvalho 2010 and Carvalho 2012).

<table>
<thead>
<tr>
<th></th>
<th>Early Neolithic</th>
<th>Middle Neolithic</th>
<th>Late Neolithic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phase 1: 5,500–5,300 cal BCE</td>
<td>Phase 2: 5,300–5,000 cal BCE</td>
<td>Phase 3: 5,000–4,500 cal BCE</td>
</tr>
<tr>
<td>Lapiás das Lameiras</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>São Pedro de Canaferrim</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Buraco da Pala IV</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Buraco da Pala III</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><em>Hordeum vulgare var. vulgare</em></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Hordeum vulgare var. nudum</em></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Triticum “nudum”</em></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Triticum durum</em></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><em>Triticum “vestitum”</em></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><em>Triticum dicoccum</em></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Triticum monococcum</em></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Lathyrus sativus</em></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><em>Lens culinaris</em></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><em>Pisum sativum</em></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Vicia faba</em></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Vicia ervilia/Lathyrus sativus</em></td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

The assemblages of domesticated plants (at least cereals, but possibly also legumes) in Estremadura sites (São Pedro de Canaferrim and Lapiás das Lameiras) are relatively diverse (*Hordeum vulgare*, *Triticum “nudum”, Triticum dicoccum, Triticum monococcum*) (*vid. Figure 123*). Remains of diverse foreign domesticated cereals are the most abundant charred plant macroremains discarded into garbage dump pits at progressive rates, showing that they were not the result of an isolated consumption event but that they had a consolidated domestic role within the human communities in the Estremadura area as early as the second half of the 6th millennium cal BCE. Diverse species of legumes, some of them also possible domesticates arriving from elsewhere (*Pisum cf. sativum*, *Lens cf. culinaris*, *Lathyrus sativus/Vicia ervilia, Vicia tp. faba, Vicia tp. sativa*) but also autochthonous species (*Lathyrus sp., Vicia sp., Vicia tp. cracca*) exploited from local sources, were also intensively processed in the sites (*vid. Figure 122*).

This diversity of crop species seems to become reduced at later stages of Neolithisation (Phase 3, *vid. Table 124*). Due to the scarcity of contexts, it is difficult to tell whether this apparent diversity it is a general trend, possibly correlated with that observed in other Iberian regions (Antolín, Jacomet & Buxó 2015), or just a taphonomical bias due to having as a reference for the period just one site, situated in a distant inner region which might have possibly undergone different Neolithisation processes.
As regards the introduction of domesticated species in the Western Mediterranean during the Early Neolithic, different regional groups, according to the predominance of some or other domesticated species, have been identified from the evidence provided by sites such as Can Sadurní, El Toro, La Lámpara, La Revilla del Campo, Los Mármoles, Los Murciélagos and Nerja (Antolín & Buxó 2012, López-Dóriga & Simões in press, Peña-Chocarro 2007, Stika 2005). Ecological and environmental conditions are thought to have, at least in a limited way, influenced in the species and varieties predominantly cultivated in each region (Pérez Jordà, Peña Chocarro & Morales Mateos 2011). However, factors such as the likelihood of certain taxa to result more often charred according to different processing choices might be biasing this panorama: it is well-known that preserved assemblages do not exactly correspond to used assemblages, thus limiting the meaningfulness of the differences in proportions of charred items per species between different contexts, even more between different regions.

Turning a blind eye to this taphonomical bias, the Early Neolithic in the Western Mediterranean European region (from South Italy to the Iberian Peninsula) seems to follow a general trend in which glume cereals (Triticum dicoccum and Triticum monococcum) predominate in agricultural systems up to
ca. 5500 cal BCE, when naked cereals (*Triticum durum* and *Triticum aestivum*) take the leading role (Buxó i Capdevila *et al.* 1997, Gassin *et al.* 2010). However, some exceptions hint that this trend should be considered with caution (Antolín & Buxó 2012), particularly as a certain degree of independence in the Iberian Peninsula seems to exist (Cruz Berrocal 2012). Current knowledge about Early Neolithic sites in the Iberian Peninsula is not geographically homogeneous: the first known contexts, from the first half of the 6th millennium, are in the East Central area (Valencia), those of the second half of the 6th millennium and beginning of the 5th spread over an ampler territory, the North East area (Catalonia), South (Andalusia) and Central Iberia (Northern Meseta). Although cereals are in all cases the most represented crops, certain differences in the most abundant species exist, and two trends can be roughly identified (Gibaja *et al.* 2012): a free-threshing cereal and pulse based agriculture, in the South and East (with two exceptions Antolín & Buxó 2012); and a hulled-cereal based agriculture in the North. Other new domesticated crops such as flax (*Linum usitatissimum*) and opium poppy (*Papaver somniferum*) have a limited presence in both the Interior and Southern regions, but not in the North-East, a fact possibly explained by a Northern European link (Antolín, Jacomet & Buxó 2015). On the other side of the Mediterranean Sea, the Northern African coast displays a different agricultural trend: hulled wheats slightly predominate over naked ones but pulses, possibly including some of local origin, are cultivated as well (Ballouche & Marinval 2003; Peña-Chocarro & Zapata 2010; Morales *et al.* 2010; Cortés Sánchez *et al.* 2012).

In Atlantic Iberia, the debate is centred on whether the domesticates came, either via sea, from the East and South of the Iberian Peninsula, the North of Africa or indeed both (Carvalho 2010a); or, via land, from the interior regions of the Central Meseta. In this context, the seed assemblages from Lapiás das Lameiras and São Pedro de Canaferrim, because of the abundance of both naked cereals (*vid.* Figure 123) and wild pulses, could be the result of agricultural influences from both the South and East of the Iberian Peninsula and the North of Africa but rather not from Central Iberia (*vid.* Figure 107).

Wild plants have some arguments to offer in this discussion. On the one hand, *Chamaerops humilis* is a wild plant exploited both in North Africa (Morales *et al.* 2013) and São Pedro de Canaferrim, in both of them possibly obtained through exchange, this could be a matter of chance (availability of the plant) or point to a stronger cultural relationship with that region. *Corema album*, on the other hand, is a very limited wild resource on the Atlantic coast of the Iberian Peninsula. Its abundant consumption in both São Pedro de Canaferrim and Lapiás das Lameiras shows a deep knowledge of the available resources. This knowledge would be more likely in possession of local peoples who adopted domesticates and incorporated them to their traditionally known resources, transmitted over generations, as is suggested for the NE with other wild fruits (Antolín & Jacomet 2015) than by recently arrived populations from other Mediterranean regions who, out of the blue, would have decided to experiment with the available local resources. This Early Neolithic (Phases 1 and 2 of Carvalho 2010) Southern influence might have been complemented by a Northern influence, carrying flax and opium poppy (Sanches 1997), in Phase 3.

It is therefore reasonable to propose that Neolithisation was the result of an acculturation of the Mesolithic populations, in two possible scenarios. On the one hand, that some local species continued to play an important role (*e.g.* wild Gramineae species and fruits), and foreign species came to complement them. On the other hand, that some local species started to play an important role (*e.g.* pulses previously unrecorded), thanks to the adoption and modification of the concepts of intensive exploitation and,
possibly, domestication. Intensive plant exploitation, which could have led to domestication, existed prior to the possible adoption of foreign domesticates by local populations. If an earlier Holocene record for the exploitation of plants was known, it may be asked whether the local populations developed intensive local-plant exploitation by themselves or they were already inspired by the neighbouring farmers of the Neolithic enclaves but without acquiring their cultivates. The exploitation of local pulses, among other particularities, could also have been the result of a population replacement with incoming populations carrying out a “partial reformulation of their material cultures” (Carvalho 2010a). Strictly regarding the archaeobotanical record, this is not a discreditable explanation, as it seems possible that foreign populations adapted their plant exploitation and cultivation knowledge and experience to local species similar to the ones they knew well and brought with them.

Figure 124: Iberian agricultural trends in the 6th millennium according to plant macroremain evidence.
11 Conclusions

Archaeobotanical assemblages from several sites in the Cantabrian region and Portugal have been studied in this thesis. They have provided substantial insights into the exploitation of wild and domesticated plant resources by human groups between 8000 and 3000 cal BCE. However, the available information about plant exploitation during the Mesolithic and Early Neolithic in Atlantic Iberia is still limited and more work is needed to reach a better understanding of past plant resource usage. More work is generally needed, in the generalisation of appropriate sampling strategies and techniques for the recovery of plant remains in archaeological sites; in the development of identification criteria for the understanding of archaeobotanical formation processes and in the research on other types of remains which might serve as alternative evidence for the study of otherwise invisible plant resources. Archaeobotanical recovery and analysis strategies should become an essential part of archaeological work, and must be included in research plans and publications.

On the one hand, ample evidence about the exploitation of a wide spectrum of wild plant resources has been obtained for each studied area. For the Cantabrian region, this evidence complements and expands the data obtained in previous studies. For Portugal, this evidence is the first obtained with a systematical strategy and fills an important gap in the knowledge about the use of the plant resources by the last hunter-gatherers. In both regions, wild plant exploitation strategies have proven to be neither improvised nor prompted by an imperious imminent need. Several wild plant processing activities, probably including storage and delayed consumption, have been suggested for several taxa (most probably for Maleae and *Arbutus unedo*, but also possibly for many other fruits and herbs). In addition, allochthonous plants have been introduced (*Ficus carica* in the Cantabrian region, *Chamaerops humilis*, *Corema album* and cf. *Atropa bella-donna* in Portugal), possibly exchanged or transported by mobile groups, in some cases over large distances. Otherwise, the distribution of some species, such as the predomestication distribution of *Ficus carica*, needs reconsideration. The rarity of natural abundant resources (notably *Quercus* sp. acorns) needs to be explored, as it could both be a result of a taphonomical bias or due to a cultural choice.

On the other hand, new evidence about the earliest domesticated plants and Early Neolithic agriculture in Atlantic Iberia has been obtained. Whilst legumes and other domesticated plants such as flax (*Linum usitatissimum*) and opium poppy (*Papaver somniferum*) continue to be absent from the archaeobotanical record in the Cantabrian region, the earliest evidence of naked barley (*Hordeum vulgare* var. *nudum*) has been recovered in the site of Arangas at the end of the 4th millennium cal BCE. This complements previous data which characterised Early Neolithic agriculture in the Cantabrian region as consisting of wheat (hulled and naked) and barley. The earliest introduction of foreign domesticates in Portugal has been attested, comprising the whole range of Early Neolithic cereals (*Hordeum vulgare* var. *nudum* and *Triticum nudum* most abundantly, but *Hordeum vulgare* var. *vulgare*, *Triticum dicoccum* and *Triticum nudum*) and potentially some of the legumes (*Lens culinaris*, *Vicia faba*, *Lathyrus sativus*/Vicia ervilia and *Pisum sativum*). Evidence of flax (*Linum usitatissimum*) and opium poppy (*Papaver somniferum*) has not been found, either due to a result of differential preservation or to a real absence of use during this period. Possible cultural links between central Portugal and the South of the Iberian Peninsula and the North of Africa have been suggested.
This work proves that ancient plant remains are preserved by charring in a wide range of heterogeneous conditions (open-air sites and rock-shelters or caves, Atlantic and Mediterranean climates, alkaline and acid soils, shell-middens and pits, etc.). Plant resource exploitation is a key element in the understanding of hunter-gatherer societies and their relationships with their natural environment. Moreover, plant data are essential for the comprehension of the Neolithisation processes and agricultural practices. A very promising pathway for future archaeobotanical research involves the taphonomy of plant remains, in order to better understand the processing activities in which they have been involved and their way of reaching archaeological sites (particularly, if they have been digested). In addition, potential indirect proxies (notably, foraminifera and arthropod faecal pellets) for otherwise “invisible” plant exploitation strategies (algae, roots and rhizomes, freshly consumed fruits and plant parts, etc.) should be explored.
Appendixes and references

Appendix 1: Complete results of the archaeobotanical analyses

| Layer | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Soil layer | 11 | 12 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 |
| Depth | 17' | 15' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' | 17' |
| Square | C5 | C5 | C5 | G2 | G2 | G2 | D5 | C5 | D5 | C5 | C5 | C5 | C5 | C5 | C5 | C5 | C5 | C5 | C5 | C5 | C5 |
| Sector | 2 | 8 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Corylus avellana nutshell fragments | 1 | 4 | 3 | 11 | 3 | 7 | 1 | 1 | 4 | 1 | 5 | 30 | 6 | 6 | 18 | 6 | 8 | 12 | 13 | 1 | 4 | 7 |
| Rosaceae fruit | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Table 125: Results from the archaeobotanical non-woody macroremain analysis at El Carabión.

| Layer | 3 | 3 | 2 – 3 | 1 | 3 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 | A2 |
|-------|---|---|--------|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Inventory nº | 16 | 359 | 25 | 134 | 378 | 399 | 278 | 156 | 476 | 182 | 384 | 460 | 347 | 410 | 15 | 226 |
| Square | 10I | 17P | 11I | 16Q | 17P | 17Q | 17Q | 17Q | 17P | 17Q | 17Q | 17Q | 17Q | 17Q | 17Q | 17Q | 17Q | 17Q | 17Q |
| Sector | 2 | 3 | 6 | 6 | 5 | 4 | 9 | 9 | 5 | 5 | 6 | 4 | 2 | 7 | 1 |
| Corylus avellana shell fragment Type 1 (<16 mm2) | 1 | 5 | 1 | 2 | 13 | 1 | 6 | 1 | 2 | 1 | 1 | 1 | 3 |
| Corylus avellana shell fragment Type 2 (17 – 60 mm2) | 1 | 3 | 1 | 3 | 1 | 1 | 1 |
| Corylus avellana shell fragment Type 3 (>60 mm2) | 1 |
| Indeterminate charred compound | x |
| Indeterminate charred plant tissue | 1 |

Table 126: Results from the archaeobotanical non-woody macroremain analysis at Mazaculos II.

<table>
<thead>
<tr>
<th>Inventory nº</th>
<th>71</th>
<th>75</th>
<th>76</th>
<th>72</th>
<th>73</th>
<th>70</th>
<th>77</th>
<th>78</th>
<th>79</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference nº</td>
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<td>1226</td>
<td>1227</td>
<td>1232</td>
<td>1149</td>
<td>1229</td>
<td>1220</td>
<td>1221</td>
<td>1236</td>
</tr>
<tr>
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<td>233/76</td>
<td>233/78</td>
<td>233/76</td>
<td>233/77</td>
<td>233/77</td>
<td>233/77</td>
<td>233/77</td>
<td>233/77</td>
</tr>
<tr>
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<td>UE 1</td>
<td>UE 2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
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<td>3</td>
</tr>
<tr>
<td>Brassica sp. / Sinapis sp. seed</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Brassica sp. / Sinapis sp. seed fragment</td>
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<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Leguminosae small seed tp. / Genista/Lotus</td>
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<td></td>
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</tr>
<tr>
<td>Medicago sp. seed</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Medicago sp. seed fragment</td>
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<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Pinus cf. pinea bract-scale fragment</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Vicia sp. / Lathyrus sp. seed embryonal fragment</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Indeterminate non-woody plant tissue fragments</td>
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</tr>
<tr>
<td>Wood charcoal</td>
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<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

Table 127: Results from the archaeobotanical non-woody macroremain analysis at Cabeço do Pez.
### Table 128: Results from the archaeobotanical non-woody macroremain analysis at Arangas (Layers 3, 4 and D).

<table>
<thead>
<tr>
<th>Inventory nº</th>
<th>Artificial sublayer</th>
<th>Corylus avellana frags. pericarp type (1&lt;16 mm²)</th>
<th>Corylus avellana frags. pericarp type (17-60 mm²)</th>
<th>Corylus avellana frags. pericarp type (&gt;60 mm²)</th>
<th>Hordeum vulgare grain</th>
<th>Quercus sp. cotyledon basal fragment</th>
<th>Sorbus sp. detached seeds</th>
<th>Sorbus sp. fruit halves</th>
<th>Parenchymatic tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 3</td>
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<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
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</tr>
<tr>
<td>Area A</td>
<td>B</td>
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<td>B</td>
<td>B</td>
<td>B</td>
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<td>E11</td>
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<td>E11</td>
<td>E11</td>
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<td>Artifical sublayer</td>
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</tbody>
</table>

Fields marked in red belong to the samples with intrusive materials. Fields marked in orange belong to samples from the same site area of the samples with intrusive materials (Area B).
<table>
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<th>E1J</th>
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<th>E1O</th>
<th>E1P</th>
<th>E1Q</th>
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<td>C</td>
<td>C</td>
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- *Inés L. López-Dóriga*

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Continues on the following page.
Table 129: Results from the archaeobotanical non-woody macroremain analysis at El Mazo.

| Square | V15 | V16 | V15 | V16 | V16 | X15 | X16 | X16 | X16 | X15 | X15 | X15 | X15 | X15 | X16 | X16 | X16 | X16 | X16 | X16 | X16 | X16 | X16 | X16 | V15 | V16 | V16 |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Depth  | 1    | 1   | 1   | 2   | 2   | 2   | 3   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 2   | 1   | 2   | 3   | 1   | 3   | 1   | 2   | 1   |
| Arbutus arbutifolium fruit fragment | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Arbutus arbutifolium seed | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Erica sp. seed | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Corylus avellana pericarp fragment | 1    | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   |
| Corylus avellana frages. pericarp sp. 1 (<16 mm²) | 1    | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   |
| Corylus avellana frages. pericarp sp. 2 (17-60 mm²) | 1    | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   |
| Corylus avellana frages. pericarp sp. 3 (>60 mm²) | 1    | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   | 8   | 15  | 2   | 1   | 1    | 2   |
| Primulaceae seed | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Rumex sp. seed without coat | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Urtica sp. seed | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Urtica sp. seed | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Total bud | 1    | 1   | 1    | 1   | 1   | 1   | 1   | 1   | 1    | 1   | 1   | 1    | 1   | 1    | 1   | 1    | 1   | 1    | 1   | 1    | 1   | 1    | 1   | 1    | 1   | 1    |
| Total leaf | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Total parenchyma | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Total plant tissue | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Total stalk fragment | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Total seed coat fragment | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Total seed with hole under beak | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Fungi sclerotia (tp. Cenococcum geophilum) | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Total oblong charred featureless item | 1    | 3   | 1    | 3   | 1    | 5   | 6   | 1   | 1    | 2   | 1   | 2   | 1   | 1    | 1   | 1   | 1    | 1   | 1    | 1   | 1    | 1   | 1    | 1   | 1    |
| Indet. stalk fragment | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |
| Indet. charred stalk | x    | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |

Table 129: Results from the archaeobotanical non-woody macroremain analysis at El Mazo.
### Table 130: Results from the archaeobotanical non-woody macroremain analysis from El Toral III.

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- *Cardueae/Cynarae* seed basal fragment
- *Corylus avellana* pericarp fragment type 1 (<16 mm²)
- *Corylus avellana* pericarp fragment type 2 (17 - 60 mm²)
- *Corylus avellana* pericarp fragment type 3 (> 60 mm²)

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- *Cardueae/Cynarae* seed basal fragment
- *Corylus avellana* pericarp fragment type 1 (<16 mm²)
- *Corylus avellana* pericarp fragment type 2 (17 - 60 mm²)
- *Corylus avellana* pericarp fragment type 3 (> 60 mm²)

| Square | M4 | M4 | M4 | M4 | M4 | M4 | M4 | M4 | M4 | M4 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Sector | A  | B-D| C  | C  | A  | C  | A  | C  | C  | D  | A  | B  | B  | B  | B  | B  | C  | C  | D  | D  | D  | D  |
| SU     | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  |
| Depth  | 1  | 1  | 1  | 1  | 2  | 2  | 2  | 2  | 2  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  |

- *Cardueae/Cynarae* seed basal fragment
- *Corylus avellana* pericarp fragment type 1 (<16 mm²)
- *Corylus avellana* pericarp fragment type 2 (17 - 60 mm²)
- *Corylus avellana* pericarp fragment type 3 (> 60 mm²)

| Square | M4 | M4 | M4 | M4 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Sector | A  | A  | A  | A  | B  | B  | B  | B  | C  | C  | D  | D  | D  | D  | D  | D  | A  | A  | A  | B  | B  |
| SU     | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| Depth  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  |

- *Cardueae/Cynarae* seed basal fragment
- *Corylus avellana* pericarp fragment type 1 (<16 mm²)
- *Corylus avellana* pericarp fragment type 2 (17 - 60 mm²)
- *Corylus avellana* pericarp fragment type 3 (> 60 mm²)
- *cf.* *Ficus carica* seed
- *Poaceae* seed apical fragment
- *Rosa* sp. seed
- *Sorbus* sp. pome half fragment
- *Sorbus* sp. seed
- *Fungi* sclerotia (tp. *Cenococcum geophilum*)
- Indeterminate round/oblong featurless item
- Indeterminate reticulate seed testa fragments
- Indeterminate fruit pericarp fragment
- Indeterminate plant-tissue compounds

| Square | M4 | M4 | M4 | M4 | M4 | M4 | M4 | M4 | M4 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 | O6 |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Sector | A  | B-D| C  | C  | A  | C  | A  | C  | C  | D  | A  | B  | B  | B  | B  | B  | C  | C  | D  | D  | D  | D  |
| SU     | 1  | 1  | 1  | 1  | 2  | 2  | 2  | 2  | 2  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  |
| Depth  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |

- *Cardueae/Cynarae* seed basal fragment
- *Corylus avellana* pericarp fragment type 1 (<16 mm²)
- *Corylus avellana* pericarp fragment type 2 (17 - 60 mm²)
- *Corylus avellana* pericarp fragment type 3 (> 60 mm²)
- *cf.* *Ficus carica* seed
- *Poaceae* seed apical fragment
- *Rosa* sp. seed
- *Sorbus* sp. pome half fragment
- *Sorbus* sp. seed
- *Fungi* sclerotia (tp. *Cenococcum geophilum*)
- Indeterminate round/oblong featurless item
- Indeterminate reticulate seed testa fragments
- Indeterminate fruit pericarp fragment
- Indeterminate plant-tissue compounds

Inés L. López-Dóriga
| Inventory nº | 58 | 60 | 77 | 78 | 130 | 159 | 180 | 235 | 258 | 376 | 860 | 946 | 1280 | 1288 | 1380 | 1494 | 1508 | 180 | 182 | 276 | 293 | 371 | 810 | 812 | 817 | 819 | 839 | 1025 | 1030 | 1042 | 1079 | 1082 | 1091 | 1280 | 1285 | 180 | 182 | 276 | 293 | 371 |
|-------------|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Sublayer     | A1 | A2 | A1 | A1 | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  | A1  |
| Level        | 4  | 4  | 6  | 6  | 5   | 5   | 5   | 4   | 4   | 4   | 3   | 3   | 4   | 4   | 3   | 3   | 4   | 4   | 4   | 4   | 4   | 4   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   |
| X            | 34 | 79 | 32 |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Y            | 36 | 88 | 66 |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

- *cf. Avena* sp. *embryonal grain fragment*
- *sp. Cruciferae / Ericaceae seed*
- *Compositae seed*
- *Corylus avellana pericarp fragment type 1 (<16 mm²)*
- *Corylus avellana pericarp fragment type 2 (17 - 60 mm²)*
- *Corylus avellana pericarp fragment type 3 (> 60 mm²)*
- *cf. Ficus carica seed*
- *Oxalis sp. *apical grain fragment*
- *sp. Malvaceae seed*
- *Potentilla sp. seed*
- *Quercus sp. *cotyledon fragment*
- *sp. Quercus sp. *cotyledon fragment with embryo*
- *sp. Quercus sp. NMI*
- *Rumex sp. Obtusifolius seed*
- *sp. Simarouba aquatica seed*
- *Triticum *'nudum'* grain*
- *Triticum sp. grain*
- *Umbelliferae seed*
- *Vitis sp.* *seed or seed fragment*
- *sp. Chenopodiaceae plant tissue fragments*
Table 131: Results from the archaeobotanical non-woody plant macroremain analysis at Los Gitanos.

| Inventory nº | 1328 | 1371 | 1391 | 1394 | 1401 | 1408 | 1409 | 1421 | 1459 | 1481 | 1499 | 1501 | 1503 | 1505 | 1507 | 1510 | 1511 | 1512 | 1513 | 1514 | 1515 | 1516 | 1517 | 1518 | 1519 | 1520 |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Level        | 10   | 10   | 11   | 14   | 14   | 14   | 13   | 13   | 13   | 13   | 13   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   | 12   |
| X            | 36   | 68   | 41   | 50   | 26   | 50   | 29   | 56   | 12   | 40   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Y            | 34   | 55   | 55   | 31   | 50   | 79   | 11   | 78   | 8    | 60   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Z            | 173  | 159  | 153  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  | 151  |

1. Anana cp. embryonal grain fragment
2. Cruciferae / Ericaceae seed
3. Compositae seed
4. Corylus avellana per tarp fragment type 1 (<16 mm²)
5. Corylus avellana per tarp fragment type 2 (17 - 60 mm²)
6. Corylus avellana per tarp fragment type 3 (> 60 mm²)

| 1. Ficus carica seed |
| 2. Gramineae tp. Bromus sp. apical grain fragment |
| 3. Indet. seeds or seed fragments |
| 4. Indet. non-woody plant tissue fragments |
| 5. Potentilla sp. seed |
| 6. Quercus sp. cotyledon fragment |
| 7. Quercus sp. cotyledon fragment with embryo |
| 8. Quercus sp. NMI |
| 9. Rumex sp. cotyledon fragment |
| 10. Senecio aquaticus seed |
| 11. Triticum "nudum" grain |
| 12. Typha sp. grain |
| 13. Urticaceae seed |
| 14. Wood charcoal |
| 15. Wood dust and plant tissue fragments |
| 16. Fungi sclerotia |

Table 131: Results from the archaeobotanical non-woody plant macroremain analysis at Los Gitanos.
Indeterminate fruit flesh fragment with seed imprint

Indeterminate non-woody plant tissue

Indeterminate seed

Indeterminate seed fragment

Indeterminate shoot

Indeterminate tuber

Wood charcoal

Charred dead/dry-wood termite faecal pellets

Charcoal

Reference nº

Inventory nº

Anagallis arvensis / monelli

seed

cf. Celtis australis endocarp fragment

Chenopodium album seed

Compositae

Coronilla sp. / Galega sp. seed

cf. Coronilla sp. / Galega sp. seed
typ.

Echium sp. seed fragment

cf. Ficus carica fruit mesocarp fragment with seed imprint

cf. Ficus carica seed

cf. Geranium sp. seed

Linaria sp. seed

Lolium sp. seed

Malva tp. nicaeensis seed

Malva tp. sylvestris seed

Malva sp. / Lavatera sp. seed

Plantago sp.

Pinus pinea bract-escale fragment

cf. Pinus pinea bract-escale fragment

cf. Pinus pinea nutshell fragment

Pistacia lentiscus endocarp fragment

Poaceae – Gramineae seed

Poaceae – Gramineae seed with round hole (insect)

Poaceae – Gramineae seed embryonal fragment

Poaceae – Gramineae seed fragment

Polygonaceae seed

Quercus sp. ½ basal pericarp fragment

Rumex sp. seed

Rumex tp. thyrsiflorus seed

Urtica membranaceae seed
typ.

Viola sp. seed

Indeterminate parenchymae fragment

Indeterminate stalk or pedicel fragment

Indeterminate succulent acicula fragment

Indeterminate thin pericarp fragment

Charred oblong featureless items – arthropod faecal pellets?

Fungi sclerotia typ.

Cenococcum geophilum

Uncharred seeds

Uncharred rodent dung pellets

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<table>
<thead>
<tr>
<th>Reference nº</th>
<th>Inventory nº</th>
<th>Anagallis arvensis / monelli seed</th>
<th>cf. Celtis australis endocarp fragment</th>
<th>reference nº</th>
<th>symbol</th>
<th>round hole</th>
<th>sample nº</th>
<th>symbol</th>
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<tr>
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<td>1</td>
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<tr>
<td>3390</td>
<td>10699</td>
<td>Charred oblong featurless items – arthropod faecal pellets?</td>
<td>Fungi sclerotia</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
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Inés L. López-Dóriga

<table>
<thead>
<tr>
<th>Reference nº</th>
<th>Inventory nº</th>
<th>Anagallis arvensis / monelli seed</th>
<th>cf. Celtis australis endocarp fragment</th>
<th>Chenopodium album seed</th>
<th>Compositae</th>
<th>Corinilla / Galega sp. seed</th>
<th>cf. Coronilla sp. / Galega sp. seed</th>
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<tr>
<td></td>
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<td>cf. Echium sp. seed fragment</td>
<td>cf. Ficus carica fruit mesocarp fragment with seed imprint</td>
<td>cf. Ficus carica seed</td>
<td>cf. Geranium sp. seed</td>
<td>Linaria sp. seed</td>
<td>cf. Lolium sp. seed</td>
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<td>cf. Polygonaceae seed</td>
<td>Quercus sp. 1/2 basal pericarp fragment</td>
<td>Rumex sp. seed</td>
<td>Rumex sp. / Rheum sp. seed</td>
<td>Viola sp. seed</td>
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<td>Indeterminate stalk or pedicel fragment</td>
<td>Indeterminate succulent acicula fragment</td>
<td>Indeterminate thin pericarp fragment</td>
<td>Charred oblong featureless items – arthropod faecal pellets?</td>
<td>Fungi sclerotia tp. Cenococcum geophilum</td>
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<th>Inventory nº</th>
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<td>Anagallis arvensis / monelli</td>
<td>cf. Celtis australis endocarp fragment</td>
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<td>Chenopodium album seed</td>
<td>cf. Coronilla sp. / Galega sp. seed</td>
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<tr>
<td>tp. Echium sp. seed fragment</td>
<td>cf. Ficus carica fruit mesocarp fragment with seed imprint</td>
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<tr>
<td>cf. Ficus carica seed</td>
<td>cf. Geranium sp. seed</td>
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<td>Linaria sp. seed</td>
<td>Lolium sp. seed</td>
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<td>tp. Lolium sp. seed embryonal fragment</td>
<td>cf. Lolium sp. seed</td>
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<td>cf. Lolium sp. seed fragment</td>
<td>Malva tp. nicaeensis seed</td>
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<td>Malva tp. sylvestris seed</td>
<td>Malva sp. / Lavatera sp. seed</td>
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<td>Plantago sp.</td>
<td>Pinus pinea bract-escale fragment</td>
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<tr>
<td>cf. Pinus pinea bract-escale fragment</td>
<td>cf. Pinus pinea nutshell fragment</td>
</tr>
<tr>
<td>cf. Pistacia lentiscus endocarp fragment</td>
<td>Poaceae – Gramineae seed</td>
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<tr>
<td>Poaceae – Gramineae seed with round hole (insect)</td>
<td>Poaceae – Gramineae seed embryonal fragment</td>
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<tr>
<td>Poaceae – Gramineae seed fragment</td>
<td>Polygonaceae seed</td>
</tr>
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<td>Quercus sp. ½ basal pericarp fragment</td>
<td>Rumex sp. seed</td>
</tr>
<tr>
<td>Rumex tp. thyrsiflorus seed</td>
<td>Urtica membranaceae seed</td>
</tr>
<tr>
<td>tp. Viola sp. seed</td>
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<td>Indeterminate succulent acicula fragment</td>
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<td>Indeterminate thin pericarp fragment</td>
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<td>Fungi sclerotia tp. Cenococcum geophilum</td>
<td>Uncharred seeds</td>
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<tr>
<td>Uncharred rodent dung pellets</td>
<td>Wood charcoal</td>
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</table>

Continues on the following page.
Table 132: Results from the archaeobotanical non-woody macroremain analysis at Poças de São Bento.

| Reference nº | Inventory nº | X     | Y     | Z     | Anagallis arvensis / monelli seed | cf. Celtis australis endocarp fragment | Chenopodium album seed | cf. Coronilla sp. / Galega sp. seed | cf. Echium sp. seed fragment | cf. Ficus carica fruit mesocarp fragment with seed imprint | cf. Ficus carica seed | cf. Geranium sp. seed | Linaria sp. seed | Lolium sp. seed embryonal fragment | cf. Lolium sp. seed | cf. Lolium sp. seed fragment | Malva sp. / Malva sylvestris seed | Malva sp. / Malva nicaeensis seed | Malva sp. / Lavatera sp. seed | Plantago sp. | Pinus pinea bract-escale fragment | cf. Pinus pinea bract-escale fragment | cf. Pinus pinea nutshell fragment | cf. Pistacia lentiscus endocarp fragment | Poaceae – Gramineae seed | Poaceae – Gramineae seed with round hole (insect) | Poaceae – Gramineae seed embryonal fragment | Poaceae – Gramineae seed fragment | Polygonaceae seed | Quercus sp. ½ basal pericarp fragment | Rumex sp. seed | Rumex sp. / Rumex thyrsiflorus seed | Urtica membranacea seed | cf. Viola sp. seed | Indeterminate parenchymae fragment | Indeterminate stalk or pedicel fragment | Indeterminate succulent acicula fragment | Indeterminate thin pericarp fragment | Charred oblong featurless items – arthropod faecal pellets? | Fungi sclerotia | cf. Cenococcum geophilum |
|--------------|--------------|--------|--------|------|----------------------------------|---------------------------------------|-----------------------|---------------------------------|-----------------------------|---------------------------------|-----------------|-------------------|----------------|----------------------------------|-----------------|-----------------------------|------------------|-------------------|------------------|--------------------------------|----------------|-----------------|----------------|----------------|----------------|---------------------------------|----------------|-------------------|----------------|----------------|-----------------|----------------------------------|----------------|-------------------|
| 102.7505     | 100.8366     | -10.6487 | -10.4705 | -10.7643 | Anagallis arvensis / monelli seed | cf. Celtis australis endocarp fragment | Chenopodium album seed | cf. Coronilla sp. / Galega sp. seed | cf. Echium sp. seed fragment | cf. Ficus carica fruit mesocarp fragment with seed imprint | cf. Ficus carica seed | cf. Geranium sp. seed | Linaria sp. seed | Lolium sp. seed embryonal fragment | cf. Lolium sp. seed | cf. Lolium sp. seed fragment | Malva sp. / Malva sylvestris seed | Malva sp. / Malva nicaeensis seed | Malva sp. / Lavatera sp. seed | Plantago sp. | Pinus pinea bract-escale fragment | cf. Pinus pinea bract-escale fragment | cf. Pinus pinea nutshell fragment | cf. Pistacia lentiscus endocarp fragment | Poaceae – Gramineae seed | Poaceae – Gramineae seed with round hole (insect) | Poaceae – Gramineae seed embryonal fragment | Poaceae – Gramineae seed fragment | Polygonaceae seed | Quercus sp. ½ basal pericarp fragment | Rumex sp. seed | Rumex sp. / Rumex thyrsiflorus seed | Urtica membranacea seed | cf. Viola sp. seed | Indeterminate parenchymae fragment | Indeterminate stalk or pedicel fragment | Indeterminate succulent acicula fragment | Indeterminate thin pericarp fragment | Charred oblong featurless items – arthropod faecal pellets? | Fungi sclerotia | cf. Cenococcum geophilum |

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| Sublayer | Cerealia | Triticeae grain fragment | Hordeum vulgare ¼ grain fragment | Hordeum vulgare twisted grain fragment | Hordeum vulgare var. vulgare grain fragment | Hordeum vulgare var. vulgare ½ longitudinal ventral-dorsal grain fragment | Hordeum vulgare var. vulgare ½ apical grain fragment | Hordeum vulgare var. vulgare 1/3 medial grain fragment | Hordeum vulgare var. vulgare ¼ grain fragment | Hordeum vulgare var. nudum grain fragment | Hordeum vulgare var. nudum ½ longitudinal ventral-dorsal grain fragment | Hordeum vulgare var. nudum ½ apical grain fragment | Hordeum vulgare var. nudum ½ embryonal grain fragment | Hordeum vulgare var. nudum 1/3 apical grain fragment | Hordeum vulgare var. nudum 1/3 embryonal grain fragment | Hordeum vulgare var. nudum 1/3 medial grain fragment | Hordeum vulgare var. nudum ¼ grain fragment | Hordeum vulgare var. nudum twisted grain fragment | Hordeum vulgare var. nudum twisted ½ apical grain fragment | Hordeum vulgare var. nudum twisted 1/3 apical grain fragment | Hordeum vulgare var. nudum twisted 1/3 embryonal grain fragment | Hordeum vulgare var. nudum twisted 1/3 medial grain fragment | Triticum sp. grain fragment | Triticum sp. ½ longitudinal grain fragment | Triticum sp. ½ apical grain fragment | Triticum sp. ½ embryonal grain fragment | Triticum sp. ¼ grain fragment | Triticum "nudum" grain fragment | Triticum "nudum" ½ longitudinal ventral-dorsal grain fragment | Triticum "nudum" ½ apical grain fragment | Triticum "nudum" ½ embryonal grain fragment | Triticum "nudum" 1/3 apical grain fragment | Triticum "nudum" 1/3 embryonal grain fragment | Triticum "nudum" 1/3 medial grain fragment | Triticum "nudum" ¼ grain fragment | Triticum cf. "nudum" grain fragment | Triticum dicoccum grain fragment | Triticum monococcum ½ apical grain fragment | Triticum monococcum ½ embryonal grain fragment | Triticum monococcum 1-grained grain fragment | Triticum monococcum 1-grained ½ apical grain fragment | Triticum monococcum 2-grained grain fragment | Fabaceae | Fabaceae pulse | Fabaceae pulse fragment | Medicago sp. / Melilotus sp. / Trifolium sp. | Pisum sativum pulse | Pisum sativum pulse cotyledon | Vicia faba pulse | Vicia faba pulse cotyledon | Vicia tp. cracca pulse | Vicia tp. cracca pulse cotyledon | Avena sp. grain fragment | Avena sp. grain | Brassica sp. / Sinapis sp. | Chenopodium sp. | Malvaceae | cf. Atropa bella-donna | Solanum nigrum | Chamaerops humilis endocarp fragment | Corema album seed | cf. Corema album fruit | Indeterminate fragment of parenchymatic tissue | Indeterminate fruit endocarp fragment with fleshy mesocarp

Continues on the following page.
| Fabaceae pulse | 1 | 1 |
| Fabaceae pulse fragment | 1 |
| Medicago sp. / Melilotus sp. / Trifolium sp. | 1 |
| Pisum sativum pulse | 1 |
| Pisum sativum pulse cotyledon | 1 |
| Vicia faba pulse | 1 |
| Vicia faba pulse cotyledon | 1 |
| Vicia tp. cracca pulse | 1 |
| Vicia tp. cracca pulse cotyledon | 1 |
| Avena sp. grain | 1 |
| Avena sp. grain fragment | 1 |
| Brassica sp. / Sinapis sp. | 1 |
| Chenopodium sp. | 1 |
| Malvaceae | 1 |
| cf. Atropa bella-donna | 1 |
| Solanum nigrum | 1 |
| Chamaerops humilis endocarp fragment | 1 |
| Corema album seed | 1 |
| cf. Corema album fruit | 1 |
| Indeterminate fragment of parenchymatic tissue | 1 |
| Indeterminate fruit endocarp fragment with fleshy mesocarp | 1 |

Continues on the following page.
Table 133: Results of the archaeobotanical non-woody macroremain analysis at São Pedro de Canaferrim.
<table>
<thead>
<tr>
<th>Grain Type</th>
<th>1/3 Embryonal Grain Fragment</th>
<th>1/3 Apical Grain Fragment</th>
<th>1/3 Longitudinal Grain Fragment</th>
<th>1/3 Medial Grain Fragment</th>
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</thead>
<tbody>
<tr>
<td>Triticum monococcum</td>
<td>2-grained</td>
<td>1-grained 1/3</td>
<td>½ embryonal</td>
<td>½ apical</td>
</tr>
<tr>
<td>Triticum dicoccum</td>
<td>½ embryonal</td>
<td>½ apical</td>
<td>½ longitudinal ventral-dorsal</td>
<td>½ longitudinal dorsal</td>
</tr>
<tr>
<td>Triticum cf. dicoccum</td>
<td>½ embryonal</td>
<td>½ apical</td>
<td>½ longitudinal ventral-dorsal</td>
<td>½ longitudinal dorsal</td>
</tr>
<tr>
<td>Triticum durum</td>
<td>¼ grain fragment</td>
<td>1/3 medial</td>
<td>1/3 embryonal</td>
<td>1/3 apical</td>
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<tr>
<td>Triticum &quot;vestitum&quot;</td>
<td>Spikelet fork with glume base</td>
<td>1-grained</td>
<td>1/3 medial</td>
<td>1/3 apical</td>
</tr>
<tr>
<td>Hordeum vulgare var. nudum</td>
<td>Twisted ¼ grain</td>
<td>1/3 medial</td>
<td>1/3 embryonal</td>
<td>1/3 apical</td>
</tr>
<tr>
<td>Hordeum vulgare var. vulgare</td>
<td>¼ grain</td>
<td>1/3 medial</td>
<td>1/3 embryonal</td>
<td>1/3 apical</td>
</tr>
<tr>
<td>Hordeum vulgare var. vulgare</td>
<td>Straight ¼ grain</td>
<td>1/3 medial</td>
<td>1/3 embryonal</td>
<td>1/3 apical</td>
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<th>Species</th>
<th>1/3 medial</th>
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**Inés L. López-Dóriga**
### Appendixes and references

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Inés L. López-Dóriga

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Cerealia
Triticeae indeterminate grain
Triticeae indeterminate grain fragment

2
3

11

1

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7

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2

Hordeum vulgare grain
Hordeum vulgare ½ longitudinal ventral grain fragment
Hordeum vulgare 1/3 apical grain fragment

1

1

Hordeum vulgare 1/3 medial grain fragment

3

2

Hordeum vulgare ¼ grain fragment

3

6

3
3
3

5

Hordeum vulgare straight 1/3 medial grain fragment

2

Hordeum vulgare twisted grain
Hordeum vulgare twisted ½ apical grain fragment

1

Hordeum vulgare twisted 1/3 apical grain fragment
Hordeum vulgare twisted 1/3 embryonal grain fragment
Hordeum vulgare twisted 1/3 medial grain fragment
Hordeum vulgare var. vulgare grain
Hordeum vulgare var. vulgare ½ apical grain fragment
Hordeum vulgare var. vulgare ½ embryonal grain fragment
Hordeum vulgare var. vulgare 1/3 apical grain fragment
Hordeum vulgare var. vulgare 1/3 embryonal grain fragment
Hordeum vulgare var. vulgare 1/3 medial grain fragment
Hordeum vulgare var. vulgare ¼ grain fragment
Hordeum vulgare var. vulgare straight 1/3 embryonal grain fragment
Hordeum vulgare var. vulgare twisted grain
Hordeum vulgare var. vulgare ½ apical grain fragment twisted

1

Hordeum vulgare var. vulgare 1/3 embryonal grain fragment twisted
Hordeum vulgare var. nudum grain

16

Hordeum vulgare var. nudum ½ longitudinal ventral-dorsal grain fragment

36

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Hordeum vulgare var. nudum ½ longitudinal dorsal grain fragment
Hordeum vulgare var. nudum ½ longitudinal ventral grain fragment
Hordeum vulgare var. nudum ½ apical grain fragment

1
8

3

Hordeum vulgare var. nudum ½ embryonal grain fragment
Hordeum vulgare var. nudum 1/3 apical grain fragment

1
1

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12

Hordeum vulgare var. nudum 1/3 embryonal grain fragment

9

Hordeum vulgare var. nudum 1/3 medial grain fragment

17

Hordeum vulgare var. nudum ¼ grain fragment

111

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Hordeum vulgare var. nudum straight grain

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Hordeum vulgare var. nudum straight ½ longitudinal ventral-dorsal grain fragment
Hordeum vulgare var. nudum straight ½ apical grain fragment
Hordeum vulgare var. nudum straight ½ embryonal grain fragment
Hordeum vulgare var. nudum straight 1/3 apical grain fragment
Hordeum vulgare var. nudum straight 1/3 medial grain fragment
Hordeum vulgare var. nudum straight ¼ grain fragment
Hordeum vulgare var. nudum twisted grain

35

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Hordeum vulgare var. nudum twisted ½ longitudinal ventral-dorsal grain fragment

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Hordeum vulgare var. nudum twisted ½ longitudinal ventral grain fragment

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Hordeum vulgare var. nudum twisted ½ apical grain fragment

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Hordeum vulgare var. nudum twisted ½ embryonal grain fragment

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Hordeum vulgare var. nudum twisted 1/3 apical grain fragment

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Hordeum vulgare var. nudum twisted 1/3 embryonal grain fragment
Hordeum vulgare var. nudum twisted 1/3 medial grain fragment

11

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Hordeum vulgare var. nudum twisted ¼ grain fragment
Triticum sp. grain

12

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Triticum sp. ½ longitudinal grain fragment

20

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Triticum sp. ½ longitudinal dorsal grain fragment
Triticum sp. ½ apical grain fragment

17

Triticum sp. ½ embryonal grain fragment

15

1

1
1

Triticum sp. 1/3 apical grain fragment

Triticum sp. 1/3 medial grain fragment

1

Triticum sp. ¼ grain fragment

50

Triticum "nudum" grain

1

85

2
2
2

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11

Triticum cf. "nudum" grain
25

2

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Triticum "nudum" ½ longitudinal dorsal grain fragment
Triticum "nudum" ½ apical grain fragment
Triticum "nudum" ½ embryonal grain fragment

19

Triticum "nudum" 1/3 apical grain fragment

13

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Triticum "nudum" 1/3 medial grain fragment
Triticum "nudum" ¼ grain fragment
Triticum durum dense-eared tps. (turgidum...) rachis segment
4

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1

1

Triticum "nudum" 1/3 embryonal grain fragment

Triticum dicoccum grain

1

1

3

Triticum sp. 1/3 embryonal grain fragment

Triticum "nudum" ½ longitudinal ventral-dorsal grain fragment

1

2

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Triticum cf. dicoccum grain
Triticum dicoccum ½ apical grain fragment
Triticum dicoccum ½ embryonal grain fragment
Triticum “vestitum” grain
Triticum “vestitum” spikelet fork with glume base
Triticum monococcum grain
Triticum cf. monococcum grain
Triticum monococcum ½ apical grain fragment
Triticum monococcum ½ embryonal grain fragment
Triticum monococcum 1-grained grain
Triticum monococcum 1-grained ½ apical grain fragment
Triticum monococcum 1-grained ½ embryonal grain fragment
Triticum monococcum 1-grained 1/3 medial grain fragment
Triticum monococcum 2-grained grain

510

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<td>Vicia tp. sativa pulse cotyledon</td>
<td>Vicia sp. pulse</td>
<td>Vicia sp. pulse cotyledon</td>
<td>Vicia / Lathyrus pulse</td>
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<td>Galium sp. / Asperula sp.</td>
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<td>Corema album seed</td>
<td>Prunus spinosa endocarp fragment</td>
<td>Rosaceae / Ericaceae pome fragment</td>
<td>Indeterminate non-woody plant</td>
<td>Indeterminate plant tissue, possible parenchymae</td>
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<td>Indeterminate fruit endocarp fragment with fleshy mesocarp</td>
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continues on the following page.
| Sublayer | Cerealia | Triticeae indeterminate grain | Triticeae indeterminate grain fragment | Hordeum vulgare grain | Hordeum vulgare ½ longitudinal ventral grain fragment | Hordeum vulgare 1/3 apical grain fragment | Hordeum vulgare 1/3 medial grain fragment | Hordeum vulgare ¼ grain fragment | Hordeum vulgare straight 1/3 embryonal grain fragment | Hordeum vulgare twisted grain | Hordeum vulgare twisted ½ apical grain fragment | Hordeum vulgare twisted 1/3 apical grain fragment | Hordeum vulgare twisted 1/3 embryonal grain fragment | Hordeum vulgare twisted 1/3 medial grain fragment | Hordeum vulgare twisted ¼ grain fragment | Hordeum vulgare var. vulgare grain | Hordeum vulgare var. vulgare ½ apical grain fragment | Hordeum vulgare var. vulgare ½ embryonal grain fragment | Hordeum vulgare var. vulgare 1/3 apical grain fragment | Hordeum vulgare var. vulgare 1/3 embryonal grain fragment | Hordeum vulgare var. vulgare 1/3 medial grain fragment | Hordeum vulgare var. vulgare ¼ grain fragment | Hordeum vulgare var. nudum grain | Hordeum vulgare var. nudum ½ longitudinal ventral-dorsal grain fragment | Hordeum vulgare var. nudum ½ longitudinal dorsal grain fragment | Hordeum vulgare var. nudum ½ longitudinal ventral grain fragment | Hordeum vulgare var. nudum ½ apical grain fragment | Hordeum vulgare var. nudum ½ embryonal grain fragment | Hordeum vulgare var. nudum 1/3 apical grain fragment | Hordeum vulgare var. nudum 1/3 embryonal grain fragment | Hordeum vulgare var. nudum 1/3 medial grain fragment | Hordeum vulgare var. nudum ¼ grain fragment | Hordeum vulgare var. nudum twisted grain | Hordeum vulgare var. nudum twisted ½ longitudinal ventral-dorsal grain fragment | Hordeum vulgare var. nudum twisted ½ longitudinal ventral grain fragment | Hordeum vulgare var. nudum twisted ½ apical grain fragment | Hordeum vulgare var. nudum twisted ½ embryonal grain fragment | Hordeum vulgare var. nudum twisted 1/3 apical grain fragment | Hordeum vulgare var. nudum twisted 1/3 embryonal grain fragment | Hordeum vulgare var. nudum twisted 1/3 medial grain fragment | Hordeum vulgare var. nudum twisted ¼ grain fragment | Triticum sp. grain | Triticum sp. ½ longitudinal grain fragment | Triticum sp. ½ longitudinal dorsal grain fragment | Triticum sp. ½ apical grain fragment | Triticum sp. ½ embryonal grain fragment | Triticum sp. 1/3 apical grain fragment | Triticum sp. 1/3 embryonal grain fragment | Triticum sp. 1/3 medial grain fragment | Triticum sp. ¼ grain fragment | Triticum "nudum" grain | Triticum cf. "nudum" grain | Triticum "nudum" ½ longitudinal ventral-dorsal grain fragment | Triticum "nudum" ½ longitudinal dorsal grain fragment | Triticum "nudum" ½ apical grain fragment | Triticum "nudum" ½ embryonal grain fragment | Triticum "nudum" 1/3 apical grain fragment | Triticum "nudum" 1/3 embryonal grain fragment | Triticum "nudum" 1/3 medial grain fragment | Triticum "nudum" ¼ grain fragment | Triticum durum dense-eared tps. (turgidum...) rachis segment | Triticum dicoccum grain | Triticum cf. dicoccum grain | Triticum "vestitum" grain | Triticum monococcum grain | Triticum cf. monococcum grain | Triticum monococcum ½ apical grain fragment | Triticum monococcum ½ embryonal grain fragment | Triticum monococcum 1-grained grain | Triticum monococcum 1-grained ½ apical grain fragment | Triticum monococcum 1-grained ½ embryonal grain fragment | Triticum monococcum 1-grained 1/3 medial grain fragment | Triticum monococcum 2-grained grain |
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<td>Poaceae</td>
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continues on the following page.
Table 134: Results of the archaeobotanical analysis at Lapás das Laneiras.

| SU (pit) | SU (infilling) | Sublayer | Poaceae | Avena sp. awn fragment | Avena sp. grain | cf. Avena sp. grain | Avena sp. grain apical fragment | Avena sp. grain medial fragment | Avena sp. grain embryonal fragment | Lolium sp. grain | Poaceae grain | Fabaceae | Fabaceae pulse | Fabaceae pulse cotyledon | Fabaceae pulse fragment | Coronilla sp. / Galega sp. | Lathyrus cicera / Lathyrus sativus | Lathyrus sp. pulse | Lathyrus sp. pulse cotyledon | Lens cf. culinaris pulse | Lens cf. culinaris pulse cotyledon | Medicago / Melilotus / Trifolium pulse | Pisum sativum pulse | cf. Pisum sativum pulse | cf. Pisum sativum pulse cotyledon | Vicia ervilia / Lathyrus sativus pulse | Vicia cf. faba pulse | Vicia cf. faba pulse cotyledon | Vicia tp. cracca pulse cotyledon | Vicia tp. sativa pulse | Vicia tp. sativa pulse cotyledon | Vicia sp. pulse | Vicia sp. pulse cotyledon | Vicia / Lathyrus pulse | Vicia / Lathyrus pulse cotyledon | Galium sp. / Asperula sp. | Malva sp. | Salsola sp. | Corema album seed | Prunus spinosa endocarp fragment | Rosaceae / Ericaceae pome fragment | Indeterminate non-woody plant macroremain | Indeterminate plant tissue, possible parenchymae | Indeterminate fruit endocarp fragment with fleshy mesocarp |
Appendix 2: Sources of the IIIPC seed reference collection

Botanical Gardens listed in Botanic Gardens Conservation International (sorted by Institution Code):

- **ALCA**: Real Jardín Botánico Juan Carlos I, Campus de la Universidad de Alcalá, 28805 Alcalá de Henares, Madrid, Spain, [http://www.rjbalcala.com](http://www.rjbalcala.com)
- **BC**: Jardí Botanic de Barcelona, C. del Dr. Font i Quer, s/n, Parc de Montjuïc, 08038 Barcelona, Spain. [http://www.jardibotanic.bcn.es/](http://www.jardibotanic.bcn.es/)
- **BLAN**: Jardí Botànic Marimurtra, Passeig Carles Faust, 9; P.O. Box 112; E-17300 Blanes, Catalonia, Spain, [www.marimurtra.cat](http://www.marimurtra.cat)
- **BORMI**: Giardino Botanico Alpino Rezia, Consorzio del Parco Nazionale dello Stelvio, Via De Simoni, 42; 23032 Bormio SO, Italy, [http://www.stelviopark.it](http://www.stelviopark.it)
- **BR**: National Botanic Garden of Belgium, B 1860 Meise, Belgium, [http://www.br.fgov.be](http://www.br.fgov.be)
- **BRNOM**: (Hortus Centralis Cultura Herbarium Medicarum Facultas Medica Universitas Masarykiana) Lékařská fakulta Masarykova Univerzita, kampus Bohunice, Kamunice 5, 625 00 Brno, Czech Republic, [http://www.med.muni.cz/medplant](http://www.med.muni.cz/medplant)
- **BRNU**: (Hortus Botanicus Universitatis Masarykianae) Botanicka Zahrrada Přírodovědecká fakulta Masarykova Univerzita, Kotlářská 2 CZ – 611 37, Brno, Czech Republic, [www.sci.muni.cz/bot_zahr](http://www.sci.muni.cz/bot_zahr)
- **CHEL**: Chelsea Physic Garden, 66 Royal Hospital Road, London SW3 4HS, Great Britain., [www.chelseaphysicgarden.co.uk](http://www.chelseaphysicgarden.co.uk)
- **COI**: Jardim Botânico da Universidade de Coimbra, Departamento de Botanica, Universidade de Coimbra, Arcos do Jardim, 3000-393 Coimbra, Portugal, [www.uc.pt/jardimboteanico](http://www.uc.pt/jardimboteanico)
- **ESSEN**: (Hortus Botanicus Assindiensis-Gruga Park) Grugapark und Botanischer Garten der Stadt Essen, Virchowstraße 167a D-45147 Essen, Germany, [www.grugapark.de](http://www.grugapark.de)
- **GADES**: Dubrava Arboretum, Miskininku g.7, Vaisvydava, LT 53106, Kauno raj., Lithuania, [http://www.dumul.lt/arboretum/](http://www.dumul.lt/arboretum/)
- **GIBR**: Gibraltar Botanic Gardens, The Alameda, Red Sands Road, PO Box 843, [www.gibraltargardens.gi](http://www.gibraltargardens.gi)
- **HEID**: Botanischer Garten Universität Heidelberg, Im Neuenheimer Feld 340, D-69120, Heidelberg, Germany [http://botgart.hip.uni-heidelberg.de](http://botgart.hip.uni-heidelberg.de)
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• IAGB, Gradina Botanica Anastasie Fatu Universitatea Iasi, Str. Dumbrava Rosie nr. 7-9; 700487, Iasi, Romania, http://www.botanica.uaic.ro

• JBAG, Jardín Botánico Atlántico, Avenida del Jardín Botánico s/n 33394 Gijón, Asturias, Spain http://www.botanicoatlantico.com


• KO, (Botanical Garden P.J. Safarik University) Botanická záhrada-University Pavla Jozefa Safárika, Manesova 23, SK-043 52 Kosice, Slovakia, http://www.upjs.sk/pracoviska/botanicka-zahrada/

• KVL, Horticultural Gardens Frederiksborg, Royal Veterinary and Agricultural University, 15 Grønengaardsvej DK-1870, Frederiksborg, Denmark, http://www.gf.life.ku.dk/haven


• LPA, Jardín Botánico Vieira y Clavijo, Carretera del Centro Km 7, Aptdo. 14 de Tafira Alta 35017 Las Palmas de Gran Canaria, Spain. jardincanario@grancanaria.com, http://www.jardincanario.org/portal/home.jc

• MA, Real Jardín Botánico CSIC, Plaza de Murillo, 2, Madrid E-28014, Spain, http://www.rjb.csic.es/jardinbotanico/jardin/


• MOD, Orto Botanico, Università di Modena e Reggio Emilia, Viali Caduti in Guerra, 127, 41121 Modena, Italy, http://www.ortobot.unimo.it

• O, Oslo Botanical Garden, Natural History Museum, University of Oslo, Botanical Garden, P.O. Box 1172 Blindem, NO-0318 Oslo, Norway, http://www.nhm.uio.no/besok-oss/botanisk-hage/

• OL, Palacký University Botanic Garden, 17 listopadu 1192/12, 771 46 Olomouc, Czech Republic. http://garden.upol.cz

• OSN, Botanischer Garten der Universität Osnabrück, Albrechtstraße 29, D-49076 Osnabrück, Germany, http://www.bogos.uni-osnabrueck.de

• PECS, (Hortus Botanicus Universitatis Pecs) Pécsi Tudományegyetem, Botanikus Kert, H-7624 Pecs, Ifjusag u.6, Hungary, bozso@gamma.ttk.pte.hu

• ROST, Botanischer Garten Universität Rostock, D-18051 Rostock, Germany, http://www.garten.uni-rostock.de

• SZU, Botanischer Garten der Universität Salzburg, Fachbereich Organismische Biologie, Hellbrunnerstraße 34 A-5020 Salzburg, Austria, http://www.uni-salzburg.at/orgbiol/botanischer.garten
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- **TABOR**, (Hortus Botanicus Scholae Agriculturae Tábor) Botanicka Zahradka Stredni zemedelske techn. skoly, 390 02 Tabor, Czech Republic, [www.szestabor.cz/botanicka](http://www.szestabor.cz/botanicka)

- **TEHFR**, National Botanical Garden of Iran, Research Institute of Forests & Rangelands P.O. Box 13185-116, Tehran, Iran, rifr@rifr-ac.ir


- **Z**, Botanischer Garten der Universitat Zürich, Zollikerstraße 107, CH-8008 Zurich, Switzerland, [www.bguz.uzh.ch](http://www.bguz.uzh.ch)


**Other gardens:**


**Private collections:**

- **Majella Larochelle**, 2-4 J. Belanger, Gatineau, Québec J8T 7Z2, Canada, [http://www.mlarochelle.net/](http://www.mlarochelle.net/)

- **Succulentarum Plantarum Collectio Universalis** PhDr. Adolf Tomandl. Českobratrská 45, 796 02 Prostějov, Czech Republic, [http://www.kaktusar.cz/](http://www.kaktusar.cz/)

**Other donations:**

- Members of the IIIPC.
- Leonor Peña-Chocarro, IH-CCHS, CSIC.
- Lydia Zapata, UPV.
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Software

- Bauble 1.0 (GNU-GPL Biodiversity Collection Manager): http://bauble.belizebotanic.org/index.html
- GIMP 2.6 (GNU Image Manipulation Program): http://www.gimp.org
- Helicon Focus (Helicon Soft Ltd. image stacking software): http://www.heliconsoft.com/heliconfocus.html
- Jabref 2.5 (GNU-GPLv2 Reference Manager): http://jabref.sourceforge.net/
- Libre Office 3.6 (GNU-LGPLv3 productivity suite): http://www.libreoffice.org
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Assume that the page is a collection of references and abstracts related to the evolution of disciplines, particularly focusing on experimental archaeology and its application in interpreting the past. The references are from various journals and publications, spanning a range of topics from hunter-gatherer adaptations in Northern Spain to the role of waterways in the spread of agriculture.

For example, one reference is "Cunningham, P. 2005. Assumptions in Experimental Archaeology in the study of the past. 7-28. Oxford: Oxbow Books." This indicates the importance of considering assumptions in archaeological research.


The references also cover a wide range of topics such as hazelnuts and acorns, Near Eastern, and the Mediterranean region. They provide insights into the use of experimental archaeology in interpreting the past and the importance of considering different factors such as climate change, food production, and trade.

Overall, the page is a collection of scholarly references that contribute to the understanding of the evolution of disciplines and the application of experimental archaeology in interpreting the past.
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