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The exploitation of small prey among the last hunter-gatherers in the Northeast of the Iberian Peninsula: the case of the leporids in the Epipalaeolithic

Nadihuska Y. Rosado-Méndez

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Facultat De Geografia i Història
Departament D' Història i Arqueologia

Doctorate Programme:
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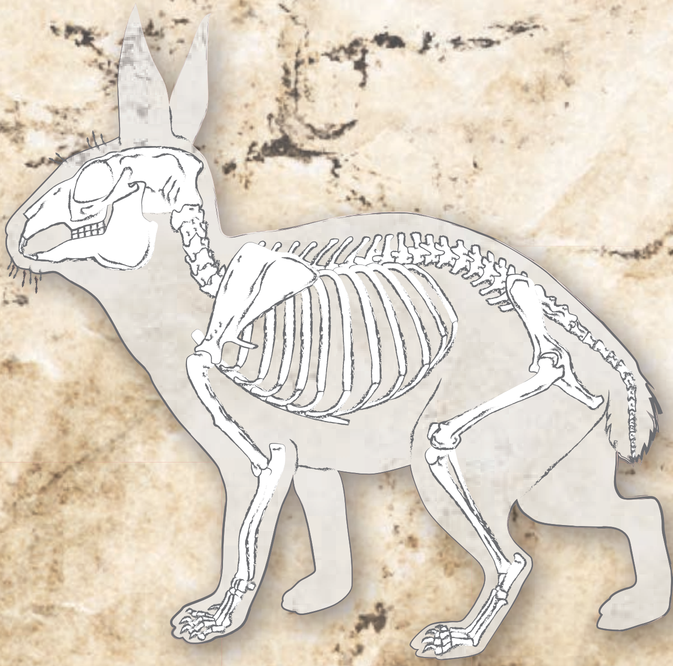
THE EXPLOITATION OF SMALL PREY AMONG THE LAST HUNTER-GATHERERS IN THE NORTHEAST OF THE IBERIAN PENINSULA:
THE CASE OF THE LEPORIDS IN THE EPIPALAEOLITHIC

PhD Thesis



by
NADIHUSKA Y. ROSADO-MÉNDEZ

supervised by
Dr. Jordi Nadal and Dr. Lluis Lloveras

Barcelona, 2017

UNIVERSITAT DE BARCELONA
FACULTAT DE GEOGRAFIA I HISTÒRIA
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BARCELONA, 2017.

Tempus fugit

To my family, I could not have achieved this without your support.
Thanks for believing in me guys!

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Abstract

This work is part of a line of research focused on the zooarchaeological and taphonomic anlysis of leporids remains (rabbits and hares) recovered in prehistoric sites of the Iberian Peninsula. The importance of small prey during Prehistory has been considered a key data in order to understand the evolution of our species, as the ways of exploitation and consumption of these prey can help us to understand some human behaviors: like mobility of groups, seasonality of camps, broad spectrum strategies, etc.

This Ph.D. dissertation pretends to elucidate, from the taphonomical analysis of rabbit remains from Epipalaeolithic sites in NE Iberia, on the importance of leporids during the Pleistocene-Early Holocene. For that matter an analysis methodology was implemented to address the study of leporid remains accumulation in three archaeological sites in Catalonia (Balma del Gai, Cova de la Guineu and Font Voltada) ascribe to the *Microlaminar Epipalaeolitic* and *Geometric Epipalaeolithic*. The methodology involved the joint implementation of the taphonomical analysis and experimental research.

Leporids, especially the European rabbit, are one of the most dominant taxa among faunal remains in archaeological sites of the Upper Palaeolithic and Epipalaeolithic in the Iberian Peninsula. The species *Oryctolagus cuniculus* first originated south of the Iberian Peninsula during the Middle Pleistocene and stayed confined in the same geographic area and south of France until the end of the Pleistocene. Because of its great abundance in faunal assemblages of archaeological sites across Iberia, and specifically Northeast Iberia, this type of prey may have played an important role in human communities in prehistory. The fact is that rabbits are the favorite prey among a great number of medium and large size predators in Iberia. They are part of the food chain of more than 30 species of predators, including: diurnal raptors (Spanish Imperial eagle), nocturnal raptors (Eagle Owl), small terrestrial carnivores (Iberian Lynx and Red fox), and humans.

Considering that leporids are part of the diet of a large number of predators, all these predators may accumulate leporid remains in caves and rock shelters. That is why it is necessary to establish the true agent in each case in order to not mislead rabbit bone accumulations in archaeological sites from this area and those periods. The use of

taphonomic studies focused on identifying diagnostic damage patterns created by different processes has proved to be essential to establish the origin of archeological leporid assemblages. We consider it is essential to identify the taphonomic changes in order to establish the responsible agent of the leporid accumulations in the archaeological sites that are covered in this PhD dissertation.

The taphonomic analysis of leporid accumulations from Balma del gai, Cova de la Guineu and Font Voltada consisted in a thorough analysis of the surface of the bone, with the intention to identify possible alterations and / or modifications, which can provide us with any information about the post-depositional processes affecting the faunal assemblages, more specifically the leporid accumulations in our study sample. Given the taphonomic patterns, obtained from a series of recent actualistic studies, that characterizes the main non-human leporid accumulators (nocturnal and diurnal raptors, and small terrestrial carnivores) in the Iberian Peninsula, and the characteristic straits on other archaeological sites from the same period, our we infer into the taphonomic agents that might be involved in the accumulation of leporid remains in the studied archaeological sites and to determine at to what extent the agent have contributed in the accumulation of leporid remains in our sample. By analyzing consumption marks, butchery and burnt marks, originated as a consequence of the anthropogenic activity on modern samples and archaeological rabbit remains (experimental research), we established a taphonomic pattern that derives from these activities in order to contrast the possibility of human activity on our archaeological sample through this type of record in order to evaluate and provide new data about the subsistence strategies of Epipalaeolitic hunter-gatherers from the area.

Resumen

Este trabajo forma parte de una línea de investigación enfocada al análisis zooarqueológico y tafonómico de restos de lepóridos (conejos y liebres) recuperados en sitios prehistóricos de la Península Ibérica. La importancia de las presas pequeñas durante la Prehistoria ha sido considerada un dato clave para comprender la evolución de nuestra especie, ya que las formas de explotación y consumo de estas presas pueden ayudarnos a comprender algunos comportamientos humanos: movilidad de los grupos, estacionalidad de los campamentos , estrategias de amplio espectro, etc.

Esta tesis de doctorado pretende elucidar, a partir del análisis tafonómico de los restos de conejo de los yacimientos de cronologías establecidas en el Epipaleolítico en el NE de Iberia, sobre la importancia de los lepóridos durante la transición del Pleistoceno-Holoceno inicial. Para ello se aplicó una metodología de análisis para abordar el estudio de la acumulación de restos de lepóridos en tres yacimientos arqueológicos de Cataluña (Balma del Gai, Cova de la Guineu y Font Voltada), atribuidos al Epipaleolítico Microlaminar y Epipaléolítico Geométrico. La metodología involucró la implementación conjunta del análisis tafonómico y la investigación experimental.

Los leporidos, especialmente el conejo europeo, son uno de los taxones más dominantes entre restos de fauna en sitios arqueológicos del Paleolítico Superior y Epipaleolítico en la Península Ibérica. La especie *Oryctolagus cuniculus* se originó por primera vez al sur de la Península Ibérica durante el Pleistoceno Medio y permaneció confinada en la misma zona geográfica y al sur de Francia hasta el final del Pleistoceno. Debido a su gran abundancia en los conjuntos faunísticos de sitios arqueológicos a través de Iberia, y específicamente al NE de Iberia, este tipo de presa desempeñó un papel importante en las comunidades humanas en la prehistoria. El hecho es que los conejos son la presa preferida entre un gran número de depredadores de tamaño mediano y grande en Iberia. Ellos son parte de la cadena alimentaria de más de 30 especies de depredadores, incluyendo: rapaces diurnas (águila imperial española), rapaces nocturnos (búho real), pequeños carnívoros terrestres (lince ibérico y zorro rojo) y humanos.

Considerando que los lepóridos son parte de la dieta de un gran número de depredadores, esto significa que todos estos depredadores pueden acumular restos lepórídos en cuevas y abrigos rocosos. Por eso es necesario establecer el verdadero agente en cada caso para no engañar las acumulaciones óseas de conejo en sitios arqueológicos de esta zona y de esos períodos. El uso de estudios tafonómicos enfocados en la identificación de patrones de daño diagnóstico creados por diferentes procesos ha demostrado ser esenciales para establecer el origen de las acumulaciones de lepóridos arqueológicas. Consideramos esencial identificar los cambios tafonómicos con el fin de establecer el agente responsable de las acumulaciones de lepóridos en los sitios arqueológicos que se tratan en esta tesis doctoral.

El análisis tafonómico de las acumulaciones de lepóridos de Balma del Gai, Cova de la Guineu y Font Voltada consistió en un análisis minucioso de la superficie del hueso, con la intención de identificar posibles alteraciones y / o modificaciones que nos puedieran aportar información sobre los procesos post-deposicionales que afectan a los conjuntos faunísticos, más específicamente los conjuntos de lepóridos en nuestra muestra de estudio. Dado los patrones tafonómicos obtenidos a partir de una serie de estudios neo-tafonómicos recientes que caracterizan los principales acumuladores no humanos de lepóridos (rapaces nocturnos y diurnos, y pequeños carnívoros terrestres) de la Península Ibérica y los característicos similares de otros sitios arqueológicos de la región, inferimos en los posibles agentes tafonómicos que podrían haber estado implicados en la acumulación de restos lepóridos en los sitios arqueológicos estudiados y determinar en qué medida el agente contribuyó en la acumulación de restos lepóridos en nuestra muestra. Al analizar las marcas de consumo, la carnicería y las marcas de termo-alteraciones, originadas como consecuencia de la actividad antrópica en muestras modernas y restos de conejos arqueológicos (investigación experimental), establecimos un patrón tafonómico derivado de estas actividades para contrastar la posibilidad de actividad humana sobre nuestra muestra arqueológica a través de este tipo de registro con el fin de evaluar y proporcionar nuevos datos sobre las estrategias de subsistencia de los cazadores-recolectores epipaleolíticos de la zona.

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I would like to express in this section my sincere gratitude for the support I have received throughout my academic training and that, in some way or another, has concluded in the development of this doctoral thesis.

This work is dedicated to my parents and brothers, who supported me to the end no matter what. Thank you, guys, for your unconditional support during all these years. Thank you for your encouragement, understanding, and above all, your patience, I know I have never been an easy-to-understand daughter or sister. For your understanding and support in difficult times, and for celebrating with me the moments of joy. I also dedicate my achievement to my furry-friends, you all know I've already be locked in an asylum, in madness like the White Rabbit of *Alice in the Wonderland* exclaiming: -Oh, God! -Oh, God!, I will arrive too late! -if it were not for the dog and cat therapy they gave me.

Although this thesis is the result of five years of work, well 6 years if we count my year of research and writing my Master's Thesis, I cannot thank enough Dr. Yvonne Narganes Storde, from the *Centro de Investigaciones Arqueológicas* from the University of Puerto Rico, Rio Piedras campus, or as I call her, "my intellectual mother". Thank you for your trust and for taking your time to train me, in an introductory way, in the field of zooarchaeology, and for the mother's patience that you have always shown me, specially during my training period. Following this line, I would like to thank my thesis directors, Dr.

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I would also like to thank Dr. Josep M. Fullola, Professor of Prehistory of the Prehistory and Archeology Section from the University of Barcelona, and director of the SERP (Seminari d'Estudis i Recerques Prehistòriques) for having accepted me as a member of that same research group.

The achievement of this doctoral work it has been possible thanks to the availability of faunal assemblage from Balma del Gai, Cova de la Guineu, Font Voltada and the Terrasses de la Riera dels Canyars, the latter being my first research paper (Master's degree in Archeology) upon entering the University of Barcelona. To Dr. Pilar García-Argüelles, Artur Cebrià, Anna Mir, Antoni Freixas, Dr. Joan Daura and Dr. Monteserrat Sanz, thank you for giving me the opportunity to analyze the fauna remains of each site, as well as providing me with contextual information. I would like to thank Dr, Ramón Viñas from the Conca de Barberà Museum (Montblanc), for the temporary assignment of the faunal material from Font Voltada.

A part of this thesis has required complementary information and analysis on topics related to infrared spectroscopy or Fourier Transform Infrared Spectroscopy (FTIR). In this subject, I would like to thank Dr. Dan Cabanes, from the Department of Anthropology and Center for Human Evolution Studies at Rutgers University (New Jersey, USA), for taking the time to train me in the infrared spectroscopy methodology, for his valuable insight on the topic, and for the comments and correction of Chapter 6, which is devoted to the analysis of modern and archaeological burnt bone. I would also like to thank Dr. Yotam Asscher of the Department of Geosciences of the University of Padova (Padova, Italy) for providing me with data on burned bones of different species of animals and for his valuable insight on the topic.

On a personal level, I have been fortunate to have people who, in one way or the other, have accompanied me, helping me to get up and even dragged me along the way. To my

comrades of the "doctoral academic office": Maria Rosa Aran, Laia Font and Mar Rey, thank you for understanding me and for your support all this time!

Taking into account the total volume of remains studied, I would also like to thank the participation of undergraduate students from the Archeology Degree Program, or as I call them the *minions* (Cristina, Marina, Alba, Carles, Susana and Zoē), for their great effort in sorting all the bags with bone remains 2 mm in size, we all know that was not an easy task!

Lastly, but not least, I would like to thank Elia Tsvetanova for the cover and back cover design.

Sincerely,
Nadihuska

Why develop a Ph. D. dissertation on Epipalaeolithic leporid accumulations in the northeast of the Iberian Peninsula?

This year marks the 7th anniversary of my arrival in Catalonia for the enrollment in the Master of Archeology at the University of Barcelona. It was not until that first year in 2010, in my Geoarcheology class with Dr. M^a Mercé Bergadà, where I would discover what would become my subject of research for these past 6 years, *Taphonomy*, a sub-discipline of Paleontology, focused on the study of the processes of preservation of organisms and how these influence the formation of the fossil record. It was at that time, during the preparation of the final work of the subject where I began to be interested in how the sedimentation processes, befitting the history - or Prehistory - of every each site, can affect the preservation of the bone remains, and therefore affecting their future cultural interpretation.

At that time I wanted to focus my research on the taphonomic study of *jutía* remains - which at no time should be confused with *"judías*"! – (a rodent, similar in size to a big rat or rabbit, from the Capromidae family, native from Central America, but introduced to the West Indies by Arawak people in Pre-Columbian time) a mistake commonly committed by the majority of my professors and classmates, and how the effects of different types of sediment could sometimes affect the structural and surface preservation, therefore affecting the identification of alterations and / or modifications of anthropic origin regarding small prey exploitation in pre-Columbian contexts in archaeological sites within the

Circum-Caribbean zone. With this research topic in mind, I began to inform myself about what kind of alterations may be present in skeletal remains as a consequence of exposure to meteorological agents prior to the burial or sedimentation of the remains and damage at a structural level once the remains where fully buried, information that led me to Dr. Jordi Nadal and, then doctoral candidate, Lluis Lloveras.

At that time it was impossible to conduct a taphonomic study on hutias (jutía in Spanish*)* remains, due to the little material available (mostly fragmented and anatomically indeterminable remains) and the almost non-existent ethological data concerning the behavior and habitat, and above all viable bone atlas for the proper identification of remains. We must add to the lack of specific information on hutias' ecology, the fact that the available remains were not only deposited in a Museum in Puerto Rico, but it needed to be sorted taxonomically first. The situation derived from the lack of published information about this small mammal led me to rethink the subject of research, and to focus my work on the study of a particular recurrent taxon in archaeological sites in the Iberian Peninsula, leporids.

During the academic year of 2011-2012, I received my training from doctors Jordi Nadal and Lluís Lloveras, and began working with the leporid asseblage from Riera dels Canyars (Gavà, Barcelona). The good performance and results of my research led me to be part of the SERP (*Seminari d'Estudis i Recerques Prehistòriques*) and the opportunity to develop a doctoral work focused on the exploitation of small prey by hunter-gatherer groups in peninsular NE.

In regard of content, leporids, and especially rabbits (*Oryctolagus cuniculus*), as already said, are especially abundant animals in the Iberian Peninsula since the beginning of the Quaternary. We see that in one hand, rabbit remains are quite abundant in the archaeological record of the prehistoric sites of the Iberian Peninsula as well, from the beginning of the Palaeolithic until the appearance of the first producing societies (Neolithic), but on the other hand, this certain abundance has favored the emergence of a whole series of predators (birds of prey, diurnal and nocturnal, and carnivorous mammals) that have specialized in the consumption of leporids or that, in a seasonal matter, are been consumed intensely by other species more generalized in their diet: Spanish Imperial

Eagle (*Aquila adalberti*) and the Eagle Owl (*Bubo bubo*) among raptors, and the Iberian lynx (*Lynx pardinus*) and Red fox (*Vulpes vulpes*) among small terrestrial carnivores.

It most be pointed out that traditionally, when rabbit remains appear in archaeological sites, these have been interpreted as evidence of consumption by humans, with all the implications that this entails: exploitation of small game, specialized strategies, use of complex hunting technologies (use of nets, traps, etc.), without there being a previous taphonomic analysis that allows to discriminate if whether the remains are the results of non-human accumulating agents or if there is a palimpsest between human occupations and potential occupations of the mentioned predators.

One of the moments in which there is an exponential increase of the remains of lagomorphs, especially leporids like the European rabbit and hare, in archeological contexts is precisely during the transition from the Pleistocene to the Holocene in the Northeast of the Iberian Peninsula, in the period known as Epipalaeolithic. As you will read in the forthcoming chapters, specifically when comparing the results of our archaeological sample with other archaeological records from the same period in other geographic areas, there is evidence of a increase patterns of leporid remains since the Late Upper Palaeolithic, corresponding to the Magdalenian period, to the Epipalaeolithic.

Based on the aforementioned points, this research work aims to solve if the remains recovered during the excavations of some Catalan archaeological records, with radiocarbon dates placing them in the Epipalaeolithic (Specifically between the XII and X millennium BP), can mostly be attributed to the hunting activity of the last hunter-gatherers or if there is a certain percentage of material that was incorporated into the archaeological record by other taphonomic agents. In the case of being a predominantly anthropic activity, it is also the objective of this work to elucidate cultural behaviors associated with the exploitation of these small prey: carcass processing, food treatment or others not directly related to animal consumption (skin removal, among others). The work that is intended to be carried out in this PhD dissertation is essentially based on three archaeological sites.

The main archaeological record, because of the exorbitant amount of material recovered in a single unit, discussed here is Balma del Gai. Gai is a rockshelter located in the municipality of Moià (Province of Barcelona) at 740 meters above sea level and about 50 km from the current coastline. Joan Surroca, who made a few interventions in 1975, discovered it. He was then involved in two short campaigns between 1977 and 1978 under the direction of Jean Guilaine and Miquel Llongueras. In any case, long-term programmed interventions to date, began in 1994, under the direction of Pilar Garcia-Argüelles, Alícia Estrada and Jordi Nadal, with the incorporation in recent years of Lluís Lloveras and Jofre Costa, and under the scientific protection of *Seminari d'Estudis i Recerques Prehistòriques (SERP),* ascribed to the Department of Prehistory, Ancient History and Archeology of the University of Barcelona. The deposit has an Epipalaeolithic level (level 1) in which two chrono-cultural can be distinguished. At the top of the sequence, up to an approximate level of -130 / -135, the room floors would correspond to a Filador type geometric facies. These are dated between 10,030 ± 160 BP and 8,930 ± 140 BP. Below the abovementioned dimensions we find the occupations of the Epipalaeolithic microlaminar, with a dating of 11,170 ± 160 BP and 10,260 ± 90 BP (with some older dating of uncertain attribution). The archaeofauna assemblage has a very high percentage of bone remains of *Oryctolagus cuniculus*. Throughout these years of excavation tens of thousands of rabbit bones have been recovered, which have not yet been analyzed from a taphonomic perspective. The material from Balma del Gai is the bulk of this study, with such a huge number o remains, we have established the strategy of analyzing a sample that is statistically representative, specifically, the rabbit bone remains from unit I3, one of the units with the least alterations and greater stratigraphic development. This material is deposited for study in the department.

The second archaeological record discussed here is Cova de la Guineu, which is located in the municipality of Font-Rubí (Province of Barcelona) at 734 meters above sea level and 30 kilometers from the present coastline. It was excavated in 1983 under the direction of Josep Mestres, until arriving to the Epipalaeolithic level. This same level (level 3) was intervened in 1988, under the direction of Artur Cebrià, and under the scientific protection of *Seminari d'Estudis i Recerques Prehistòriques (SERP),* ascribed to the Department of Prehistory, Ancient History and Archeology of the University of Barcelona. Although the excavations of Cova de la Guineu continue to take place since then, the Epipalaeolithic level has not been re-excavated. This level has provided a radiocarbon date of 9,850 ± 80 BP and it registers chrono-culturally to the microlaminar Epipalaeolithic complex. Jordi Nadal studied the archaeofauna assemblage for his doctoral thesis. He identified *Cervus elaphus*, *Capra pirenaica, Capreolus capreolus, Sus scrofa*, and an important accumulation of *Oryctolagus cuniculus* remains, with a total of 5,089 remains, which are the ones included for this study according to the new taphonomic methodology that is developed in this thesis.

Our third and final record is the archaeological site of Font Voltada, which is located in the municipality of Sarral (Province of Tarragona), to about 600 meters on the level of the sea and to about 36 kilometers of the present coastline in a straight line. The site was discovered during the opening of a road that affected it. At the beginning of the 1980s, the site was the subject of intermittent scheduled interventions under the direction of Anna Mir and Antoni Freixas. The site has one archaeological level (level 2) with a radiocarbon date of approximate 10,920 ± 240 BP and corresponds to the microlaminar Epipalaeolithic complex. The material recovered during these campaigns is today deposited in the Museum of the Conca de Barberà, in Montblanc. At the time, J. Nadal also studied this assemblage for his doctoral thesis, among which were the bones of leporids that are now included within this PhD dissertation. In J. Nadal's first study 1,735 rabbit remains were counted (not including deer, wild boar, mountain goat, lynx and fox).

In regard to the content structure, this doctoral thesis is divided into three blocks of content (divided into twelve chapters), bibliography and annex. The contents of the various chapters are presented below:

Part I, constitute the theoretical framework of this dissertation and is divided into 4 chapters. It was though as an introduction, basically dedicated to a prehistoric contextualization of the Epipalaeolithic period in the peninsular NE (Chapter 1), where we take into account the inclusion of leporids into the human diet assessing aspects such as size, weight, energy optimization, as well as other cultural aspects. The explanation of our research objectives is presented in Chapter 2, while in Chapter 3 we present the taxonomy and systematics of leporids, as well as their ecological and ethological characteristics, in order to explain possible techniques and patterns of procurement in archaeological accumulations. Chapter 4 presents the variety of leporid accumulation processes that we can encounter during an archaeological campaign, and the different types of alterations and modifications that can be found during the taphonomic analysis of the remains. In this chapter, a distinction is made between natural or intrusive contributions, exogenous contributions (the different types of nonhuman accumulations) and the characteristics of occupations of anthropic character.

Part II is dedicated to the presentation of data, results and discussion. It is subdivided into two parts: Part IIa dedicated to experimental research and Part IIb dedicated to the presentation of the data of our archaeological sample.

Part IIa is divided into two chapters: Chapter 5 and 6. In Chapter 5 we presents the theoretical framework, methodology, results and discussion of the experimental work carried out on rabbit carcasses with the aim of clarifying and characterizing, to some extent, the origin of pseudo marks. While Chapter 6 is devoted to the theoretical framework, methodology, results and discussion of the experimental work focused on the analysis of modern and archaeological of thermo-altered leporid remains, using *Fourier Transform Infrared Spectroscopy* (FTIR) technique, with the aim to identify, at atomic level, whether a bone remain is actually thermo-altered or not.

The next four chapters of Part IIb comprises the bulk of the zooarchaeological and taphonomic analysis developed in this doctoral thesis. Chapter 7 focuses on the methodology applied to the study of archaeological leporid accumulations, addressing the processes of quantification and creation of a database, taxonomic determination, as well as calculations of estimation of the age of death, anatomical representation and breakage patterns, and establishing the different types of alterations and modifications in the surface of the bone. Chapters 8, 9 and 10 focus on the archaeological sites, where the main features, such as geographic location, chronostratigraphy, material culture, paleoenvironment (flora and fauna) are exposed. Chapter 8 includes data, results and discussion from the taphonomical analysis of the Balma del Gai remains, while Chapters 9 and 10 present the results and discussions on the leporid accumulations of Cova de la Guineu and Font Voltada, respectively.

Part III focuses on the general discussion of the archaeological sample and the final conclusions. Chapter 11 begins by recapitulating specific data about our archaeological samples and proposing possible models of subsistence. Taking into account the anthropic origin of all of our sample, we have compiled data of anthropogenic leporid accumulations, dated to the Pleistocene-Holocene transition (chrono-culturally, transition between the Magdalenian and Epipaleolithic) and during the Upper Paleolithic period (Aurignasian, Gravettian and Solutrean) in Iberia and southwestern European sites (South of France), basically with the intention of obtaining other references, in terms of characteristics and models of subsistence, of anthropic origin. Chapter 12 is written by way of conclusions and final recapitulation.

Part IV includes the PhD thesis synthesis written in Spanish.

PART I:

INTRODUCTION

CHAPTER 1

THE EPIPALAEOLITHIC PERIOD IN THE NORTHEAST OF THE IBERIAN PENINSULA: A BRIEF SYNTHESIS.

From the very moment, our research is aimed at solving a historical problem, which is the evaluation of leporid exploitation by prehistoric human communities during the Epipalaeolithic period in Northeast Iberia (Catalonia). It is clear that the chronological limits of our study most be defined. In principle, such limits are established by the absolute dates obtained for each of the archaeological sites discussed within this PhD dissertation: Balma del Gai, Cova de la Guineu and Font Voltada. According to radiocarbon dates for our first site, Balma del Gai, with a longer chronological occupation, it is set approximately mid XII to X millennia BP (non-calibrated dates). At the present time, and according to recent research, this chronological margin, as will be seen in other chapters of this dissertation, is placed well enough in the Pleistocene-Holocene geoclimatic phase boundary.

Already at the beginning of this section we have clearly define our archaeological samples as “Epipalaeolithic”. What does that mean exactly? In this regard, the fact of naming this phase “Epipalaeolithic” has cause some debate during the evolution of Prehistory as an academic discipline. In our case, it is considered a minor debate since we know what specific archaeological record we want to study, which moment and the historic implications it may bring: hunter-gatherers societies that during the final moments of the Pleistocene-Early Holocene are forced, or perhaps favored, to an economical and subsistential adaptation due to climate amelioration that are progressively been establish during this period, a few thousands years before the arrival of pre-agricultural societies, establishing themselves (directly or indirectly) within Catalonian territory from the Eastern Mediterranean. However, we consider it appropriate to provide a brief comment as to why we use the term “epipalaeolithic” to define the human groups that are the object of study of this PhD dissertation.

1.1. WHY EPIPALAEOLITHIC INSTEAD OF MESOLITHIC?

During the XIX century, with the start of Prehistory as a scientific discipline, two periods of great archaeological clarity were established: 1) the Palaeolithic, the oldest period characterized by a predation economy and stone carving technology, and 2) the Neolithic period, involving the adoption of a production economy and the use of polish stone systems, and the manufacture of pottery. Immediately, and perhaps for a certain fear of establishing excessively rigid limits (during the gradualist interpretations of change, from Lyell geologic evolution to Darwin’s evolution of the species), an intermediate period was defined: the *Mesolithic* (Westropp, 1872). Despite its birth as a transitional phase, it necessarily required intrinsic features to differentiate it in part from previous and following phases. The Mesolithic was named the “Middle Age of Prehistory”, as a phase of certain cultural degradation compared to the previous phase, the Upper Paleolithic, a period of food abundance, and artistic and technological wealth, and at the time prior to one of the great milestones of humanity, as was the Neolithic Revolution (Childe, 1981). The Mesolithic is characterized for the lack of Paleolithic art, its microlithic industry and the need for adaptation to a, apparently, “lower quality” food resources (Cohen, 1977; Fullola and Nadal, 2005).

Over time, one can see clear similarities between the final phases of the Upper Palaeolithic and the Early Holocene hunter-gatherers, which is why the term “Mesolithic” is perceived as something inappropriate, more related to a geoclimatic change (the Pleistocene-Holocene transition) rather than a cultural change, from there, the adequacy of the term “Epipalaeolithic” as a continuity from the previous phase. A term coined for

Scandinavian prehistory, by K. Stjerna at the beginning of the XX century, but which spreads quickly to French literature and in Spain's case, reaches the hands of H. Obermaier. Its widespread acceptance would occur during the 50's (Fullola et al., 1993).

In Iberia, F. J. Fortea, with his chronocultural classification of gatherers societies subsequent to the Upper Palaeolithic, clearly states that all those facies between the final Upper Palaeolithic and Neolithic be named "Epipalaeolithic", both those corresponding to the Microlaminar complex (Mallaetes and Sant Gregori facies) and Geometric complex (Filador and Cocina type) (Fortea, 1973). This is the paradigm that will last for all this time in the study area (Mediterranean coast of Iberia). Nonetheless, the terminological acceptance will not be absolute, and different interpretations of the model, over time and in particular the definite transformation of the paradigm, with the characterization of new facies, breaks the consensus. So during the 80's, the theorical interpretation of the hunter-gatherers archaeological record during the Pleistocene-Holocene transition or fully in the Holocene caused some researchers to decant for the term "Epipalaeolithic" understanding that in the process of neolithization in our latitudes predation societies had no conclusive role or motor in the process (Diffusionist theory). Moreover, researchers who defended autochthonous theories, in which natives societies where the active agents of change, made use of the term "Mesolithic", explaining in some way there were not strictly in a continuity phase with the Palaeolithic. But on this basic approach, the possibilities were infinite, as keeping the term "Epipalaeolithic" for the microlaminar complexes and consider as "Mesolithic" the geometric complexes, similarly as used by French researchers (Bernabeu et al., 1993; Fullola et al., 1993). The emergence of a new complex, characterized by the abundance of notched and denticulate elements, in the Mediterranean coast and the Ebro Valley chronologically separating both Geometric complexes, has ended up complicating things. Further, some authors have explained the direct relation between the microlaminar facies with the Magdalenian period and, moreover, the clear link of the first geometric complex, Filador type, with microlaminar technology, so that it is separated from the next, both chronologically (separated by the notch and denticulate phase) and technologically (Roman, 2012). In the face of this new situation, many authors restrict the use of the term "Epipalaeolithic" for the old microlaminar and geometric type Filador complexes renaming them *Epimagdalenian* and *Microlaminar Sauveterroide* respectively (García-Argüelles et al., 2013), while reserving the term “Mesolithic” for notches and denticulate elements, and what will now strictly be called geometric, which would include only the old geometric complex type Cocina.

Our work, in this sense focuses exclusively in what is currently distinguished strictly as epipalaeolithic, since we only count with Microlaminar/Epimagdalenian occupations (Font Voltada, Cova de la Guineu and the older occupations from Balma del Gai) and Geometric type Filador/Sauveterroide Microlaminar (recent occupations from Balma del Gai). For the most recent occupation, it should be said that the Catalonian sites corresponding to the notches and denticulate Mesolithic are usually poor in leporid remains an that, moreover, Catalonia has not yet provided information of archaeological sites with geometric occupations, which are present in the Ebro Valley or Valencia.

Either way, it is necessary to clarify that for us the terminological confusion has little significance at the time of interpreting the archaeological record and that, as many authors conclude either for the “Epipalaeolithic” or “Mesolithic” terms, one and other only refers to the concept of hunter-gatherers in Europe or Near East during the Holocene, or the Pleistocene-Holocene transition (Price, 1983). In general lines, the characteristics that define this phase far and wide along the European continent are, the trend toward the microlithization of the industries, as well as its regionalization and the use of local raw materials, the diversification in the exploitation of food resources, which on the other hand shows specialization in certain sites, not to mention the increase exploitation of marine resources, and the collection of plant resources and small animals. There is also a demographic increase, as shown by the number of archaeological sites and perhaps an increase in the complexity of societies (Spikins, 2008). Beyond this, we continue with hunter-gatherers societies that do not seem to have led a change toward production economies.

Definitely, along this PhD dissertation, we will use the term “Epipalaeolithic” to define the cultural period of the archaeological sites studied.

1.2. THE PLEISTOCENE – HOLOCENE TRANSITION IN THE NE MEDITERRANEAN REGION: LANSCAPE AND CHRONOCULTURAL EVOLUTION.

1.2.1. Landscape evolution

After the *Last Glacial Maximum* (LGM) or *Pleniglacial*, a period with a eustatic minimum of 130m below the actual mean sea level due to the global ice sheets on landmasses (the so called *inlandsis*) occurring at approximately 23- 19.0 ka BP (Cacho et al., 2010)*,* the last period of the Pleistocene began. This last period, *Late Glacial* or *Tardiglacial*, is characterized by some important climatic oscillations, between cold and dry periods and more temperate phases. The continental ice sheets retreat, the Baltic Sea forms and Great Britain separates from the mainland. In the Mediterranean area, deltaic plains form; while in the Near East and Middle East there is a tendency to aridity and drought (Clarck et al., 2009). Due to the melting of glaciers sea levels begin to rise and a remodeling of the coastlines occurs. It ends between 10.5 ka-10.3 ka BP making way to the Holocene, a major climate change that represents climatic and ecological conditions similar to the actual conditions.

The Pleistocene to Holocene transition must not be understood as a radical and sudden transformation of Earth's general climate. This change shows a tendency between colder (stadial) and warmer (interstadial) phases. Although the Holocene is considered a moment of our present climate, throughout this phase changes in temperature and humidity have occurred. An increase of forest areas occurs toward the north, as well as trees and shrubs. With an increase in temperature and forest areas cold climate species, like for instance reindeers and bison, migrate to northern areas. Species like the mammoth, the woolly rhino, and saber tooth tigers and cave lions become extinct. Other species adapted to forest conditions, like deer, boar and rabbits, increases in numbers (Roberts, 2014).

In the Mediterranean region of Spain this period did not corresponded to the extreme cold, aridity and the maximum extensions of glaciers experienced in other regions of the Northern Hemisphere (Aura et al., 1998; García-Ruiz et al. 2003, 2010a, 2010b, González-

Sampériz et al., 2006; Hughes and Woodward, 2008; Jiménez Sánchez and Farias Arquer, 2002). The Mediterranean region, due to its low latitude and location outside the glacial zone and the effects of the sea on coastal environments, can be described as a period of relatively warm and stable temperatures and define by the development steppe vegetation (Aura et al., 1998; Badal and Carrión, 2001; Cacho et al., 2010; Carrión Marco, 2005; Sánchez Goñi and de Errico, 2005). The Tardiglacial begins approximately 15.5 ka BP with the generalized and gradual increase in temperatures in both the Atlantic Ocean (≈ 5º C in the Atlantic margin of Iberia) and the Mediterranean Sea (≈ 8º C). The increase in temperatures is accompanied by the expansion of thermophiles forests (Badal and Carrión, 2001; Cacho et al., 2001, 2010; Carrión Marco, 2005; Martrat et al., 2007; Pailler and Bard, 2002). An increase in temperature and humidity due to the development of humid zones and lacustrine environments also occur. According to Abrantes et al. (2012) and Cacho et al. (2010), this process is not homogeneous in all Iberia, the continental interior suffered more durable arid conditions and a low increase in temperatures while the temperature increase in the south was fast, also the north and northeast of Iberia has a fast increase on both temperature and humidity but not as much as the south of Iberia.

This period of global warming begins with the end of the cold event HS-1 (GS-2) followed by the amelioration stage of Bölling-Alleröd (GI-1c to GI-1a), which ends with a sharp decline in temperatures over most of the Northern Hemisphere known as the Younger Dryas (GS-1). This new stage of abrupt interruption of global warming conditions will entail a very rapid reorganization of the circulation of the North Atlantic and the zone in contact with the Alboran Sea, as well as an enrichment of the primary productivity of this marine area caused by the reinforcement of the Atlantic water intake (Hughen et al., 2000; Jiménez-Espejo et al., 2008). The Younger Dryas seems to have had a significant impact in Iberia with strong regional variations and aridity. According to Sánchez Goñi and d'Errico (2005), pollen records indicate a drop in temperatures during this time estimated at around 3ºC in the Alboran Sea and an increase in aridity in Mediterranean regions. A moderate reduction in Mediterranean temperate forest and the expansion of semi-desert plants are recorded (Abrantes et al., 2012).

The climate improvement period known as the Holocene begins approximately 11.7 ka BP (Walker et al., 2009). Marine records show that the maximum temperature in superficial waters around Iberia during the early Holocene were approximately between 19º C (in the

Atlantic margin) and almost 20º C in the Alborán Sea (Cacho et al., 2001, 2010; Martrat et al., 2004, 2007; Pailler and Bard, 2002). The expansion of the *Quercus* forests continues to develop and gradually gain ground over the pioneer formations of *Juniper sp*. There are no radical changes in the evolution of plant formation from the beginning of the Tardiglacial to the definite establishment of the thermo-Mediterranean forest landscapes. However difference like the replacement of steppe by *Juniper* formations, and the disappearance or substitution by *Quercus* forests are evident in anthracological sequences (Carrión Marco, 2005).

The Pleistocene-Holocene transition in Northeast Iberia has been studied from different points of views in order to understand how such changes might have affected the last hunter-gatherers occupation within this territory (Allué et al., 2010, 2012; Aura et al., 2002; Martínez-Moreno and Mora, 2009; Mangado et al., 2010; Mercadal, 2009). Anthracological data for archaeological sequences in Northeast Iberia during the Final Upper Paleolithic (15-11 ka cal BP) show an absolute dominance of *Pinus sylvestris* and an increment in flora diversity (*Juniperus, Acer, Rhamnus cathartica/saxatilis* and *Prunus* during the Epipaleolithic (11-7 ka cal BP) (Alcalde and Saña, 2008; Allué, 2009; Allué et al., 2010, 2012, Aura et al., 2002; Martínez-Moreno et al., 2007; Morales et al., 2012, Piqué et al., 2010). Carpological evidence referring to the Pleistocene-Holocene transition is punctual due to conservation issues and the lack of systematic sampling. Still, some exceptional finds include evidence of *Prunus spinosa, Pyrus pyraster*, *Prunus sp*., *Rosa sp., Corylus avellana, Sorbus sp., Juglans regia, Pinus sp., Pinus pinea, Quercus sp., Malus sylvestris* and *Arbutus unedo* (Alcalde and Saña, 2008; Allué et al., 2012; Buxó, 1997; Buxó and Piqué, 2008; Piqué et al., 2010). The existing data for Northeast Iberia reflects a landscape that is evolving under climate conditions with a tendency towards favorable climate conditions with a continuous tree cover constituted by coniferous trees in older phases and the evolution towards the formations of deciduous trees from the beginning of the Holocene (Allué et al., 2012; Bergadà, 1998; Burjachs, 2009; Carrión et al., 2010; González-Sampériz et al., 2005).

1.2.2. Chronocultural evolution

The cultural evolution for this period show two chronological phases that coincide, as already mention at the beginning of this chapter, with the Pleistocene-Holocene transition. During this transition, it must be mentioned that lithic industries went through a rapid process of development compared to other techno complexes of the Upper Paleolithic characterized by changes in manufacturing techniques, dimensions and morphology (Román-Monroig, 2012). These changes, while maintaining the regionalization at least at the end of the Pleniglacial, it will be linked to global processes occurring in Western Europe by that time. By 12.5 ka BP we see lithic industries that are characterized by and increase in curved backed and backed elements (bladelets), a reduction in the size of some of the most common elements, fork example endscrapers, and a significant reduction of burin, bone and antler elements. In the Mediterranean coast of Iberia, the main characteristic is an important continuity with the final Magdalenian complexes. It must be noted that by this time changes in food resources such as a diversification with the incorporation of a broader spectrum of macrofauna, an increase in small game hunting, fishing, exploitation of marine resources, and the decline of ungulate hunting is recorded in the archaeological records of site across the territory (Aura and Pérez Ripoll, 1992; Aura et al., 1998; Villaverde and Martínez, 1995). Changes in the economic spectrum of late Pleistocene- early Holocene human groups must have certainly influenced the design of some of their hunting instruments.

Terminal or final Upper Magdalenian industries developed between 14 ka and 10.5 ka without a clear inflection point in the development of these Magdalenian industries towards the microlaminar Epipaleolithic (Aura et al., 1998; Román-Monroig, 2012; Villaverde Bonilla et al., 2012). As already said in section 1.1, according to the traditional division led by Fortea (1973), this period begins with the end of the Upper Magdalenian, which leads to a Microlaminar Epipaleolithic and an Epipaleolithic Geometric Filador type (linked to sauveterrian facies).

The final Upper Magdalenian in Iberia was defined from certain variations in the own characteristics of industries of the Upper Magdalenian, and was documented in various deposits (Vaquero, 2004; Olària, 1999; Casabó, 2004; Martínez Andreu, 1989; Aura, 1995, Aura et al., 1998; Villaverde, 1981, 2001; Cortés, 2008). The dominant microlaminar group characterizes the industry from this period with blades, fine backed bladelets, endscrapers, with a variable but constant presence of those of small size. Burins are often fewer presents, although there are some variations resulting from a greater presence in the upper Magdalenian. Fortea divided the post-Magdalenian moments into two complexes: the Microlaminar Epipalaeolithic and the Geometric Epipalaeolithic. The former, clearly related in a typological and a technological manner to the Magdalenian industries with the main difference being the relative proportion of the main typological groups in which a decrease in diversity of the microlaminar elements and the disappearance of bone artifacts is evident (Aura et al., 1998). However, most researchers have noted on several occasions that at the level of the lithic industry it is not possible to differentiate this Microlaminal Epipalaeolithic from the Upper Magdalenian, so that these industries could form a true Epimagdalenian (Aura, 2001; Casabó, 2004; Olària, 1997, Román-Monroig, 2012; Villaverde, 2001; Villaverde et al., 1998) leading to the existence of a great variability of the nomenclature to refer to this period. Some researchers argue that the diversity of terms used to refer to this period reflects the complexity of the moment (Aura and Pérez Ripoll, 1995). According to data obtained for his PhD dissertation, Román (2009, 2011, 2012) reflects on the appropriate use of the term Microlaminar Epipalaeolithic or directly choosing the use of Epimagdalenian to define the industries after the Upper Magdalenian and anterior to the Mesolithic.

The transition between the final Upper Magdalenian and Microlaminar Epipalaeolithic (Epimagdalenian) is not an abrupt process but an continuity in which we see an increase of certain elements and the slightly modification of others. There is an increase in doubled-sided points (with retouches on both sides), an increase of burins and scrapers, particularly small endscrapers, in general a decrease in the size of the lithic tool or microlithism. The sites that provided further information for characterization of the ancient Epimagdalenian: Cova del Parco (Fullola et al., 2004; Mangado et al., 2005, 2006), Balma Guilanyà (Martínez Moreno et al., 2009) Molí del Salt (Vaquero, 2004), Filador (Fortea, 1973; García-Argüelles et al., 2005), La Cativera (Fontanals, 2002) and Cova del Vidre (Bosch, 2001) in Catalonia; Cingle de l'Aigua (Román, 2010a), La Roureda (Aura et al., 2006, Román, 2010b), Matutano (Olària, 1999), Blaus (Casabó, 2004), Malladetes (Fortea, 1973; Fortea and Jordà, 1976), Tossal de la Roca (Cacho et al., 1995, 2001) and Santa Maira (Aura, 2001; Aura et al., 2006) in the Valencian Country.

According to data obtained from materials recovered from the mentioned archaeological sites, the Epimagdalenian period, clearly a continuation of the Magdalenian, can be divided into two phases: 1) Early Epimagdalenian (13.7-12.9 ka cal. BP) and 2) Late Epimagdalenian (12.9-11.5 ka cal. BP) (Roman, 2012; Villaverde Bonilla et al., 2012).

The Early Epimagdalenian (13.7 ka - 12.9 ka cal BP) is characterized by the predominace of the microlaminar group composed by straight back bladelets, pointed backed bladelets and endscrapers, with an important increase in size reduction. There is also a reduction of burin elements and a decline of bone artifacts. This period is parallel to the Azilian period of the French and Cantabrian areas (Villaverde Bonilla et al., 2012). The Late Epimagdalenian (12.9 ka- 11.5 ka cal. BP) differs only with the former in the increase of arched backed bladelets or points and segments. There is also the presence of geometric shapes (triangles) and the microburin technique. By, a great diversity of cultural attributions is recorded with an overlap of sites that have been linked to the Epimagdalenian, microlaminar Sauveterian, Mesolithic and Denticulate Mesolithic (Román, 2012) with only a few sites (Bosch, 2001; Fontanals, 2002; Fortea and Jordà, 1976; Fullola et al., 1998, 2004; Martínez Andreu, 1989; Román, 2010b, 2011) that have good sequences that allow to redefine the phase. Archaeological sites dated to the XI millennium BP showing a certain number of geometric elements in industrial complexes dominated by the Magdalenian microlaminar tradition would be included in the Late Epimagdalenian.

At the beginning of the X millennium BP (11.5 ka - 9.5 ka BP) archaeological sites were less abundant, but also attributed to a different industry; mostly linked to what is known as Microlaminar Sauveterroide, although some are attributed to Epimagdalenian and Mesolithic (notches and denticulates). As with the Epimagdalenian, there are a lot of sites located at the north of the Ebro River that have a large number of geometric elements than those sites located south. Notwithstanding, microlaminar components in those sites remain the main typological group, showing that they are linked to the previous Epimagdalenian tradition (Román, 2012). Román (2009, 2011, 2012) reflects on the appropriate use of the term Microlaminar Sauveterroide to define the geometric elements. The main data for the characterization of this phase come from: Balma del Gai (García-Argüelles et al., 2009), which is one of the archaeological sites deeply discussed in this PhD dissertation, Filador

(Fortea, 1973; García-Argüelles et al., 2005), Cova del Parco (García-Argüelles et al., 2013), Blaus (Casabó, 2001, 2004), Santa Maira (Aura, 2001; Aura et al., 2006) and Tossal de la Roca (Cacho et al., 1995); been the archaeological site of Filador the one that led to the proposal of the existence of the Sauveterroide in Mediterranean Iberia.

From a demographics point of view, within the Mediterranean area of the peninsular NE we see archaeological sites located in the interior mostly located in the Pre-Littoral Mountain Range (Montsant, Padres Mountains and sources of Boix river): *Abric del Filador, Colls, Hort de la Boquera* (Fullola, 1983-1984; García-Argüelles et al., 1992; Fullola, 1996; Fullola et al., 1996; García-Argüelles et al., 2002; Fullola and García-Argüelles, 2006; García-Argüelles et al., 2007, Fullola et al., 2012), *Cova del Boix, Balma de l'Auferi* (Adserias and Bartrolí, 2007), *Picamoixons* (García-Catalán et al., 2009), *Molí del Salt* (Vaquero, 2004), *Balma de la Vall, Cova de les Borres, Font Voltada* (Mir and Freixas, 1993), *Cova de la Guineu* (García-Argüelles et al., 1992) and *Abric Agut* (Vaquero et al., 2006). Other sites located in great proximity to the coast are: *Cova del Vidre* (Bosch, 2008), *Clot de l'Hospital* (Esteve-Gálvez, 2000), in Tortosa-Beseit mountains *la Cativera Shelter* (Fontanals et al., 2009), Balma de la Griera (Fullola et al., 1997), *Cova de Mas Romeu, Cova Foradada, Can Sadurní* and *Marge del Moro* (Fullola et al., 2011) in the Catalonian central coast and in the Garraf mountains.

1.3. THE IMPORTANCE OF SMALL PREY IN THE EPIPALEOLITHIC PERIOD: THE ROLE OF LEPORIDS.

If we assume that landscape influences the way things are routinely carry out during the day, and that our subsistence or food resource is in the same way highly influenced by how we perceive the environment, then we could say that the landscape influences the food resources and how we interact with the environment to obtain such resources. This is why, if we take under consideration the nature of hunter-gatherers relationship with the landscape, the zooarchaeological analysis of prehistoric faunal remains can demonstrate not only to be a great tool to learn about the dietary changes these people made, but to what extent they interacted with the surrounding areas they live in as well.

The establishment of temperate weather conditions eased the occupation of inhabited zones, with a deployment to new specialized areas. From a cultural point of view, these cultures submerged in the Pleistocene – Holocene transition, were marked by a change toward new economic forms, related to the emergence of new landscapes and natural resources. The Holocene increase in both variable landscapes and resource predictability may have fostered new subsistence adaptations, certainly a time in which both climatic and environmental variability have been more or less predictable. The ability to access where specific resources will be ahead of time would have has a major impact on hunter-gatherers decision-making. Variables like climate and vegetation, without any doubt affected the distribution and abundance of animal species (Allué et al., 2010; Aura et al., 2002; Boyd et al., 2006; Jones, 2012; Marshall and Hildebrand, 2002).

In terms of subsistence, the assumption that "bigger prey equals better" has been the subject of considerable debate since the Upper Palaeolithic is portrayed as a time of abundance for hunter-gatherers based on the faunal assemblages containing the remains of large herbivores. However, at the same time an increase in sites characterized by assemblages dominated by small game taxa (that for some is considered evidence of environment with poor resources) are recorded. Palaeolithic populations of the Mediterranean Basin obtained most of their meat from ungulates until very late in the Pleistocene, based on biomass corrected data in prey species abundance collected by Stiner (2004). It is during early in the Upper Palaeolithic, and perhaps even in the Middle Palaeolithic (Blasco, 2008; Blasco and Fernández Peris, 2009; Sanchis Serra and Fernández Peris, 2008), with significant proportions of rabbit, fish and shellfish included into the diet, showing signs of diet breadth (Allué et al., 2010; Aura and Pérez Ripoll, 1992, 1995; Aura et al., 1998; Badal, 1998; Stiner, 2004; Villaverde and Martínez, 1995). Factors such as demographics, ecological, nutritional technological aspects and mobility have been used to explain the inclusion of small game into prehistoric groups diet (Aura et al., 2002; Binford, 1968; Costamagno et al., 2008; Flannery, 1969; Hockett and Bicho, 2000; Hockett and Haws, 2002; Jones, 2006; Martínez -Valle, 2001; Stiner, 2001; Stiner and Munro, 2002; Vaquero, 2004; Villaverde et al., 1998).

Based on *Broad Spectrum Revolution* (Flannery, 1969) theory, the *prey choice model* predicts that the resources a forager will pursue once the potential resource or prey type has been encounter. Within this model, foragers chose to pursue prey, or not, based on resources place in a ranked-ordered set (Stiner, 2004). This is based on prey energy return rates that it is how much energy is returned from prey of a given type, per unit pursuit and handling. It states that a forager interested in maximizing foraging efficiency will pass up prey only if there is a very high probability of encountering higher-ranked prey. Only as encounter rates with high-ranked resources decline, a wider array of lower-ranked prey types will be taken to make up the difference. This means that increasing numbers of lower-ranked prey types within a foragers diet will indicate a scarcity of high-ranked resources (Jones, 2012, 2016).

The prey choice model often correlates to the body-sized proxy. In *optimal foraging* terms, “prey type” is not necessarily equivalent to a species, but instead defined by returns per unit handling time (Hockett and Haws, 2002). Zooarchaeologist use the term prey mobility to rank prey (slow/fast taxa) with the former with the former assumed to be higher-ranked. However, prey mobility only covers one aspect of the amount of time it takes to pursue, capture, and process game since hunter-gatherers often use technology and other cultural innovations to decrease handling time, and this too can impact prey rankings (Hockett and Haws, 2002; Jones, 2012, 2016; Kuhn and Stiner, 2001; Lupo and Schmitt, 2002, 2005; Soffer, 2004). It must be noted that forager gender and age can impact future applications of prey choice models, because of a significant increase in the relative abundance of small prey in archaeological assemblages as it might indicate women/children hunting (Stiner, 2004, Stiner and Kuhn, 2006).

As for the climate and environment in the final Upper Paleolithic, Iberia was considered a “refugium” during glacial periods (Gómez and Lunt, 2006; Jones, 2012, 2016; Naughton et al., 2007; Sommer and Nadachowski, 2006). While the rest of Europe got colder, warmer adapted fauna and flora taxa move south. Iberia environments were not uniform, not even today. It can be divided into two bioclimatic zones: a) the mountainous northern strip and adjacent high elevation areas termed the Euro-Siberian zone, and b) the Mediterranean zone (Aura et al., 2002, 2010; García-Guixé et al., 2009; Hockett and Bicho, 2000; Straus, 2005, 2009; Straus et al., 2002; Villaverde et al., 1996). Since the archaeological sites discussed within this dissertation are located in NE of Iberia, will be discussing findings within the Mediterranean region.

Paleoenvironments seem to be marked by strong latitudinal gradients with species turnover from north to south. Recent research suggests human also responded to climate change regionally. Taking into account the geographical diversity of the Iberian Peninsula, everything seems to indicate that the reason for this change in focus to small game should be looked in a point of view of territorial occupation patterns (Aura et al. 2002a,b). While differences in environmental richness are often used to explain differences in faunal assemblages between regions, there is a factor to consider, and that is *forager mobility* (Aura et al., 2002a; Stiner, 2004). This term implies that different use of landscape and the representation of sites are expected given the different environmental situations.

According to various authors (Aura et al., 2002, Jones, 2012, Rillardon and Brugal, 2014) there are two types of mobility: *residential* and *logistical*. The term *residential mobility* refers to the action of shifting base camp; sites that reflect this kind of mobility often exhibit bone assemblages that generally contain narrow fauna with just a few taxa. While groups showing *logistical mobility* make residential moves less often; instead, it is more likely that individuals or small task specific groups venture out from and back to a residential camp. Sites that exhibit this type of mobility have broader faunal assemblages.

Archaeological data show that, based on the faunal assemblages, many prehistoric sites in NE Iberia show a logistical mobility patterns. Broad faunal assemblages composed of medium sized animals and small prey such as small size mammals, birds, land snails and marine resources evidence this. This type of mobility might be expected in a situation where variable landscapes are less defined or less predictable. In this situation sites would presumably and predominantly be located at mid-range elevation sites. Since forager mobility has an impact on site elevation variance, logistic sites should, theorically, be located within range of the widest number of patches. Thus sites in a logistical mobility situation would presumably be located at mid-range elevation sites, and overall elevation variance could be expected to be relatively low, with less predictable resources and infrequent movement. This suggests resources are scattered across the region.

Research done by Jones (2012, 2016) shows that sites located in the Mediterranean region have lower site elevation variance suggesting less predictable resources distribution than in high elevation regions. But site elevation seems to increase through time. The site elevation variance doubles during the Epipalaeolithic suggesting hunter-gatherers subsistence by that time went through a major reorganization concurrent with the climate variability associated to the transition to the Holocene.

Leporids, especially the European rabbit, as already said, are one of the dominant taxa among faunal remains in final Upper Paleolithic and Epipalaeolithic archaeological sites in the Iberian Peninsula (Aura et al., 2002; Hockett and Haws, 2003; Jones, 2006; Lloveras et al., 2008a, 2008b, 2009a; Martínez-Polanco et al., 2016; Villaverde et al., 1996), although they are also present in some Middle Paleolithic archaeological sites (Blasco and Fernández Peris, 2012; Cochard et al., 2012; Sanchis and Fernández Peris, 2008).

As will be discussed in more detail throughout this entire PhD dissertation, the European rabbit originated in Southern Iberian Peninsula during the Middle Pleistocene (López-Martínez, 2008; Pelletier et al., 2015), and stayed confined to the area and Southern France until the closing of the Pleistocene (Callou, 2003; Nowak and Wilson, 1999; Pelletier et al., 2015). It was not until historic times, due to human intervention, that wild populations dispersed throughout Europe, Africa and other parts of the world (Cochard, 2004).

Rabbits are small, fast and so required more energetic investment to hunt successfully; they are assumed to be nutritionally deficient due to low fat content and historically they are seen as starvation food. Even problems associated with excessive protein intake are even colloquially known as “rabbit starvation syndrome” (Harris, 1985). It must immediately be added; when the remains are considered of anthropogenic origin they are valued as a minor food resource, and ultimately as an indicator of food shortage for human populations (Davidson, 1976; Morales et al., 1998; Villaverde and Martínez Valle, 1992). For a long time in archaeological research rabbit remains have been undervalued since they were considered of little importance to human populations, assuming that their presence in archaeological faunal assemblages was due to accumulation by non- human predators (Lloveras et al., 2008a, 2008b, 2009a; Martínez-Valle, 1996) they were also considered of intrusive nature due to the rabbit’s tendency to burrowing. This situation has change considerably in this passed decade. Authors (Aura et al., 2002; Bicho et al (2000); Hockett and Bicho, 2000; Hockett and Haws, 2002; Jones, 2006; Lupo and Schmitt, 2002; Stiner, 2000, Stiner and Munro, 2002; Stiner et al., 1999) have questioned the importance of this group as a food resource, and propose that a progress in technology could have permitted capturing leporids in a more easy way, which increases and regularizes protein intake in the Paleolithic, Epipalaeolithic and Neolithic diet (Lloveras, 2011).

Even though the archaeofaunas from the Mediterranean region exhibit characteristics that are not typical from other regions of Southwest Europe, many authors (Aura et al., 2002; Jones, 2012, 2016; Stiner, 2004) have stated that in terms of *Broad Spectrum Revolution*, the consistency throughout time, in both site location and archaeofaunal assemblages' composition, does not seem to support such "revolution". The faunas of this regions suggested continuity with some minor shifts in response to climate.

CHAPTER 2

RESEARCH OBJECTIVES

After reflecting on the importance of small prey in hunter-gatherer communities in prehistoric times, especially leporids, the general objective of this thesis is precisely to evaluate the importance of leporids in the economy, mainly subsistence, in the predatory populations of the Northeast of the Iberian Peninsula (Catalonia) during the climatic transition Pleistocene – early Holocene and more specifically in the chrono-cultural phases that experienced this change, known as microlaminar Epipalaeolithic (or Epimagdalenian) and geometric Epipalaeolithic type Filador (or Microlaminar sauveterroide). This evaluation is made possible through the study and interpretation of leporid remains, rabbits (Oryctolagus cuniculus) remains in most of the cases recovered from three archaeological sites in the area: Balma del Gai (Moià, Barcelona province), Cova de la Guineu (Font Rubí, Province of Barcelona) and Abric de la Font Voltada (province of Tarragona). In some cases, these assemblages had been previously studied (Nadal, 1998). This time the material is studied and evaluated in the framework of a new protocol of archeozoological and taphonomic study (Lloveras, 2011). In this sense, the specific objectives of our work will be:

1. Through a thorough analysis of the surface of the bone, our intention is to identify possible alterations and / or modifications and to evaluate, firstly, whether or not the analyzed sets have had post-depositional bias (biostratinomic and diagenetic) to be considered reliable for analysis.

2. To discriminate if these leporid assemblages are of anthropogenic origin or could have been accumulated by other agents, mainly other predators of leporids: small terrestrial carnivores (mammals) and raptors (nocturnal and diurnal). In case of predator activity, try to identify the species through neo-taphonomic reference models.

3. In case of having discriminated the groups as accumulations of a fundamentally anthropogenic nature, our aim is to elucidate the gestures and cultural activities that generated the accumulation, similarities and differences in each of the studied occupations, to determine specific characteristics of each settlement, determined by variables that relate immediately.

4. To assess the importance of leporids in terms of pelt and leather producer through the identification of marks that shows carcasses processing (skinning activities).

5. To evaluate the meat consumption pattern, taking into account disarticulation and defleshing models through the anatomical representativeness, marks' location and nature of fractures.

6. To discuss the ingestion of nutrients from the immediate consumption of the carcases, deferred through the differential preservation of anatomical parts, models of bone fragmentation (evidence of the marrow extraction from the long bones) or by stripping or the extraction of muscular packages in different states of conservation (fresh or already treated and adhered to the bone).

7. To try to relate the extraction and use of rabbit pelt to the models of meat consumption described in the previous point, which could determine the main objective of leporid procurement and consumption.

8. Try to determine other uses: use of tendons, bone for the manufacture of tools, etc.

9. To detect the use of fire for the culinary treatment of the leporid carcasses or for the removal of unconsumed remains, by characterizing the thermal alteration on the bone remains through techniques that overcome the classic discrimination through the color of the surfaces, and thus avoiding the biases produced by the natural pigmentation of the sediment.

10. To make an approximation of the hunting techniques applied to small prey for this chronology, according to the quantitative importance of the sample and try to infer hunting strategies (massive, opportunistic, collective, seasonal, etc.) that can vary according to settlements.

11. Deferring from the previous premise, and with previous data (intensity of carcasses processing and used resources), to extrapolate occupational models for each archaeological site (seasonality, base camps, logistic camps, etc.) through the analysis of leporid remains.

12. Finally, to compare the results of the studied sites with the data from other sites in Iberian and south of France, especially those located in the Mediterranean basin, or in environments of Mediterranean-continental climate, in subsequent phases (Upper Paleolithic), in order to observe similarities and differences and thus to establish a general model of leporid exploitation between the hunter-gatherers communities of anatomically modern humans at the end of the Pleistocene and early Holocene in the Mediterranean basin of the Iberian Peninsula.

CHAPTER 3

LEPORIDS: ORIGIN AND CHARACTERISTICS

3.1. TAXONOMY AND GEOGRAPHIC DISTRIBUTION

Kingdom: *Animalia*
Phylum: *Chordata*
Class: *Mammalia*
Order: *Lagomorpha*
Family: *Leporidae*

Leporids belong to the taxonomic order **Lagomorpha**. Up until 1912 they were classified within the order Rodentia, then later classified as a separate order due to their morphological differences: the presence of two pairs of upper incisors, a fused fibula to the distal part of the tibia and a certain degree of mandible and forearm movement (Gidley, 1912). Lagomorphs are widespread around the world and inhabit every continent except Antarctica. However, they are not found in the southern cone of South America, in the West Indies, Greenland, Indonesia or Madagascar, nor on many islands (Angerbjörn, 2005). Although they are not native to Australia neither to any other island in the world, humans have introduced them there and they have successfully colonized many parts of the country and caused disruption to native species.

Lagomorphs are divided into two families: **Ochotonidae** and **Leporidae**. Currently there are 91 living species contained in 12 genera (Chapman & Flux, 2008; Hoffmann & Smith, 2005) (Fig. 3.1). The family Ochontodinae (Pikas) includes one single genus *Ochotona* (Chapman & Flux, 2008) and 30 recognizable species, and represents 1/3 of the lagomorph diversity in the world (Smith, 2008). Today ochononids are only found in Asia (Iran, India, Myanmar and Northern Russia) and the high mountains of Western North America (Alaskan Range, Canadian Rockies, Sierra Nevada and the Great Basin) (Smith et al., 1990), although historically, their geographic range included Europe and Northern Africa (Smith, 2008).

Leporidae is a family of small mammals that include 10 genera of rabbits (*Brachylagus, Bunolagus, Caprolagus, Nesolagus, Oryctolagus, Pentalagus, Poelagus, Pronolagus, Romerolagus* and *Sylvilagus*) and one unique genus of hares (*Lepus*). On the whole, they are divided into 11 genera and 61 species (Chapman & Flux, 2008; Hoffmann & Smith, 2005). Leporids have a wide geographic range, occupying most of the world's landmasses. As mentioned before, humans have introduced them to South America, Australia, New Zealand and Java. Hares (*Lepus sp.)* are the most spread of the leporids (Fig. 3.2). They are distributed through Africa, Eurasia, North America, and the Japanese archipelago. Currently, three hare species coexist in the Iberian Peninsula. Two are endemic: the Iberian hare (*Lepus granatensis*) (Fig. 3.2 A) and the broom hare (*Lepus castroviejoi*) (Fig. 3.2 B), which is restricted to the Cantabrian Mountains. The third species is the European hare or brown hare (*Lepus europaeus*) (Fig. 3.2 C), which is native to Europe and parts of Western and Central Asia. The European rabbit (*Oryctolagus cuniculus*) (Fig. 3.2 D) is the only current species in its genus; since the last ice age they were confined to the Iberian Peninsula and areas of France and Northwestern Africa. Today they exist in the wild in every continent except Asia and Antarctica.

3.2. LEPORIDAE ORIGINS

Species of both genera, *Oryctolagus* and *Lepus*, are abundant in paleontological and archaeological sites across Western Europe. The earliest fossil ancestor of leporids lived in Mongolia 55 millions years ago (Chapman & Flux, 2008) and modern rabbits and hares first appear in Europe during the Pleistocene (Callou, 2003; De Marfà, 2009; López-Martínez, 2008; Pelletier et al., 2015).

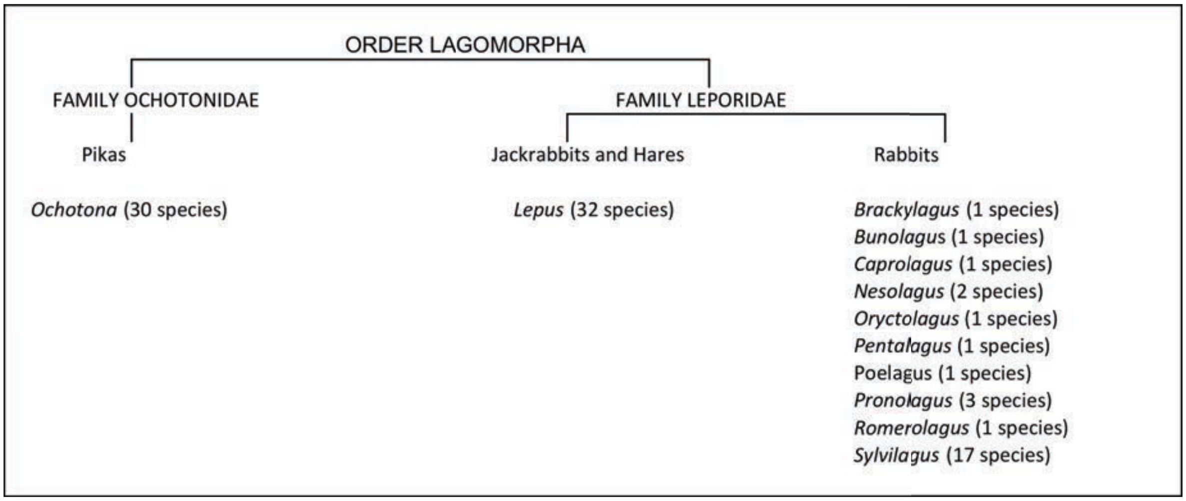

Figure 3.1 Families and genera of the order LAGOMORPHA. Modified from Chapman & Flux, 2008, and Hoffmann & Smith, 2005.

3.2.1. Origins of the European Rabbit (Oryctolagus cuniculus)

The first recorded species of the genus *Oryctolagus*, from Middle Pliocene (3.5 Ma) deposits at Layna, Soria, was *Oryctolagus laynensis* (López-Martínez, 2008; Pelletier et al., 2015). This species was present in Northeastern, Central and Southern Spain, and Southeast France. Also in South France (2.5 Ma) and later in Italy (2 Ma), another species of rabbit appear, *Oryctolagus lacosti (*De Marfà et al. 2006; López-Martínez, 2008; Pelletier et al., 2015); the individuals from Italy were initially assigned to *Lepus sp*., due to its size. *Oryctolagus laynensis* and *Oryctolagus lacosti* both emerged in the Pliocene and shared a common ancestor, but evolved independently from one another (López-Martínez, 2008), initially in the Iberian Peninsula, and then France and Italy, respectively. Another species of *Oryctolagus* was identified in Murcia from lower Pleistocene (1.4 Ma) deposits. As noted by De Marfá (2008), *Oryctolagus giberti* could well represent a transition species between *Oryctolagus laynensis* and *Oryctolagus cuniculus.* In Italy, there was a contemporary species, the *Oryctolagus valdarnensis,* which was very large in size. Also in Italy, another species appear during the Middle Pleistocene (0.8 - 0.1 Ma), *Oryctolagus burgi*. It is during the Middle Pleistocene, at approximately 0.6 Ma, that the modern European rabbit (*Oryctolagus cuniculus*) emerge in the Iberian Peninsula. In the Late

Pleistocene, only *Oryctolagus cuniculus* remained, and the species quickly spread throughout the Mediterranean and North Africa (Callou, 2003). During the Last Glacial Maximum and the Early Holocene, the modern rabbit is confined to the Iberian Peninsula and south of France, were it suffered a genetic differentiation (López-Martínez, 2008). Today some authors defend the existence of two subspecies of *Oryctolagus cuniculus* in Iberia: 1.) *O. c. algirus* distributed Southwest of the Iberian Peninsula and North Africa, and 2.) *O. c. cuniculus* that can be found across the Iberian Peninsula (Estévez et al., 2006).

3.2.2. Origins of the European hares (Lepus sp.)

It is very likely that the genus *Lepus* emerged in North America in the Lower Pleistocene (2.5 Ma) (Ge et al., 2013; López-Martínez, 2008; Pelletier et al., 2015). They can also be found in sites across Central Europe, Germany, Italy and Spain. From the Middle Pleistocene onward different species of hare emerged: *Lepus granatensis, Lepus timidus,* and *Lepus europaeus (*Callou, 2003; De Marfà, 2009). The Iberian hare (*Lepus granatensis)* was first documented in Cúllar de Baza, whilst the mountain hare (*Lepus timidus)* and the European hare (*Lepus europaeus)* appeared in Western and Central Europe. Other species of hare emerged in Europe during the Pleistocene: *Lepus castroviejoi,* found in the central Cantabrian Mountains, and *Lepus corsicanus*, found in Corsica and Southern Italy.

3.3. MORPHOLOGICAL DESCRIPTION

3.3.1. General characteristics

Members of the Leporidae family exhibit a high variability, depending of genera and species, they range in size and weight, from the pygmy rabbit, with a head and body length of 25–29 cm and 0.46 kg, to the European hare, which is 50–76 cm in head-body length and 5 kg. Females tend to be much larger in size. Color patterns vary between species and across seasons, and range from black to reddish brown to white. Habitat type may affect the fur color as well as litter size. Most leporids are counter colored, with dark-colored dorsal pelage and light-colored ventral fur. The fur texture can be thick and soft or coarse and woolly and may become increasingly sparse along the length of the ears (Angerbjörn, 2005; Hoffmann & Smith, 2005; Nowak & Wilson, 1999).

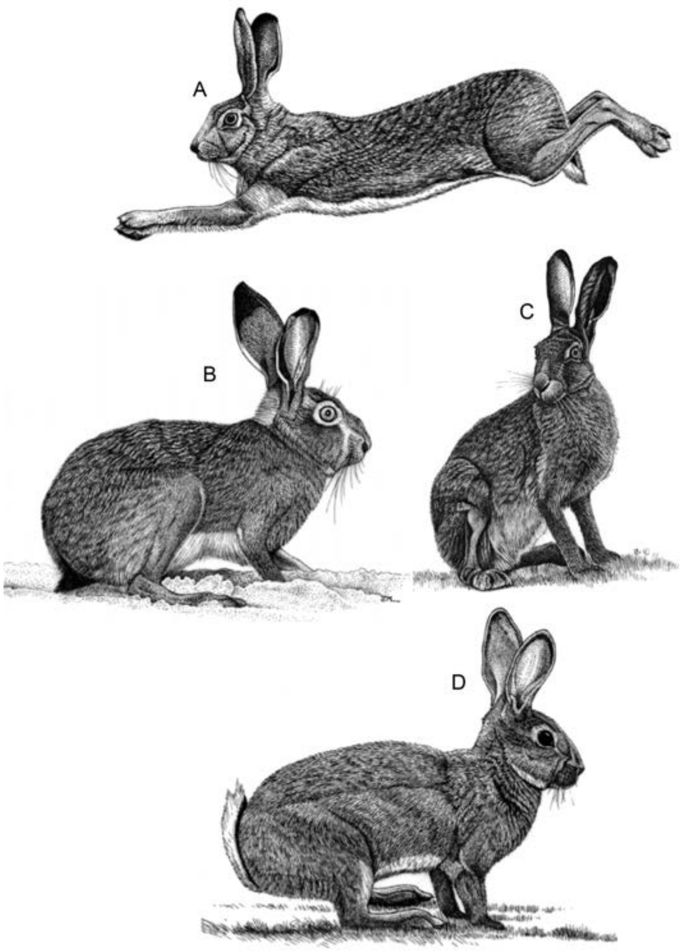

Figure 3.2 A. *Lepus granatensis*, B. *Lepus castroviejoi*, C. *Lepus europaeus*, and D. *Oryctolagus cuniculus*. Modified from *Atlas y Libro Rojo de los Mamíferos Terrestres de España* (2007).

They are adapted to rapid movements, so they have long hindlimbs with four toes on each foot, and shorter forelimbs with five toes each, terminating in long, slightly curved claws. The soles of their feet are hairy, to improve grip while running. Leporids also have distinctive ears, relatively long and mobile.

The leporid skeleton is light (Aspinall & O'Reilly, 2004) and contains approximately 216 bones (Fig. 3.3; Table 3.1), without counting sesamoid bones, sternum or clavicles. The skull has an arched profile, slightly constricted between the orbits. They have prominent post and supra-orbital processes, and the parietal bone, occipital bone and maxillae are fenestrated. In some species, the squamosals are fenestrated as well (Fig. 3.4). They have a moderately robust zygomatic arch, a relatively short jugal, and tubular external auditory meatuses that are vertically positioned. The spinal cord is naturally curved and contains: 7 cervical vertebrae, 12-13 thoracic vertebrae, 7 lumbar vertebrae, 4 sacral bones and 16 caudal vertebrae.

The dental formula of most leporids is 2/1, 0/0, 3/2, 3/3 = 28 (Schmid, 1972) (Fig. 3.5 A). The primary incisors are enlarged, and the secondary are small, peg like, and located immediately posterior to the primaries. The primary incisors resemble those of rodents, except that they are completely encased in enamel. A large diastema separates the incisors from the cheek teeth (Fig. 3.5 B). Their molars and premolars have relatively simple cusp morphology, with the occlusal surface being made up of two transverse ridges.

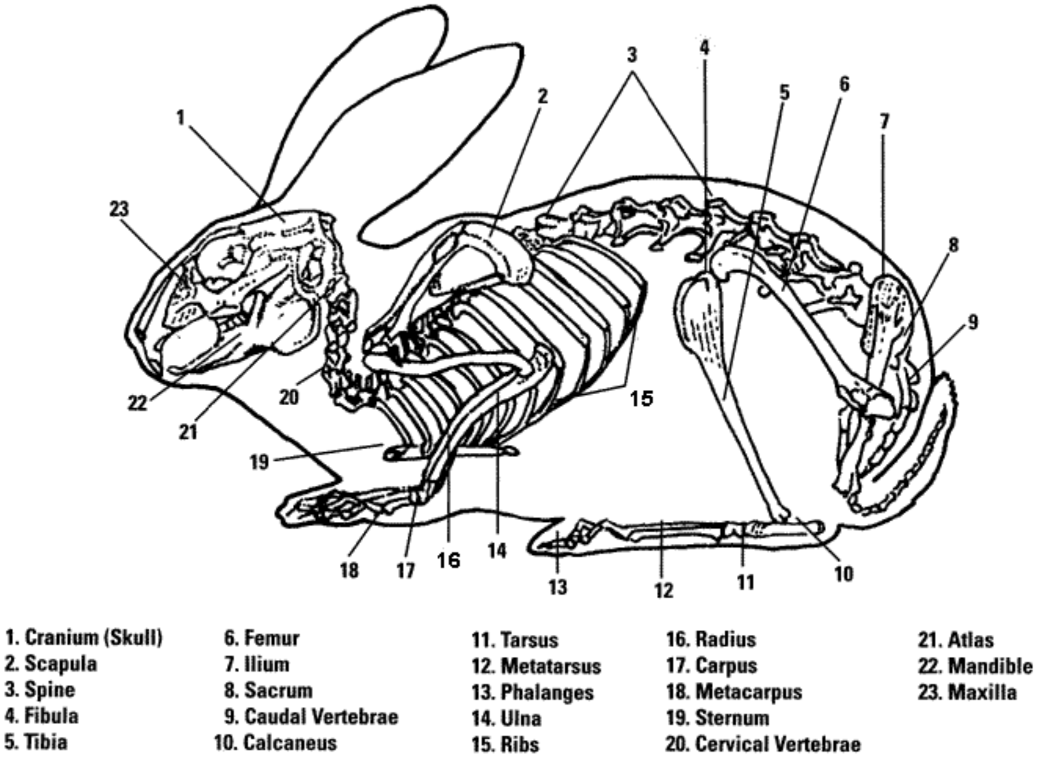

Figure 3.3 Left profile of a leporids skeleton. (http://www.geauga4h.org/rabbits/rabbit_skeleton.htm)

Table 3.1 Number of skeletal and dental elements present in a leporid skeleton.

Element	Nº	Element	Nº
Mandible	2	Scapula	2
Maxilla	2	Innominate	2
Incisors	6	Metacarpals	10
Upper molars	12	Metatarsals	8
Lower molars	10	Phalanges 1/2	34
Humerus	2	Phalanges 3	18
Radius	2	Calcaneus	2
Ulna	2	Astragalus	2
Femur	2	Carpal/Tarsal	24
Tibia	2	Vertebrae	46
Patella	2	Ribs	24

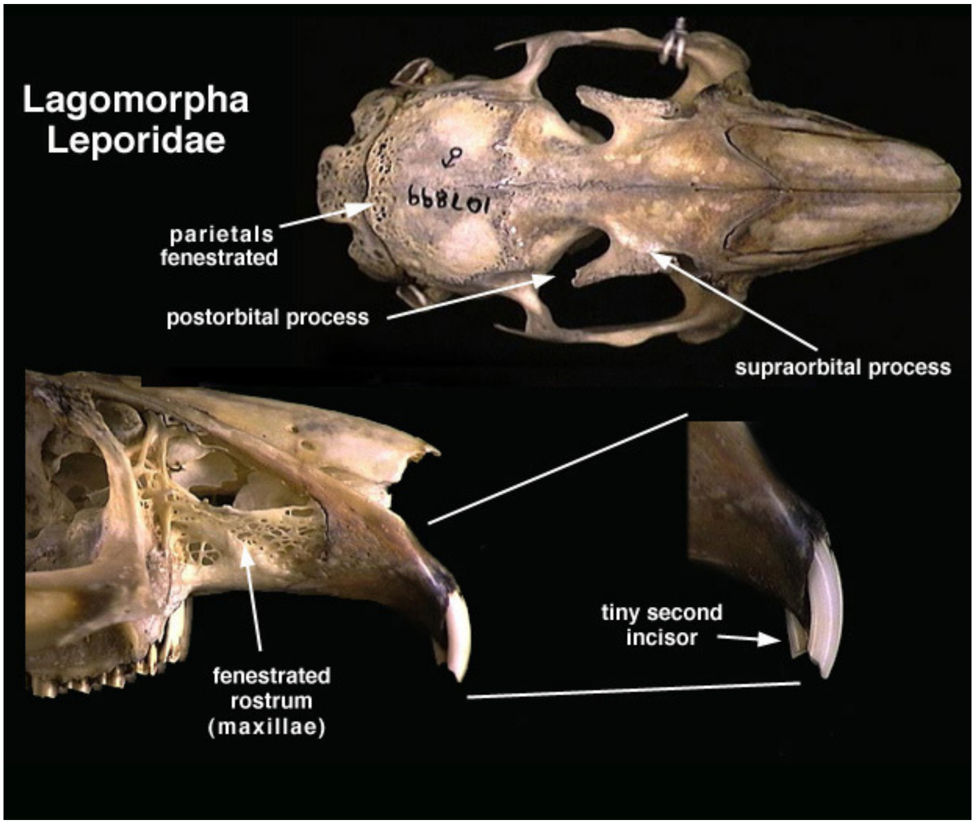

Figure 3.4 Leporid skull. Photographed by Phil Myers, Museum of Zoology, University of Michigan-Ann Arbor. (www.animaldiversity.org).

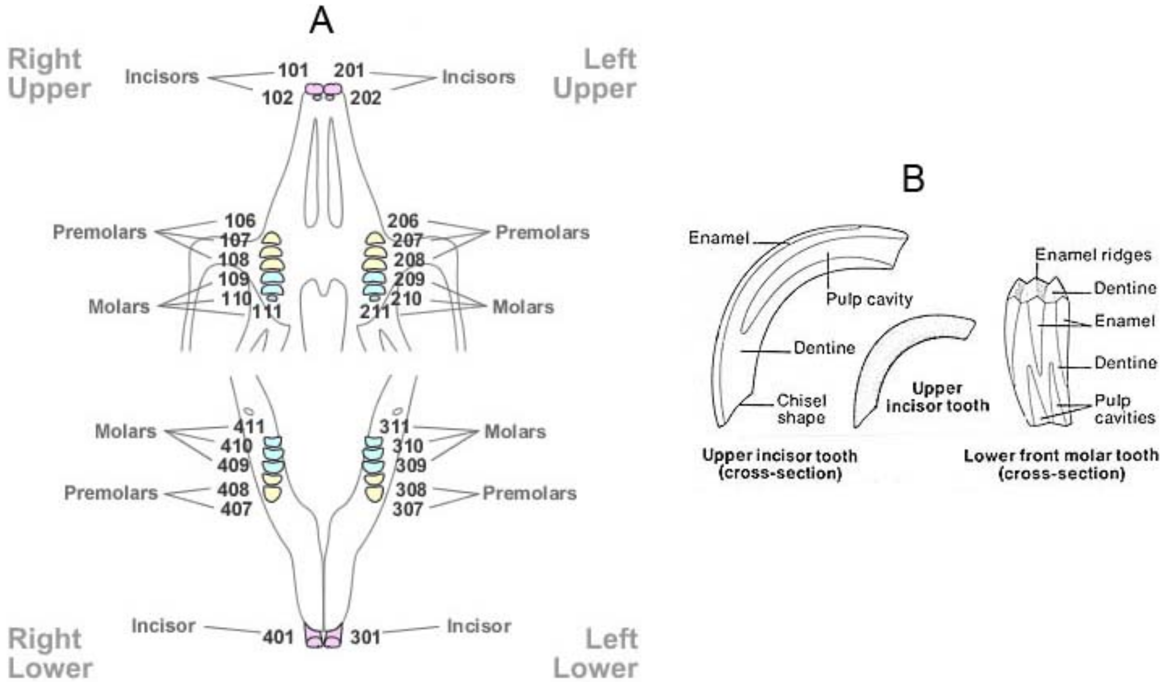

Figure 3.5 A. Leporids dental formula. B. Primary incisors encased in enamel and molar cusp morphology.

3.3.2. Differences between genera

Rabbits and hares skeletons are quite similar, size been the difference. However, the size variable cannot be taken slightly since it has been proven that it can be influenced by environmental and habitat issues. While hares are well adapted for running long distances, rabbits run in shortbursts and have modified limbs adapted for digging. We cannot rely on morphometric differences given that, sometimes, you can come across a very big rabbit or, on the other hand, a very small hare. To solve this problem, Callou (1997 & 2003) and Llorente (2010) established some diagnostic characteristics that allow distinguish, between both species at an osteological level.

3.4. THE EUROPEAN RABBIT

3.4.1. Habitat

The European rabbit (Fig. 3.6) can inhabit different regions (temperate and tropical) and different biomes (savannah, grassland and even forest) but their preferred habitat include dry areas near sea level with soft, sandy soil for easy burrowing. Also, brushy fields are preferred for the cover they provide. This species is characterized by its easy adaptation to different biotopes, avoiding mountainous areas under 1,000- 1,500 m of altitude and humid zones. There is a rich abundance of this species in the Mediterranean area (Fig. 3.7), with arid and hot climate.

Figure 3.6 European rabbit (*Oryctolagus cuniculus*). Photo taken by Manual Estébanez, http://miradascantabricas.blogspot.com.es/2015/02/conejo-de-monte-oryctolagus-cuniculus.

Figure 3.7 current geographic distributions of *Oryctolagus cuniculus* in the Iberian Peninsula, North Africa and Europe (According to Flux, 1994 and Callou, 2003).

3.4.2. Behaviour

The European rabbits are gregarious and territorial (Cowan, 1987); preferring to live in groups, in large and complex burrow systems called warrens. These warrens can be 3 m deep and 45 m in length. A typical colony consists of six to ten adults of both sexes. Colonies have distinct dominance hierarchies, which are particularly important for males, as dominance position determines which male will have preferential access to mates. They prefer dry and well-drained soil when digging their burrow (Fig. 3.8 A). Home range size varies with population density and food abundance, but is usually under 0.20 km^2 and often as small as 0.0081 km^2. *Oryctolagus cuniculus* is generally nocturnal, spending its days underground and foraging from evening until morning. The rabbit is a generalized herbivore, eating a diverse diet of grasses, leaves, buds (Villafuerte, 2007), tree bark, and roots (Nowak & Wilson, 1999). Although the diet is relatively low in nutritional value, and high in indigestible material, *Oryctolagus cuniculus* is one of several rabbit species that are known to reingest feces (coprophagy) to obtain extra nourishment from their food (Nowak & Wilson, 1999).

Rabbits are well known for their reproductive capacity, the gestation period is about 30 days, and the average litter contains 5 to 6 young. Although these animals breed throughout the year, most breeding takes place in the first half of the year. The neonates are called kittens, and they are born completely helpless, naked and blind (Fig. 3.8 B, 3.8 C). The mother visits the nest for only a few minutes each day to nurse them, but the milk is extremely rich. Young are weaned at four weeks of age, attain sexual maturity at about eight months, and can live up to nine years old. However, mortality rates in the first year of life frequently exceed 90%, they are preyed upon by a wide variety of carnivores, including canines, felines, mustelids, hawks and owls.

3.5. HARES *(Lepus sp.)*

3.5.1. Habitat

Hares can occupy a large variety of environments, but they prefer places with dense vegetation and open fields. The Iberian hares (*Lepus granatensis*) (Fig. 3.9) are only found in the Iberian Peninsula (Fig. 3.10). They are common throughout the peninsula, except in the far northeast.

They may occupy a variety of landscape types within their range including forests, shrub lands and grasslands. Iberian hares are most common in the northern Iberian Mountains. Much of this area has a less extreme climate than other parts of the peninsula, such as the Ebro Depression and the southern Iberian Mountains, suggesting that Iberian hares prefer moderate climates.

The species tends to prefer the agricultural ecosystems common to this region. On the other hand, European hares or brown hares (*Lepus europaeus*) prefer open fields and pastures bordered by hedgerows and woodlots, often around agriculture fields and crops. They live in shallow forms; clumps of grass, weeds, or bush. The broom hare (*Lepus castroviejoi*) is an endemic species restricted to northern Spain, inhabiting elevations from

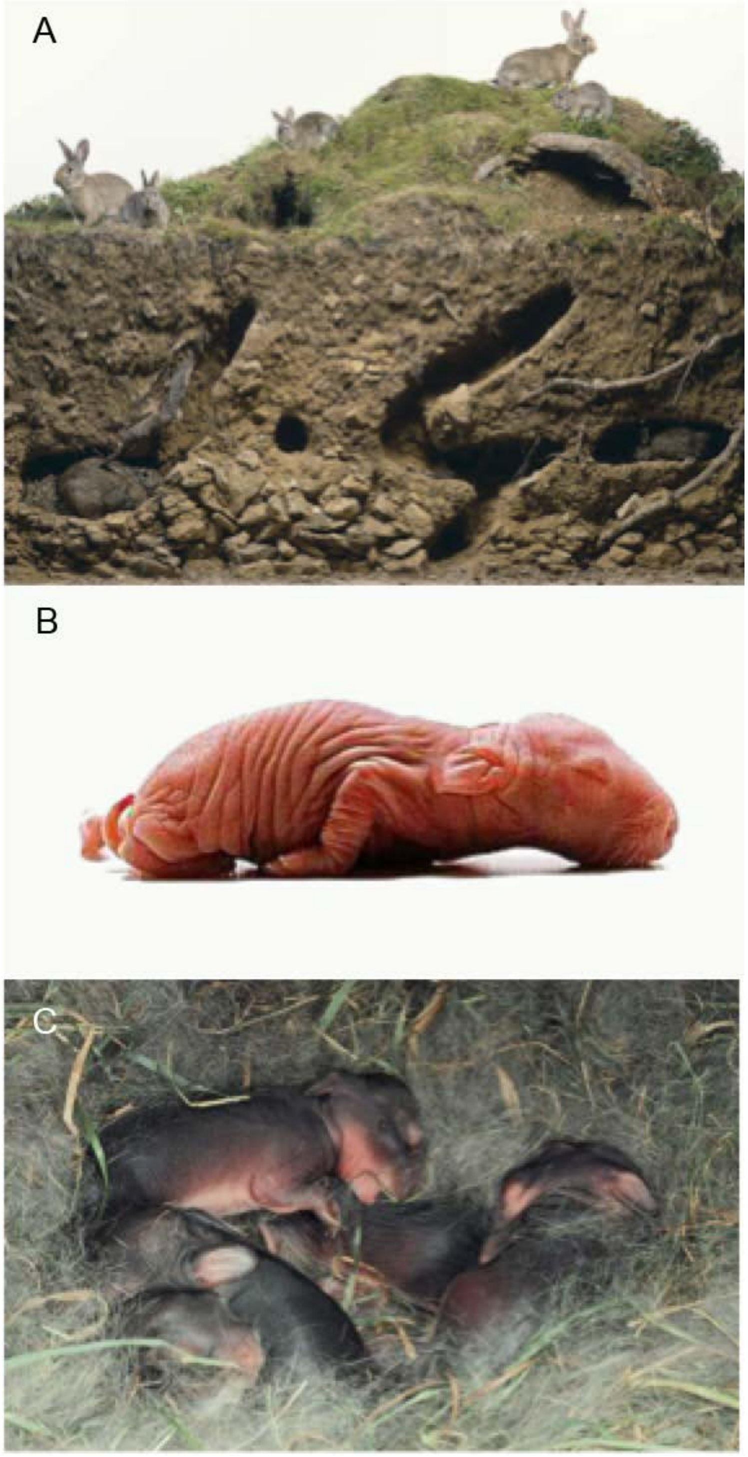

Figure 3.8 A. Profile of a rabbit's warren (Obtained from www.watership-down-under.wikispaces.com), **B.** Image of a 1-day-old rabbit kitten (Obtained from http://www.orcca.on.ca), and **C.** Image of a 10 days old rabbit kittens (Obtained from www.arkive.org and www.gettyimages.com).

Figure 3.9 Iberian hare (*Lepus granatensis*). Photo taken by Javier Núñez Saínz.

1,300 m to 1,900 m in the Cantabarian Mountains (Fig 3.10.). They have been know to descend to lower elevations of about 1,000 m in winter to avoid snow. Much of the native habitat is heathland, mostly consisting of shrubs. Broom hares may spend additional time in mixed deciduous forest of oak and beech.

3.5.2. Behaviour

Hares are nocturnal, however, activity periods can vary and Iberian hares (*Lepus granatensis*) are commonly seen during daylight hours. Hares typically travel long distances and have larger home ranges than rabbits. Hares live completely aboveground (Fig. 3.11 A), they build their nest by scratching a depression or form into the soil. The nests are usually found in sheltered areas, such as under brush and logs. They are solitary animals, except when mating and raising young. The gestation period last 42 days,

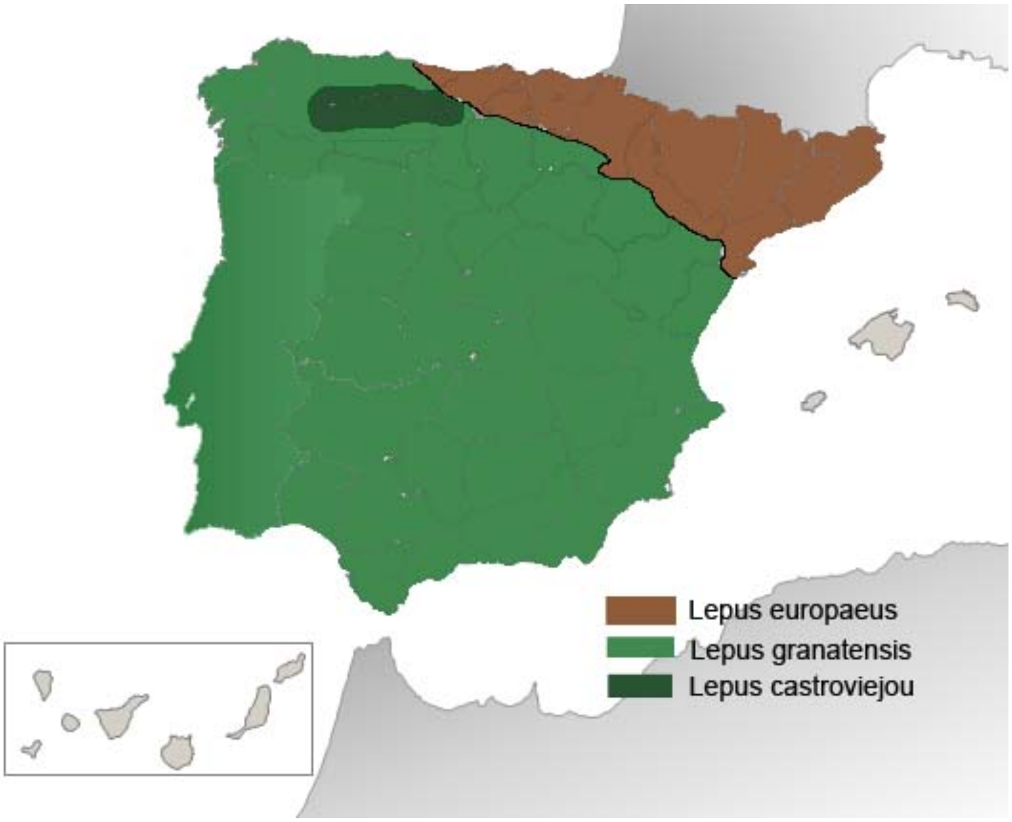

Figure 3.10 Current distribution of the three hare species present in the Iberian Peninsula (According to Ballesteros, 2003, 2007a, 2007b).

compared with rabbits' 30-31 days. Baby-hares, unlike rabbits, are called leverets and they born fully furred (Fig. 3.11 B), able to see and capable of independent movement. The average litter size consists of 6 -7 leverets. Because hares can live on their own after one hour from they birth, their mothers feel free to leave them on the bare ground and hop away soon after the baby is born. They are herbivores, feeding on plant material. They can be found in agricultural regions where they feed on crops and in vineyards. In forested areas, hare feed on buds, twigs and bark, especially in winter.

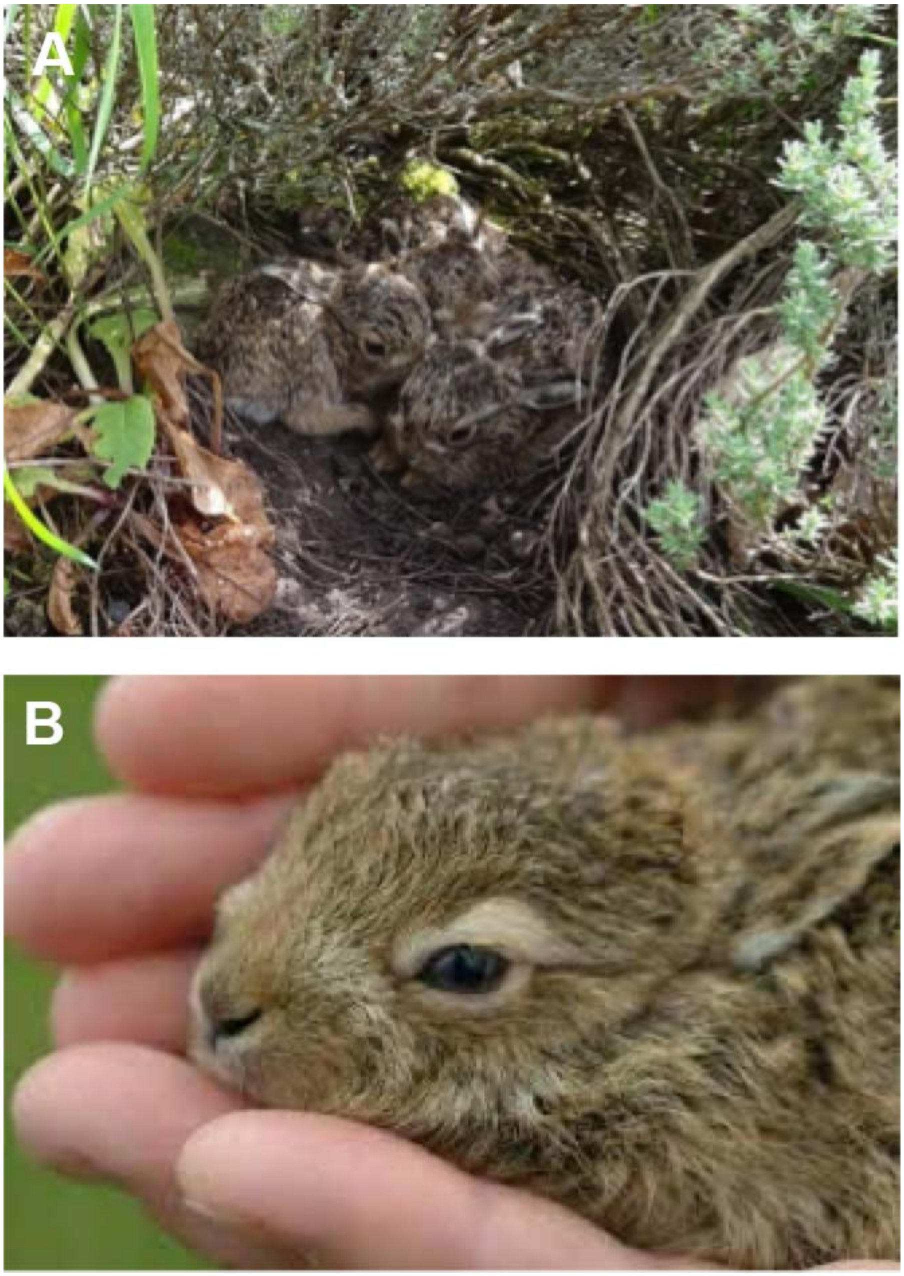

Figure 3.11 A. Three hare leverets found shortly after been born in a thyme bush (Photo obtained from http://www.theguardian.com/environment/guardianwitness-blog) and B. One-day-old hare leveret fully furred (Photo obtained from http://www.orcca.on.ca).

CHAPTER 4

LEPORIDS ACCUMULATIONS: FORMATION PROCESSES AND ALTERATIONS

In the following chapter we examine the different types of leporid accumulations that can be found in archaeological contexts, taking into account the main agents that may be responsible of the assemblages and the different types of alterations present in a bones as consequence of the agents' activities. For this matter, data obtained from actualistic and experimental studies have been considered.

Leporid accumulations are very abundant in archaeological sites of the Iberian Peninsula. The problem is that, apart from humans, there are many agents that may be responsible for such assemblages. Thus, in order to assess the importance of these prey for human communities in the past it is necessary discriminate between different agents and confidently establish which is the origin of leporid archaeological remains.

Terrestrial carnivores and raptors that are regular visitors to caves and rock shelters may accumulate leftovers and pellets, and scats containing bones of their prey. The accumulated leporid remains may suffer different types of alterations related to the activity of the accumulating agents or consequence of other biostratinomic or diagenetic causes.

To analyse these types of modifications is essential to establish the origin of the assemblage.

Within an archaeological context we can find two possible origins for leporid accumulations: intrusive and exogenous.

4.1. INTRUSIVE ORIGINS

By intrusive origin we mean all of those individuals that are accumulated as the result of natural causes, without the intervention of any predator. When dealing with leporids, especially European rabbit (*Oryctolagus cuniculus*) remains, within an archaeological context, it is worth bearing in mind its habit of digging warrens and living underground, since some remains might not be contemporary (intrusive origin) to the ones found in the archaeological levels or, in the other hand, be contemporary to archaeological remains but accumulated by non human predators. Individuals who survive been preyed upon can often find death from: age, disease, parasites, accidents or catastrophic events, such as flooding of the warren (Lyman, 1994). To determine the various agents or processes responsible for such type of accumulations is essential when evaluating the role-played by leporids in the prehistoric diet.

According to different researchers (Cochard, 2004; Lyman, 1994; Patou, 1987; among others), when analysing accumulated remains of probable intrusive origin the following variables must be taken into consideration: faunal composition, demographic structure, anatomical representation and spatial scattering, breakage patterns and lack of traces.

- *Faunal composition*- the faunal bone assemblage shows a reduced taxonomic list of one or two species, or an important accumulation of a single taxon. Also, the environment and behaviour of certain species must be taken into consideration as they may provide information.

- *Demographic structure*- the demographic structure of the death assemblage may vary depending on the type of mortality (Lyman, 1994). Regarding age classes, since rabbits have an extensive reproductive period, it is possible to find infants and juvenile individuals all year long, but being more abundant during the spring through summer season. In the case of attritional mortality the frequency distribution of age classes show that very young and very old individuals are overrepresented in relation to their live abundance (Domínguez-Rodrigo, 1999; Lyman, 1994) because they are weaker it is more likely to fall ill and die from natural causes. In case of catastrophic or mass mortality, the mortality profile reflects the actual numbers of different age classes of a living population; adults and sub-adults individuals will be more represented but all age classes will be found.

- *Anatomical representation and spatial scattering*- almost every element of the skeleton is represented, there is a high proportion of anatomically connected bones and low scattering of skeletal remains represented in the bone collection. The differential conservation of the remains it is expected to coincide with the theoretical differential conservation, meaning that the most resistant elements will be the ones that are best represented, meanwhile the frailest will be considered the scarcest, all of this according to the bone density values established by Pavao (1999). Although, the presence of skeletal elements in anatomical position may be difficult to detect during excavation at an archaeological site, mostly because of the leporids small size.

- *Breakage*- the absence or scarcity of fractures can be an indicative feature of intrusive origin. In any case, it must be noted that if fractures are present, and if they are produced by post-depositional processes, they most certainly be located on the most fragile parts of bone and may resemble dry bone fractures.

- *Lack of traces*- alterations on the bone surface, made by non-human (raptors and terrestrial carnivores) and human predators (carcasses processing), is absent. Should be taken into account that a number of postdepositional alterations to the bone surface, such as trampling and diagenetic processes, can mimic the appearance of cut marks.

4.2. EXOGENOUS ORIGIN

The human being is one of many predators that prey upon and accumulate leporid remains within archaeological sites, located on caves and rock shelters where alternate occupations between human groups and other predators often occur. As noted before, such places are used as habitat by predators for prolonged periods of time, leading to multiples accumulation agents.

The characteristics that define this type of bone assemblages have emerged from the development of taphonomic research on contemporary remains accumulated by different non-human predators and from remains of anthropic origin obtained from modern experimental samples and from archaeological sites. Most of these research studies have focused on traits present in modern and prehistoric remains for each predator, and to infer on the ecology and behaviour based on the patterns detected on the bone surface.

4.2.1. Non- human accumulations

During the last few decades, taphonomic analysis have been applied to both, macrofaunal and microfaunal remains (Behrensmeyer and Hill, 1981; Binford, 1981; Blumenshine, 1988; Denys, 1985; Fernández-Jalvo and Andrews, 1992; Gifford, 1981; Lyman, 1994; Marean, 1998; Schmitt and Lupo, 1995;) providing key information on animal exploitation, subsistence strategies, mobility patterns and paleoenvironmental reconstruction. Based on experimental research done on faunal remains, these studies established a number of criteria in order to determine the non-human origin of bone accumulations, focusing on variables such as: location of the remains within an archaeological site, faunal or taxonomic composition, number of individuals, age classes, anatomical representation, breakage patterns, and the presence of bone surface alterations such as toothmarks and digestion damage. Similar criteria have been applied to the analysis of leporid accumulations created by different species of predators, which in the last years have been the focus of different researchers (Barja and Corona, 2007; Cochard, 2004a, 2004b;

Guillem and Martínez-Valle, 1991; Hockett, 1991, 1995, 1996; Hoffman, 1988; Esteban-Nadal, 2012; Esteban- Nadal et al., 2010; Esteban-Nadal, 2012; Hockett, 1991; 1995; 1996; Lloveras et al., 2008a, 2008b, 2009, 2011, 2012a, 2012b, 2014a, 2014b, 2016a; Rodriguez-Hidalgo et al., 2013, 2015; Sanchis, 2000; Sanchis Serra et al., 2014; Schmitt, 1995; Schmitt and Juell, 1994; Yravedra, 2004; among others). The basic modification categories analysed in those studies included:

- *Analysis of anatomical representation*- the presence of different skeletal elements and the proportion in which they appear can be useful when identifying accumulations made by different predators.

- *Breakage patterns*- the degree of fragmentation can be used as a marker to identify predators. For this, it is important to assess the degree of completeness of the assemblage and to distinguish between different types of fractures: caused by mechanical action (ingested or non-ingested remains), chemical action (caused by digestion), and post-depositional nature.

- *Bone surface modifications*- marks present as the result of consumption and digestion. The presence of tooth and beak marks is evidence of the intervention of predators. Also, different degrees of digestion depending on the intensity of damage caused by digestive enzymes can vary depending of the predator.

In the Iberian Peninsula, the list of predators that prey upon leporids is quite long. Specially, the European rabbit is a keystone species in this area since it is an important food resource for more than 30 species (Delibes and Hiraldo, 1981). From an archaeological point of view the most interesting species are those able to accumulate leporid remains in the same sites occupied by humans. Considering all the categories described previously, the main leporid remains accumulators can be classified within three groups: (1.) terrestrial carnivores, (2.) diurnal raptors and (3.) nocturnal raptors.

4.2.1.1. Terrestrial Carnivores

Among this group we can include members of the Canidae, Felidae, Mustelidae and Viverridae families. However, in this dissertation, we will be focusing on the main leporid remains predators, which are the Iberian wolf, red fox, Iberian lynx, and the European

wildcat. All these terrestrial carnivores may assemble different types of accumulations from (1) scats, (2) non-ingested remains, or (3) a combination of scats and non-ingested remains, and as a result the taphonomic patterns may vary accordingly.

Iberian wolf, *Canis lupus signatus* (Linnaeus, 1758)

The Iberian wolf is the largest canid in the Iberian Peninsula, and it is subspecies of grey wolves. It inhabits the forests and plains of northern Portugal to the North-western Spain. Since it is a generalist species, highly capable of adapting to different environments, it occupies a wide variety of habitats, from: scrubland, woodland, grassland and cereal plains (Grande del Brío, 2000). They often hunt prey on their own or in pack; they might also steal the prey of other predators, or scavenge carrion. Animals included in the wolf's diet vary geographically and depends on prey availability. In the Iberian Peninsula wolves primarily hunt in packs for large prey such as moose, elk, bison, musk oxen and reindeer (Barja, 2009; Barja and Corona, 2007; Llaneza et al., 1996; Roque et al., 2001; Salvador and Abad, 1987). They usually utilize the entire carcass, sometimes ingesting some hair and bones. Lone wolves usually hunt smaller prey such as beavers, rabbits, hares and other small mammals, and they are a substantial part of their diet (Barja, 2009; Barja and Corona, 2007; Castroviejo et al., 1975; Cuesta et al., 1991; Roque et al., 2001; Salvador and Abad, 1987).

During the Pleistocene, both humans and wolves cohabited in the same regions. This relation between this two agents meant that, wolves produced accumulations in places that coincide with areas of anthropic activity. Works dedicated to the taphonomic modifications on wolf's non-ingested and scatological remains are focused on big game (Barja and Corona, 2007; Binford, 1981; Esteban Nadal et al., 2010; Esteban Nadal, 2012), but to this date there are non neotaphonomic studies on leporid remains accumulated by wolves. According to the most recent study on bones recovered from wolf's scatological samples (Esteban-Nadal, 2012; Esteban- Nadal et al., 2010), it can be expected to find:

- An abundance of small sized and immature individuals.
- Remains found in scat mainly correspond to cranial, axial and appendicular skeleton.
- An elevated percentage of remains show signs of biochemical modification (digestion), with partial or total disappearance of the cortical tissue.
- Tooth marks and gnawing tend to appear on larger bones.
- There is a high degree of fragmentation, with fragments ranging from 1 – 20 mm, although in the studies conducted by Barja and Corona (2007), and Binford (1981) the average size of fragments range between 10- 30 mm.

These traits observed on large prey are not the same that could be expected for animals of the size of leporids. It is clear the need to conduct research in this area to full this gap and obtain adequate reference data.

Red fox, *Vulpes vulpes* (Linnaeus, 1758)

The red fox is a very adaptive and successful carnivore, it has the widest geographical range of any canid, and it's distributed across the entire Northern hemisphere from the Artic Circle to North Africa, North America, Europe and Asia. Its range has increased alongside human expansion, having been introduced to Falkland Islands and Australia in the 1800s, where it is considered harmful to native mammals and bird populations (Macdonald, D.W. & Reynolds, J.C. 2008; NSW, 2001). The red fox is distinguished from other fox species by its ability to adapt quickly to new environments. Red foxes utilize a wide range of habitats including forest, tundra, prairie, desert, mountains, farmlands, and urban areas. They prefer mixed vegetation communities, such as edge habitats and mixed scrub and woodland, and they are found from sea level to 4500 meters elevation (Hoffman and Sillero-Zubiri, 2016; Macdonald, D.W. & Reynolds, J.C. 2008).

Normally, foxes are solitary animals and do not form packs like wolves. An adult male and one or two adult females occupy ranges with their associated young. Outside the breeding season, most red foxes favour living in the open, in densely vegetated areas, though they may enter burrows to escape bad weather, during the winter, or during birth and rearing of the young. Individuals and family groups often have other emergency burrows in the home range, which may be dug on hill or mountain slopes, ravines, bluffs, steep banks of water bodies, ditches, depressions, gutters, in rock clefts and neglected human environments Macdonald, D.W. & Reynolds, J.C. 2008; Wilson and Reeder, 2005). Red foxes prefer to dig their burrows on well-drained soils. Also, rabbit and marmots burrows are often taken over by foxes. The same den is often used over a number of generations. Pathways throughout the home range connect the main den with other resting sites, favoured hunting grounds and food storage areas (Lloyd, 1981).

Red foxes are essentially omnivores. They feed on a wide group of prey and food spectrum, mostly eating rodents, rabbits, insects and fruits (Macdonald, D.W. & Reynolds, J.C. 2008; Nowak, 1991; Wilson and Reeder, 2005). Since they are considered an opportunistic feeder, they will also eat carrion. In addition, they are known to store food and are very good at relocating these caches. Even thought they have a wide food spectrum, leporids, especially the rabbit, may be one of the most important food resource. The red fox is also a regular visitor to caves and rock shelters, where they may consume leftovers and leave scats (Lloveras et al., 2012a).

Research papers focused on red foxes as leporid accumulators are scarce (Cochard, 2004b; Lloveras et al., 2012a; Sanchis, 2000). According to these studies it can be expected to find differences between leporid remains accumulated from scats and non-ingested remains. Results obtained by Lloveras et al. (2012a) show that scatological samples are characterized by:

- A high percentage of adult individuals.

- Skeletal elements with the higher values of relative abundance (RA%) were cranial elements, long bones and scapulae. It is more likely to find proximal limbs elements and more hindlimbs.

- One can observe a 12% of complete bones. The average length of recovered specimens was 9.3 mm and a 61% of remains were under 10 mm.

- Remains are characterized by digestion damage to the bone. A total of 99.5 of the remains were affected by digestion, mostly on a heavy degree of damage.

- Only 3% of the sample presents teeth marks.

On the other hand, accumulations of non-ingested remains are characterized (Cochard, 2004b; Lloveras et al., 2012a; Sanchis, 2000) by:

- A scarce number of axial skeleton remains and a high frequency of distal hind limbs elements. Skeletal elements with the higher values of relative abundance (RA%) are metatarsal bones, calcanei, astragali and tibiae. It is more likely to find postcranial elements that comprise the distal limbs and hindlimbs.

- Also, non-ingested remains show less fragmentation and more complete bones with a mean value total of 89.4%, an average length of 19.3 mm and 28% of remains are under 10 mm.

- Obviously, non-ingested remains are characterized mostly by null presence of digestion damage.

- Abundance of tooth marks, up to 19% of the sample shows damage on the bone surface caused by teeth. Around 5% of bones display tooth pits and/or punctures.

Since scat remains (in the wild or captivity) seem to be scarcer than the non-ingested ones, we can assume that, on archaeological sites, it is more likely to recover skeletal element from leftovers or mixed origin than scats.

Iberian lynx, *Lynx pardinus* (Temminck, 1827)

The Iberian lynx is a top predator endemic to the Iberian Peninsula. Their historical range is restricted to, primarily, the southwestern region of Spain and much of Portugal. However, a study of mitochondrial DNA from fossil remains (Rodríguez-Varela et al., 2015), suggests the Iberian lynx had a wider range during the Late Pleistocene and Holocene, including the entire Iberian Peninsula, northern Italy and southern France. Their geographic range has contracted at an alarming rate over the last century and it is considered one of the world's most threatened felid. A century ago, the species was still present in northern Iberia and maintained relatively high densities in the south. Within fifty years, they had become nearly extinct in the north and were rapidly declining in the south (Delibes et al., 2000; Delibes, 2009; Ferreras et al., 2004; Sarmento et al., 2008).

This predator requires variable terrain below 1300 m, containing a mosaic of closed Mediterranean scrubland interspersed with open patches of grassland, often with marsh ecotones. This natural mosaic landscape creates the optimal balance of shrub cover and open space since they use areas of scrubland as shelter, as well as for bedding and breeding. Areas with minimal cover provide habitat for their primary prey. The decline of the lynx population has been primarily caused by habitat loss and a decline of their main prey species, the European rabbit with the spread of the poxvirus, myxomatosis, introduced from South America in the early 1950s and the rabbit haemorrhagic disease in 1980s (Real et al., 2009). In the early years of the epidemic, rabbits virtually disappeared from many areas.

The Iberian lynx is a rabbit specialist; it prefers the European rabbit for the bulk of its diet, approximately 80-100% (Aldama and Delibes, 1991a, 1991b; Calzada and Palomares, 1996; Delibes, 1980; Delibes and Hiraldo, 1981). Studies on the Iberian lynx diet show that rabbits usually accounts for 85 to 100% of their diet, the rest is composed by small prey

like small mammals, birds, reptiles and small ungulates, whose frequency of occurrence is usually less than 1% (Aldama y Delibes, 1991; Calzada, 2000; Calzada and Palomares, 1996 Delibes, 1980; Delibes and Hiraldo, 1981). Although it is considered that most rabbits hunted by the lynx are individuals adults, juvenile individuals may also predated, especially at certain times of the year when they are most abundant. In fact, in a study conducted by Lloveras et al. (2008a) the percentage of immature was clearly higher than adults, reaching more than 78%. Secondary prey (non-rabbit) appears especially during autumn and winter, when the availability of rabbits throughout the annual cycle tends to be minimal. During this time ungulates, for example, can acquire some importance in some areas of Doñana, where young fallow deer (*Dama dama*), which are locally abundant, can reach 5-10% of the biomass in the feline diet (Delibes, 1980; Beltran et al, 1985).

Lynxes are solitary carnivores that exhibit metapopulation social structure. They are nocturnal or crepuscular, with activity peaking around sunset, when prey is most active. Daily activity patterns are linked to those of their primary prey, the European rabbit (Delibes et al., 2000; Ferreras et al., 2004). The lynx and the European rabbit are related at a temporal and spatial scale, since both originated in the Iberian Peninsula at just about the same time (Real et al., 2009). The success of the former depends on the abundance of the latter.

According to the few studies done on remains accumulated by the Iberian lynx (Lloveras et al., 2008b; Rodriguez-Hidalgo et al., 2013, 2015), as occurs with other terrestrial carnivores, the taphonomic signature of the lynx will vary depending on the accumulation origin: non-ingested, scat or mixed remains. Bone remains recovered from scatological samples (Lloveras et al., 2008b) show:

- An abundance of cranium, appendicular skeleton and proximal forelimbs elements. Teeth and cranium elements are the most abundant showing a high rate of survival, with a mean value total of 43%. On the contrary, vertebrae and ribs are poorly represented.

- There are a high percentage of fragmented remains with an average length of 7.1 mm and an 80% of elements under 10 mm.

- Bone surface damage in form of digestion is present in 97.2% of the remains most displaying a high degree of damage.

- Only a 0.3% of remains show bone surface damage caused by teeth.

Results obtained for non-ingested remains are clearly different, complementary in fact (Rodriguez-Hidalgo et al., 2013; 2015); we can see:

- A prevalence of postcranial elements. Abundance of distal and hind limbs elements, specifically elements such as: tibiae, metatarsals, calcaneus and astragali. Vertebrae and ribs are poorly represented.

- The range of complete elements is 73.2 – 94.9%, with an average length of 16.7 mm and a range of 19.7 to 81.3% of remains under 10 mm.

- Bones affected by tooth marks are scarce, only 0.9 to 1.8% of remains with this type of damage.

<u>European wildcat, *Felis silvestris sivestris*</u> (Schreber, 1777)

Wild cats are found throughout continental Europe, southwestern Asia, China, Mongolia and the savannah regions of Africa (García-Perea, 2007). European wildcats present a rather fragmented geographic distribution, ranging from the Iberian Peninsula to the eastern part of the continent (Stahl and Artois, 1991; Sunquist and Sunquist, 2002). They are found primarily in deciduous forests but they may use also coniferous forests as marginal habitats. They are restricted in their northern distribution by snow depth and are typically found in areas of low human populations. They are known from human dominated landscapes where grazing is the dominant form of agriculture and, therefore, land use is not intensive. They are also known from scrublands, riparian habitats, and coastal areas.

The wildcat's primary preys are small rodents followed by birds, dormice and insects; however, rabbits may be the preferred prey in some areas (Condé et al., 1972; Gil-Sánchez et al., 1999; Sunquist and Sunquist, 2002; Malo et al., 2004; Lozano et al., 2006; Lozano, 2008). The wildcat will pursue prey atop trees, even jumping from one branch to another. On the ground, it lies in wait for prey, and then catches it by executing a few leaps, which can span three meters. When hunting rabbits, it has been observed to wait above the warrens for their prey to emerge. Although primarily a solitary predator, the wildcat has been known to hunt in pairs or in family groups, with each cat devoted entirely to listening, stalking, or pouncing (Nowak, 1991).

Fossil remains of the wildcat are common in cave deposits dating since the Middle Pleistocene 250 ky ago raising the possibility of them being active leporid accumulators in caves and shelters shared with others non-human predators and humans. Up until now, only recent taphonomic studies on leporids consumed by the European wildcat have been conducted (Lloveras et al., 2015). The results for this first study on the European wildcat taphonomic signature demonstrates that the rabbit accumulation produced by this predator may differ significaly depending on its origin (non-ingested remains or scats). According to this research, the European wildcat removes a specific numbers of skeletal remains during feeding, with parts of the carcasses remaining unconsumed. It means that such behaviour can generate important accumulations of non-ingested remains and few bones will come from scats. Scat assemblages are characterized by:

- An abundance of scapulae.
- A prevalence of postcranial elements and forelimbs.
- High frequencies of fragmented bone; with a mean value total of 11.5% of complete elements, a maximum length of 11.4 mm and 98.8% of remains under 10 mm.
- 98.6% of the remains suffered from bone surface damage ranging from null to an extreme degree of digestion.
- As a consequence of the high degree of breakage and digestion damage, tooth marks were not found.

On the other hand, non-ingested remains accumulations appear to be characterized by:

- Skeletal elements with the higher values of relative abundance (RA%) were cranial elements, metatarsals and calcanei. There is a prevalence of cranial elements and distal and hindlimbs elements. Scapulae, ribs, humerus, and vertebrae are poorly represented.

- There are a high percentage of complete elements with a mean total value of 92.3%, an average length of 138.2 mm, and 35% of elements are under 10 mm.

- 97.2% of the remains suffered from bone surface damage being most of them affected by an extreme degree of digestion damage.

- Teeth marks are scarce (1.2%).

4.2.1.2. Raptors

Many different types of birds kill in order to eat. Some eat rodents; others eat fish, worms or other living creatures. However, birds that use their beaks in order to hunt do not necessarily fall into the category of birds of prey. The birds of prey, also known as "raptors", are characterized by keen vision that allows them to detect prey during flight, and powerful talons (for catching, killing or holding prey) and strong curved beaks (for tearing flesh). Raptors generally prey on vertebrates, which are usually quite large relative to the size of the bird. Most of them, for example vultures and condors, also eat carrion, at least occasionally. Since they lack a masticatory apparatus for chewing their prey, they have to dismember, tear up into small pieces, and then swallow the meat and bones; producing breakage, shearing and punctures marks on the bone (Perrins and Middleton, 1984). Once inside the animal's digestive system, gastric juices can cause even more damage and bone surface alterations such as pits or polish bone (Hockett, 1991, 1995).

Subsequently, bone remains along with undigested tissue, like fur and feathers, are regurgitated into the form of pellets. These birds may sleep or raise their young in caves and rock shelters leaving pellets and prey leftovers.

Raptors are divided into two main groups, the diurnal (day flying) and the nocturnal (night flying) birds of prey. Each on them is capable of accumulating bone remains from pellets and non-ingested remains, on nest and feeding stations.

4.2.1.2.1. Diurnal raptors

Raptors in this category include four families: Accipitridae (hawks, eagles, buzzards, harriers, kites and old world vultures), Pandionidae (the osprey), Sagittariidae (the secretary bird), and Falconidae (falcons and caracaras). In more o less frequent form, over 12 species prey upon leporids. Among the species present in the Iberian Peninsula, the Spanish Imperial Eagle, the Golden Eagle, Bonelli's Eagle and the Egyptian Vulture are the principal leporid remains accumulators, as this type of small prey constitute approximately 57 to 70% of their diet (Delibes and Hiraldo, 1981).

Spanish Imperial Eagle, *Aquila adalberti* (Brehm, 1861)

The Spanish Imperial Eagle is a threatened species that is present only in central and Southwest Spain, and adjacent areas of Portugal. It was considered to be a subspecies of the Eastern Imperial Eagle, but is now widely recognized as a separate species. It is present in alluvial plains and dunes in the Guadalquivir marshes, plains and hills in central Spain, and high mountain slopes and other areas of Portugal, where there is an absence of irrigated farmland. Their distributions, population density, range, and reproductive performance is influenced by the abundance of its main prey, the European rabbit (Fernández *et al.* 2009). Its evolutionary dependence on rabbits has been suggested as permanently limiting its abundance and distribution (Ferrer and Negro 2004), although a recent study has suggested the species exhibits a certain dietary plasticity, at least during the non-breeding season, adapting its diet when rabbits are scarce (Sánchez *et al.* 2008). Data from Doñana National Park in Spain show that the most important variables explaining nest site selection are height of tree and distance from human activity (Bisson *et al*. 2002). Many recently colonized territories are in marginal areas, and several of the occupying pairs include at least one sub-adult bird (González and Oria 2004, González *et al*. 2006b, Margalida *et al*. 2007).

At the moment there is only one study on the Spanish Imperial Eagle's taphonomic signatures, using bone remains recovered from 79 pellets of captive individuals in Toledo, Spain (Lloveras et al., 2008b). According to Lloveras et al. (2008b), the Spanish Imperial Eagle produces:

- Skeletal elements with the higher values of relative abundance (RA%) were third phalanges, upper molars and tibia. There is a prevalence of cranial elements, abundance in distal elements, and hindlimbs elements. Ribs, femora, and radius elements are poorly represented.

- The mean total value of complete elements is 27%, an average length of 8.4 mm was recorded and 73% of elements were under 10 mm.

- 98% of the remains suffered from digestion damage and 0.5% of beak marks.

Golden Eagle, *Aquila chrysaetos* (Linnaeus, 1758)

The Golden Eagle is one of the most widely distributed species of eagle. This species is exclusive from the Northern Hemisphere, with a Holarctic distribution (Arroyo, 2003, 2004; Del Hoyo et al., 1994; Sánchez-Zapata et al., 2010; Watson, 2010) it has disappeared from many areas that are now more heavily populated by humans (Tapia et al., 2007). The species is found everywhere, being present in sizeable stretches of Eurasia, North America, and parts of North Africa (Kochert et al., 2002; Watson, 2010). They are found in open and semi-open habitats from sea level to more than 3600 m elevation. Habitat types that they inhabit include tundra, shrublands, grasslands, woodland-brushlands, and coniferous forests. Most golden eagles are found in mountainous areas, but they also nest in wetland, riparian and estuarine habitats. Their diet is very broad, often preying upon

small mammals such as rabbits, hares, squirrels, prairie dogs and marmots, but they also prey on birds, reptiles and fish in smaller numbers. Golden eagles occasionally capture large prey; they have also been known to capture large flying birds such as geese or cranes. Also can carry up to 3.6 kg during flight. A pair of eagles will often hunt together;

one chasing the prey to exhaustion, and the other swoops down for the kill (Kochert et al., 2002; Watson, 2010).

In Europe, the Golden eagle is scarce, while in Spain it is considered an endangered species (Arroyo, 2003, 2004). In the Iberian Peninsula it occupies the main mountain systems with numerous populations in the Iberian System, the Betic mountain range, the Sierra Morena and the Pyrenees (Arroyo, 2003, 2004), with a special preference for open landscapes avoiding heavily forested areas (Arroyo, 2003, 2004; Tucker and Evans, 1997). In Mediterranean habitats, the European rabbit (*Oryctolagus cuniculus*) tends to be its main food resource comprising the 30-65% of its prey (Delibes et al., 1975; Fernández and Purroy, 1990; Sánchez-Zapata et al., 2010).

Golden eagles typically build several eyries within their territory and use them alternately for several years. Their nesting areas are characterized by the extreme regularity of the nest spacing. They seem to prefer to build their nests on cliffs where they are available. These are generally located at around half of the maximum elevation of the surrounding land; this height preference may be related to having the ability to transport heavy prey downhill rather than uphill. A massive benefit to cliff nests is that they tend to be largely or entirely inaccessible to mammalian predators on foot, including humans (Watson, 2010). In Spain, studies revealed the preferred sites of golden eagle nests were on inaccessible cliffs at a great distance from tracks, roads and villages (Donázar et al., 1989).

Taphonomic research on Golden Eagle's Mediterranean habitat is scarce. The only research on the taphonomic signature of the Golden Eagle has been done by Hockett (1991, 1995, 1996) and Schmitt (1995). According to Hockett's (1991, 1995) studies on leporid remains contained in pellets, such accumulations are characterized by:

- There is a predominance of adult individuals remains.
- A scarcity of cranium elements and mandibles, since Golden eagles tends to decapitate its prey before taking it to the feeding station. Skeletal elements with the higher values of relative abundance (RA%) were vertebrae, calcanei and

innominates, while ribs were poorly represented. There is a prevalence of postcranial elements and abundance in hindlimbs elements.

- A high percentage of fragmentation is present in remains recovered from pellets; an approximate mean value total of complete bones are 0.06%, with a maximum length of 80 mm.

- A significant percentage of remains suffered from digestion damage.

On the other hand, Schmitt (1995) and Hockett (1996) study on non-ingested leporid remains recovered from Golden eagles nests shows:

- There is a predominance of adult individuals remains (Schmitt, 1995), although juvenile individuals are also found (Hockett, 1996).

- A scarcity of cranium elements and scapulae. Skeletal elements with the higher values of relative abundance (RA%) were tibiae, femora, calcanei, astragali, metatarsals, carpal/tarsal, and radius elements. There is a prevalence of postcranial elements, an equal proportion of proximal and distal elements, and abundance in hindlimbs elements.

- A significant percentage of remains suffered from bone surface damage ranging from null to an extreme degree of digestion.

Bonelli's Eagle, *Aquila fasciata* (Vieillot, 1822)

The Bonelli's Eagle forms a super species with the African Hawk Eagle (*Aquila spilogaster)* (Helbig et al., 2005). The African Hawk Eagle was sometimes considered to be just a subspecies of the Bonelli's Eagle but is now considered a separate species. Both species were formerly placed in the Genus *Hieraaetus* but recent research shows that they should now be included in the genus *Aquila*, as both are closely related to the Verreaux's Eagle (*Aquila verreauxii)* (Helbig et al., 2005). Two subspecies have been described: *A. f. fasciata* that occurs over most of the species' range and *A. f. renschi* that can be found on the Lesser Sunda Islands.

This species has a very large range; it is present around the Mediterranean and eastwards in Asia in Iran, Arabia, Oman, Turkmenistan, India, Southern China and Pakistan. In Europe, the Bonelli's Eagle is a bird of the Mediterranean landscape. It prefers open and partially open landscapes, in hilly or mountainous areas, and sparse vegetation. However, its habitat is highly variable, they can be found in rocky, arid to semi-moist habitat, from sea level to 1500m, but up to 3000m in Africa and 3750m in the Himalayan foothills. Outside the breeding season it can also be found in lowlands and wetlands and large water bodies (Ferguson- Lees and Christie, 2001). They can breed once reached the age of three. The adults stay together even outside of the breeding season. The nest is composed of sticks, up to 2m in diameter, located on remote cliff ledges or in a large tree. The nest is re-used in successive years (Ferguson- Lees and Christie, 2001).

The Bonelli's eagle takes a wide range of prey, all taken alive. Rabbits and Red-legged Partridges form an important diet where they occur. Also takes a lot of other birds like pigeons, crows, ducks, gulls and others up to the size of herons (Ferguson- Lees and Christie, 2001). During the summer, lizards are also taken. It is a powerful hunter that is capable of killing large birds like herons or storks.

This bird of prey has been found on remains from Pleistocene deposits in Portugal and Spain (Tyrberg, 2008), raising the possibility that they were also bone accumulation agents in caves and rock shelters (Lloveras et al., 2014). Studies on remains recovered from pellets that were collected from nest show:

- Skeletal elements with the higher values of relative abundance (RA%) cranial elements such as upper molars and mandibles; while ribs, astragali and patellae were poorly represented. There is a prevalence of cranial elements, and abundance of proximal and hindlimbs elements.

- The mean value total of complete bones is 59.6%, with an average maximum length of 19.7 mm, and 78.1% of elements under 10 mm.
- 72% of remains suffered from bone surface damage ranging from null to an extreme degree of digestion and no evidence of beak marks.

It must be noted that non-ingested remains recovered from the nest and its vicinity show (Lloveras et al., 2014):

- Skeletal elements with the higher values of relative abundance (RA%) are cranial elements such as upper molars, and innominates; while mandibles, lower molars and metacarpals were poorly represented. There is also a prevalence of cranial elements, and abundance of proximal and hindlimbs elements.
- The mean value total of complete bones is 86.9%, with an average maximum length of 43.1 mm, and 6.8% of elements under 10 mm.
- 4.1% of remains suffered from beak/talons marks.

<u>Egyptian Vulture, *Neophron percnopterus*</u> (Linnaeus, 1758)

The Egyptian vulture is a small Old World vulture, and it is widely distributed. The Egyptian vulture is found from southwestern Europe and Northern Africa to India, also isolated populations inhabit the Canary and Cape Verde Islands. They are seasonal, spending the winter in North Africa and breeding in Europe in spring (Del Moral, 2009; Lloveras et al., 2014). Egyptian vultures are carnivorous, feeding mostly on carrion, but they are also known to eat insects, small reptiles and mammals, crustaceans, snails, bird eggs, nestlings, and the faeces of larger animals. In areas were they are abundant rabbits form a significant part of its diet (Donázar and Ceballos, 1988; Margalida et al., 2012; Mundy et al., 1992).

Social behaviour of Egyptian vultures varies, depending on available resources. Numerous individuals can be found together, along with immature birds and other carnivores, at preferred feeding locations with abundant resources. The home range of an individual, mating pair, or family group is larger than the territory that it defends and will often include human refuse areas or areas where livestock are held. Egyptian vultures are purely visual hunters and do not use smell to locate food; they seek food mostly in open areas where carcasses can be discovered from a soaring height. Breeding takes place once a year and its timing varies slightly between populations in different regions, but egg laying usually occurs between March and May. They typically nest on ledges, or in rock shelters on cliffs crags and rocky outcrops, but occasionally also in large trees (Jackson et al., 2003; Mundy et al., 1992; Perrins and Middleton, 1984; Sarà and Di Vittorio, 2003).

Over the past few years, research papers on the taphonomic signature of the Egyptian Vulture have been published (Lloveras et al., 2014; Sanchis Serra et al., 2013). Skeletal elements recovered from pellets show:

- 100% of the individuals were adults.
- Skeletal elements with the higher values of relative abundance (RA%) are cranial elements such as mandibles and teeth; while phalanges, carpal/tarsals, long bones and vertebrae were the elements with a lower relative abundance values.
- The mean value total of complete bones is 81.2%; with an average maximum length of 70.1 mm, and 52.4% of elements were under 10 mm.
- 0.8% of the remains suffered from damage caused by digestion while 7.5% show beak/talons marks.

On the other hand, non-ingested remains recovered from nests shows:

- 41.7% of the individuals were adults.

- Skeletal elements with the higher values of relative abundance (RA%) are femora, innominates, radius, ulna and metatarsals; while ribs and cranial elements lower relative abundance values.

- The average maximum length is 46.6 mm and a mean value total of complete bones of 80%.

- 10.4% show beak/talons marks.

4.2.1.2.2. Nocturnal raptors

The owls are members of the order Strigiformes and are classified within the following two families: Strigidae (true owls or typical owls) and Tytonidae (barn owls). The owls are characterized by un-proportionally big heads compared to the size of their short strong bodies, short necks and short tails. Their food includes rabbits, insects and rodents. Unlike diurnal raptors, most of which have excellent peripheral vision due to having their eyes positioned on two sides of the head, the nocturnal owls have, like humans, both of their eyes in front. In the Iberian Peninsula, the Eurasian Eagle Owl or, more commonly, Eagle Owl is one of the principal leporid bone accumulators (Guillem and Martínez-Valle, 1991; Lloveras et al., 2009).

Eagle Owl (Linnaeus, 1758)

The Eagle owl is the largest owl in the world, and they primarily live in the Palearctic region, although they can travel as far south as the Eastern and Ethiopian region, and as far north as Siberia. They are found in North Africa, Europe, the Middle East, and Asia (Mikkola, 1994). They live in a variety of wooded habitats and are more commonly found in areas with rocky outcrops and cliffs, but they also live in open habitats that have some trees, and rocky areas like taiga, farmlands, steppes, semi-arid areas, and grasslands (Mikkola, 1994).

Both sexes are usually solitary but they pair up during courtship. Pairs are formed in early fall and they nest in late January and early February, preferring to nest in crevices between rocks, sheltered cliff ledges, cave entrances, as well as abandoned nests of other large birds. Usually egg laying begins in late winter (Konig et al., 1999). Like many raptors, the Eagle owl is a top predator, as they play an important role in nature by helping to control populations of prey animals and maintain a balance in the ecosystems where they live. They feed on almost anything they can catch including rats, mice, lemmings, beetles, and even large prey like deer fawns and foxes. They will also feed on other birds such as crows, ducks, and even other owls. Dominant prey can vary from habitat to habitat but is most often small rodents (Hiraldo et al., 1975; Lourenço, 2006; Mikkola, 1994; Serrano, 1998). In Mediterranean areas it depends heavily in leporids, especially on the European rabbit, which constitute between 23-62% of their diet (Donázar, 1989; Hiraldo et al., 1975; Lourenço, 2006; Mikkola, 1983; Pérez Mellado, 1980; Serrano, 1998).

Analysis of modern bone assemblages produced by the Eagle owl has been done in the past few years (Andrews, 1990; Bochenski et al., 1993; Cochard, 2004a; Guillem and Martínez-Valle, 1991; Hockett, 1995; Hoffman, 1988; Lloveras et al., 2009a, 2012; Sanchis, 2000; Yravedra, 2004). Variability may occur depending on the origin of the accumulation; variables such as anatomical representation, breakage and damage to the bone surface cause by digestion are expected to be different in an assemblage (pellets and non-ingested remains) accumulated in nests that the ones concentrated in roosting platforms.

According to Lloveras et al. (2009a, 2012), variables related to the anatomical representation, breakage patterns and digestion can be use to identify the taphonomic signature of the Eagle owl in remains accumulated in nests. Accumulation of mixed origin (degraded pellets and non-ingested remains) are characterized by:

- Around 50% of adult individuals.
- A high relative abundance (RA%) of patellae, calcanei, innominates, femora, tibia and metatarsal bones, while metacarpals, carpal/tarsals, and radius elements are

less represented. Abundance of postcranial elements, a loss of distal elements, and presence of hindlimbs elements.

- The mean value total of complete bones ranges between 53 to 46%, with a maximum average length between 14.1 – 14.8 mm, and a 40 – 49% of elements under 10 mm.
- A 65 to 69% of the sample suffers from surface damage caused by digestion, most affected by a light and moderate degrees of damage.
- 1.3 to 2 % of the remains show beak/talons marks.

4.2.2. Anthropic accumulations

As already said, leporids, especially European rabbit, occupied an important position in the Iberian food chain since the coldest phases of the Pleistocene (Delibes and Hiraldo, 1981). They also constituted an important food resource to human populations through out time, mainly in the Upper Paleolithic and Epipaleolithic (Aura et al., 2002; Brugal, 2006; Cochard and Brugal, 2004; Hockett, 2000; Hockett and Haws, 2002; Jones, 2006; Lloveras et al., 2010, 2011, 2016; Martínez-Valle, 1996; Sanchis Serra and Fernández Peris, 2008). From capturing to the processing of leporid carcasses, the human being consequently leaves marks or signature patterns (Binford, 1981). Bearing this in mind, some authors have proposed a methodology that analyses specific variables in order to discriminate between human and non-human accumulations. This criteria, that was earlier applied to the study of macrofaunal remains (Binford, 1981; Lyman, 1994) and it has been modified and consequently applied to the study of leporids (Aura Tortosa el al., 2002; Bicho et al., 2006; Brugal, 2006; Charles and Jacobi, 1994; Cochard, 2004a; Guennouni, 2001; Hockett and Bicho, 2000; Hockett and Haws, 2002; Lloveras et al., 2009b, 2010, 2011, 2016; Pérez Ripoll, 1993; Sanchis Serra and Fernández Peris, 2008; Villaverde et al., 1996; among others). The following features characterize an anthropic accumulation:

a. *Spatial distribution*

In anthropic accumulations one can expect to find a spatial concentration of remains associated with the presence of lithic industry, surely as consequence of certain spaces been used as dumping sites of bone waste and worn tools after processing the animal carcasses. Also, bone material can be associated with combustion structures such as hearths (Bicho et al., 2006; Hockett & Bicho, 2000; Payne, 1983). One can observe that leporid remains resulting from human consumption are related to human activity, presenting a minor dispersion of the remains as opposite to the ones found in accumulations created by non-human predators (Vigne & Balasse, 2004).

b. *Representation of age classes*

In anthropic assemblages, high values of adults and sub-adult individuals are to be expected, often exceeding the 85% (Brugal, 2006; Cochard, 2004b; Guennouni, 2001; Hockett; 1991; Hockett and Ferreira Bicho, 2000; Rillardon and Brugal, 2014). Adults and sub-adult individuals normally are the most abundant since they tend to be bigger and fleshy. This characteristic has been observed trough different geographic zones and periods (Brugal, 2006; Cochard, 2004a; Hockett & Bicho, 2000; Lloveras et al., 2016). Since adult individuals are bigger and provide more resources than immature individuals, one can assume this difference is due to prey selection (Charles and Jacobi, 1994), either for its energetic return or pelt exploitation. The representation of age classes is also related to hunting techniques (Cochard, 2004a; Jones, 2006): individual or mass collection. Rabbits breed from the months of January to August, with an approximate total of 60 individual per warren during this time (Delibes and Hiraldo, 1981), and are most exclusively inhabited by females of reproductive age and new born kittens, while rabbits scattered around the landscape, in proximity, are adult males. According to Jones (2006), an age profile for individual hunting should be predominantly adult (> 2 years) males, while a warren (mass collection) generated assemblage should be predominantly adult females and young individuals (< 1 month). Maybe because of mass collection, anthropic assemblages with lower percentage of adults (around 50-60%) have also been noted (Martínez-Valle, 1996; Sanchis Serra and Fernández Peris, 2008). Besides, it must be taken into consideration that a high proportion of adult individuals is also a factor present in other non-human predators accumulations (Lloveras et al., 2012a, 2016).

c. Skeletal representation

Based on work done with archaeological leporid accumulations, Cochard (2004) identifies few parameters common in anthropic assemblages: a) abundance of long bones and innominates, b) a balance between proportions of forelimbs and hind limbs, even though some archaeological sites show a higher proportion of hind limbs, c) mandibles are well represented, d) elements that constitute the axial skeleton are not well represented, and e) some assemblages are characterized by a low proportion of autopodium (metacarpals, metatarsals, carpal/tarsal, phalanges, calcanei and astragali) elements. Differences in

proportion, if not caused by bone conservation (Brugal, 2006; Hockett, 1995; Hockett and Haws, 2002), might be the result of:

- Selective transport between the place of capture and the place were the carcasses were been processed.
- Differential treatment between skeletal elements such as the grinding of vertebrae and ribs, or the extraction of bone marrow.
- Selective refusal of parts with less meat.
- Loss of skeletal elements as a consequence of animal scavenging.

d. Degree of breakage

Breakage in an anthropic leporid accumulation is subjected to variability. That is why some authors (Dodson and Wexlar, 1979) proposed that a way to value breakage patterns is to calculate the number of determined remains (NDR) and minimal number of elements (MNE), and to value how both calculations are related to the breakage categories of the recovered remains.

Normally, breakage is assessed based on breakage degree of long bones and if fractures occur due to marrow extraction; a procedure in which the epiphysis of the long bones are fractured to extract, i. e. by suctioning the marrow through one end, resulting in shaft cylinders. Many of the resulting bone shafts come from tibiae since it is one of the most resistant bones. Also, since bone tend to be fractured in order to extract the bone marrow, it is very common to find lone epiphysis fragments among the assemblage. After experimental research on long bone fragmentation (Cochard, 2004; Pérez Ripoll, 1993; Sanchis et al. 2011) differences between types of fractures (flexion, percussion and by bite) have been established:

- Breakage by flexion can cause curve and spiral fractures.
- Breakage by percussion can cause deep notches along the impact surface.
- Breakage caused by bite show characteristic notches left by the imprint of teeth.

According to several studies (Aura Tortosa et al., 2002; Brugal, 2006; Cochard, 2004; Hockett, 1991; Hockett and Bicho, 2000; Hockett and Haws, 2002; Ibánez and Saladié, 2004; Lloveras et al., 2016; Pérez Ripoll, 1993; Sanchis Serra and Fernández Peris, 2008; Schmitt and Lupo, 1995) the presence of shaft cylinders in anthropic sites accounts by more than 5% of long bone fragments.

e. Cut marks

Cut marks left in the bone surface by the action of lithic tools are most important, as they are a clear indication of human activity. They are mostly related to the processing of the animal carcasses (evisceration, skinning, disarticulation and defleshing) as a food resource (Binford, 1981). Most researchers (Domínguez-Rodrigo, 1997; Lupo and O' Connell, 2002; Selvaggio, 1994; among many others) have focused in big and medium sized animals, since cut marks on small animals tend to be less common, although there is multiple evidence in archaeological deposits. Experimental research on anthropic marks (Lloveras et al., 2009) show:

- The use of lithic tools can or may not leave marks at all. Traces left by lithic tools may vary in frequency and location.
- When skinning a rabbit, cranium and mandible elements may display a high frequency of marks (usually transverse), mostly in the incisive and nasal bones.
- In the process of disarticulating a carcass, most marks are located in vertebrae, innominate, especially the isquium and acetabulum, proximal epiphysis of the femur and distal epiphysis of the tibia; the marks are usually transverse and oblique. If feet are separated, metapodials, calcaneum and astragalus also display high frequency of marks.
- When defleshing, fewer marks are produce since this procedure involves pulling off chunks of muscle packs from the bone. These types of marks are often seen on vertebrae and ribs and innominate (isquium and acetabulum); marks are oblique and longitudinal.

f. Burnt marks

According to Shipman et al. (1984), thermo-altered bones suffer loss of water content, carbonate and minerals. Based on archaeological and experimental research (Snoeck et al., 2014) authors have found correlation between temperature and colour, which indicates that colour changes progressively with an increase in temperature.

Recovery of meat on fresh carcasses for human consumption is also characterized by the presence of burned bones. The most usual thing among anthropic leporid remains are burnt marks in specific parts of the bone, particularly in the distal ends of long bones produced upon contact with fire (Lloveras et al., 2009b). It is also common to find incinerated bones associated to hearths structures, which has been toss to clean the area (Shipman et al., 1984; Stiner and Kuhn, 1995; Stiner et al., 2001; Thompson et al., 2011).

According to Cochard (2004) burnt bones in anthropic accumulations range between 5-40%. It must be taken into account that burnt remains are not always an indicative of human activity as natural fires and other sources of heat can affect sediments were the remains are buried.

g. Tooth marks

Another evidence of human activity within an archaeological site are tooth marks, although it should be noted the difficulty in trying to distinguish between human tooth marks and carnivores tooth marks, despite of experimental research done on characterizing human teeth marks (Elkin and Mondini, 2001; Fernández-Jalvo and Andrews, 2010; Landt, 2007; Laroulandie, 2001; Lloveras et al., 2009b; Romero et al., 2016; Pérez Ripoll; 1992; Saladié et al. 2013; Sanchis Serra et al., 2011). The most common damage caused by human teeth relates to the removal of minimal to moderate amounts of cancellous bone tissue (e.g. removal of trochanter or ends of ribs) (Landt, 2007) and to bone breakage for marrow consumption (Sanchis Serra et al., 2011). According to Perez Ripoll (1992), who analyse human tooth marks left when biting rabbit bones to extract the marrow, this type of fracture leaves a double notch imprint, in opposing sides of the bones due to the pressure of upper and lower teeth. Gnawing, in the form of scoring with transversal orientation, produce by the incisors is also present. In his experimental research of butchery, cooking and human consumption marks left in rabbit bones, Lloveras et al. (2009b) recorded that bones recovered after consumption show low frequency of marks.

PART II:

EXPERIMENTAL RESEARCH AND TAPHONOMICAL ANALYSIS

PART II. A

EXPERIMENTAL RESEARCH

This part consist of the applied methodology, materials, results, discussion and conclusions of two experimental studies done to improve our understanding and the evolution of site formation processes in order to ease the taphonomic analysis of the archaeological sample discussed in this dissertation. During the microscopic analysis of the archaeological leporid assemblage from Balma del Gai, Cova de la Guineu and Font Voltada, we stumbled upon some remains that show bone surface alterations that were difficult to identified.

We came across with skeletal elements that presented, what appear to be transversal and parallel marks, accompanied by bone loss. Elements that present this type of marks were long bones, such as femurs and tibiae, and calcanei. For this matter, we performed three rounds of experimentation between March, April and November 2014. Chapter 5 present the results of our experimental study, with the objective to clarify the origin of cut marks located in archaeological appendicular bones of European rabbit (*Oryctolagus cuniculus*). The results will help to discriminate, through type, number, intensity, location and dimension of the marks, the activities perform in bone: removing the muscle packs, tendons and scraping the cortical bone.

Also, due to the high incidence of burnt bones, and the presence of peculiar colorations, possibly caused by diagenetic factors, a decision was made to analyse a small sample, of each archaeological site included in this dissertation, using the Fourier transform infrared spectroscopy (FTIR), and then contrast it with modern samples burned at different temperatures for 2 hours.. Chapter 6 includes the results of our experimental study on burnt marks with the objective of clarifying if a “burnt sample” from each of the archaeological leporid assemblages included in this dissertation were indeed burnt or if the presence of burnt colourations might have been caused by diagenetic processes, mineral dyes or sedimentation processes.

CHAPTER 5

TOWARDS THE CHARACTERIZATION OF DIFFERENT BUTCHERY ACTIVITIES ON LEPORID CARCASSES THROUGH EXPERIMENTAL STUDIES.

5.1. INTRODUCTION

Leporids, and especially the European rabbit (*Oryctolagus cuniculus*) are small mammals whose remains constitute one of the most abundant taxa among faunal assemblages in most Paleolithic and Epipaleolithic archaeological sites in the Iberian Peninsula (Aura et al., 2002; Hockett and Haws, 2002). The reason behind this abundance may vary. First, the substantial introduction of leporids into the human diet from the Upper Paleolithic is interpreted as an indication of diet widening by many authors (Aura et al., 2002, 2009; Hockett and Haws, 2002; Stiner and Munro, 2002; Pérez Ripoll, 2001; Villaverde et al., 1996). Such trend is revealed by the presence of cut marks and other anthropogenic evidences (Aura et al., 2002; Cochard and Brugal, 2004; Hockett and Haws, 2002; Pérez Ripoll, 1992, 2001, 2004, 2005; Villaverde et al., 1996). Second, rabbits are considered a key stone species, being the favourite prey among a large number of predators, especially diurnal and nocturnal raptors, and small terrestrial carnivores, and since human and all these predators are known to coexist and occupy the same habitation spaces, it is important to researchers to be able to distinguish between the taphonomic signatures for each accumulating agent. Third, it is worth bearing in mind rabbit's behaviour consisting on digging complex burrow systems called warrens and live underground, which means that some remains might be of intrusive origin to the ones found in archaeological levels.

Thus, considering that archaeological leporid bone remains may display a variety of imprints or marks, whose origin varies and may respond to the actions of different accumulating agents, it is imperative to study those factors that modify and alter the bone surface. For these reasons it is important to be able to detect different types of butchery marks, as they are a clear evidence of anthropogenic activities (Bromage & Boyde, 1984; de Juana et al., 2010; Domínguez-Rodrigo et al., 2009; Fernández-Jalvo & Cáceres, 2010; Lloveras et al., 2009; Pérez Ripoll, 1992; 2001; 2002; 2004; Shipman & Rose, 1984; Walker & Long, 1977).

Butchery marks on leporid carcasses have been analysed in very few experimental studies (Charles & Jacobi, 1994; Lloveras et al., 2009). Pérez Ripoll also studied different types of marks from the observations made on archaeological leporid assemblages (1992, 2001, 2004, 2005). However, the different types of cut marks that can be produced as consequence of diverse activities of the butchering process (skinning, disarticulation, defleshing, bone scraping) are not still well known. Besides, sometimes we may find marks of non-anthropogenic origin that can mimic cut marks and are difficult to distinguish. This is the case, for instance, of trampling marks, which have been addressed in several studies on large prey (Dominguez-Rodrigo et al., 2009; Shipman & Rose, 1984) but are not easy to discriminate yet. It is also known that some scavengers, such as the case of small rodents, may produce some kind of modifications close to "cut marks" when gnawing bones to sharp their teeth (Lyman, 1994; Reitz & Wing, 2008). All these facts set a complex scenario where different agents may be implicated. As consequence, when dealing with archaeological materials we often see marks that do not match well any characteristics defined in existing experimental studies, and we don't know at which point they may be considered butchery marks or if they are caused by other taphonomic agents.

As an example, this is the case of some bone surface alterations detected on the archaeological leporid assemblage from three Epipaleolithic sites from the Northeast of the Iberian Peninsula (Cova de la Guineu, Font Voltada and Balma del Gai), analysed as part of the first author's PhD dissertation (NRM). Some rabbit bones in these samples (mainly l ong bones, such as femurs and tibiae, and calcanei) show bone surface alterations that are difficult to identify. We came across skeletal elements that presented, what appear to be transversal and parallel marks, some accompanied by bone loss (Fig. 5.1) and difficult to certainly attribute to a particular anthropogenic activity.

With all this in mind, an experimental research was conducted to deepen into the taphonomic signature resulting from butchering activities on rabbit bones. Our goal is to assess marks related to specific butchering activities conducted in different conditions. The experimentation was focused on the premise of expanding our knowledge on marks produced when defleshing and scraping the surface of limb bones with a lithic tool in order to separate flesh and soft tissue from bone.

The objectives for this experimental study are: (1) to describe and analyse traces left on bone during the stages of defleshing and scraping meat out of the bone, in various levels of meat preservation (fresh and dried); (2) to asses the taphonomic signature resulting from such anthropogenic activities; and (3) to provide information that will help us understand the procurement and processing strategies used by prehistoric population.

5.2. MATERIALS

In total, eight European rabbits were butchered by the authors with the aid of 12 unretouched flint flakes. Rabbits were skinned and disarticulated in order to separate the skeletal portions in which we were interested: forelimbs, hindlimbs, scapulae and innominate (Fig. 5.2a). On the whole, a total of 29 limbs: 15 forelimbs and 14 hindimbs, and 13 scapulae, and 9 innominate (Table 5.1) were used. Three rounds of experimentation were conducted between March, April, and November 2014. In the first round, the material consisted on fresh forelimbs, hindlimbs, scapulae, and innominate corresponding to five rabbits.

For the second round of experimentation, as we wanted to assess the influence of different levels of meat preservation, two fresh limbs and two dried limbs were used. One forelimb and hindlimb were dried with salt and exposed to the sun for 7 days. The fresh and the dried limbs were weighted; a reduction in size and weight was recorded for the two limbs that were dried, a reduction in water content due to the salt caused a volume reduction in the muscle packages as well. It also causes the meat to attach firmly to the bone, especially in the case of the tibia (Fig. 5.2b, 5.2c).

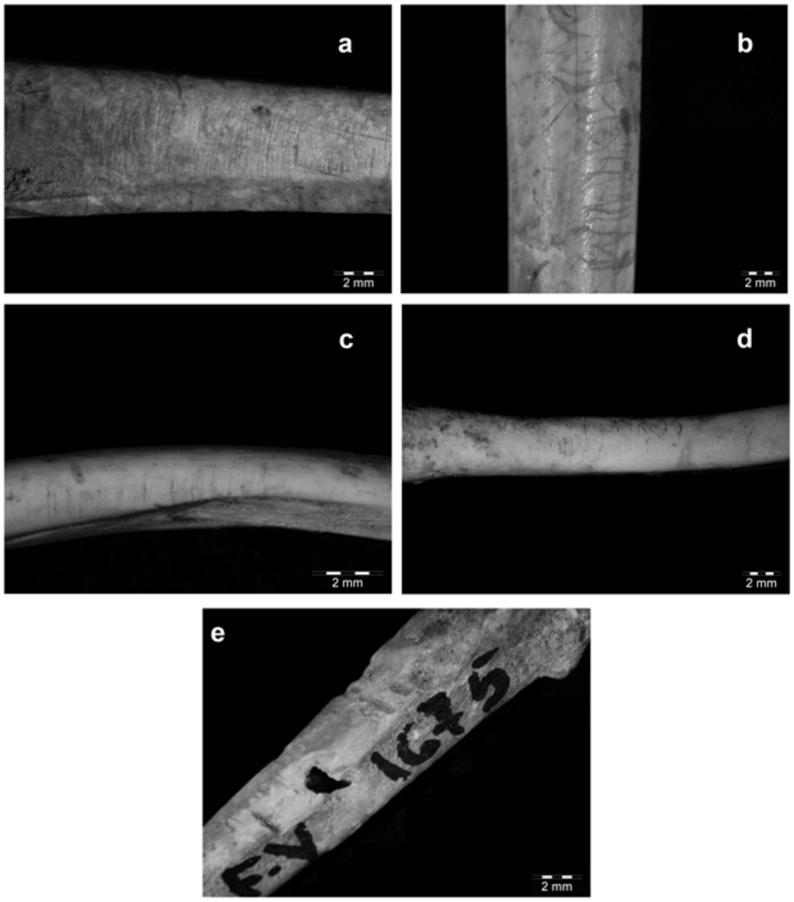

Figure 5.1. Traces observed in archaeological leporid remains from the Northeast of the Iberian Peninsula: (a - c) tibia, femur and radius, respectively, from the archaeological site of Balma del Gai (Moià, Barcelona); (d) radius from Cova de la Guineu (Font-Rubí, Barcelona); (e) ulna from Font Voltada (Montbrió de la Marca, Conca de Barberá).

In the last round of experimentation, one dried forelimb and two dried hindlimbs, a roasted forelimb, and a rehydrated forelimb were used. As in the previous round, rabbit legs were dried with salt and exposure to the sun for 7 days (Fig. 5.2d). One of the dry limbs was rehydrated submerging it in water for 2 hours before the experimentation. A fourth limb was roasted using a grill.

5. 3. METHOD

The study is focused on the analysis of damage caused during the carcasses processing, specifically marks caused by three activities: defleshing, scraping off meat out of the bone, and Achilles tendons removal.

5.3.1. Butchery

The whole rabbit specimens were butchered positioned on their backs on a laboratory table. They were skinned, eviscerated and disarticulated in raw with the aid of lithic tools. Even thought our study focus on traces left by the activities of defleshing and scraping soft tissue off the bone, two disarticulation stages were established in order to ease the identification of marks: a) *Stage 1*- forelimbs and hind limbs were separated from the trunk; forelimbs were detached cutting the muscles around the scapula, while hind limbs were removed cutting through the articulation of the femur head and acetabulum, and b) *Stage 2*- innominate was removed cutting through the vertebrae and femur head. As mentioned above the butchery activities considered were:

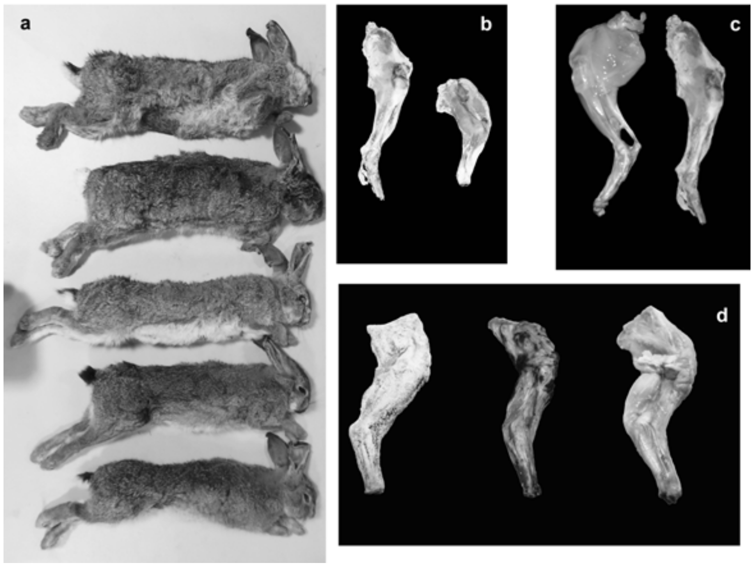

Figure 5.2. (a) Five whole individuals of *Orytolagus cuniculus* used in the experiment conducted on March 2014, (b – c) Two dry and two fresh limbs used in the experiment conducted on April 2014, and (d) Dried, roasted and rehydrated limbs used in the experiment conducted on November 2014.

Table 5.1. Total number of limbs, scapulae and innominates used for each category.

	Forelimbs	Hindlimbs	Scapulae	Innominates
Fresh	11	11	10	8
Dry	2	3	1	1
Roasted	1	0	1	0
Rehydrated	1	0	1	0
TOTAL	15	14	13	9

a. Defleshing- this task consisted in the removal of meat from the bones. For this activity muscle packs were removed whenever possible by pulling up the meat and then cutting. Twenty-two limbs, ten scapulae and eight innominate were defleshed in raw; five limbs, one scapulae and one innominate were defleshed dry; one rehydrated limb and scapula; and another limb and scapula were defleshed roasted. Dried material was used to assess the possibility that some marks (multiple transverse and parallel markings) observed on archaeological materials could be the result of cutting out the flesh with a sawing motion, while sliding thought the bone.

b. Scraping- every attempt was made to scrape down all of the flesh and soft tissue out the scapulae, tibia, femur, humerus, radius, and ulna bones (fresh) by sliding the lithic tool in a downward motion (longitudinal orientation) perpendicular through the bone surface. This activity was conducted only on elements with fresh meat in order to recover small portions of meat adhered to the bone.

c. Tendons removal- every attempt was made to scrape down the calcanei of two individual (four fresh hindlimbs) in order to remove tendons from the bone.

5.3.2. Sample preparation and analysis

Once the experiment was concluded, the bones were boiled for approximately one hour to facilitate the removal of any remaining soft tissue. After that, they were washed with water

and let to dry. Our analysis follows the same methodology applied in a previous experimental study on butchery marks on rabbit bones (Lloveras et al., 2009). Cut marks were identified under a light microscope (x10- x45), counted and recorded according to skeletal element, section and side of the bone.

Three types of cut marks were identified (Binford, 1981; Pérez Ripoll, 1992; Potts & Shipman, 1981, Shipman & Rose, 1983; Shipman et a., 1984):

- *Incisions*- defined as thin V shaped grooves with variable depth, width and length. Such traces occur when the edge of the lithic tool is oriented in the same direction as the cut marks.

- *Sawing marks*- defined as short incisions in zigzag pattern, corresponding to the repeated movement in which the edge of the lithic tool remains in continuous contact with the bone surface.

- *Scrape marks*- defined as shallow and wide striae that run lengthwise, in an up to downward movement.

Cut marks depth was classified as: (a) s*uperficial*- very light damage which is hard to see without the need of a microscope, (b) *moderate*- damage cause by the edge of the lithic tool penetrating into cortical bone leaving a visible mark, and (c) *strong*- clear fracture through cancellous bone.

In addition to depth, marks were also classified depending on their orientation to the axis of the bone on which they appear: longitudinal, transversal and oblique.

5.4. RESULTS

A total of 943 butchery marks were recorded on fresh, dried and rehydrated limbs. Most of marks are located on the femur and humerus, with a mean value of 18.6 and 13 marks per element respectively (Table 5.2). From a total of 29 limbs, 27 presented butchery marks (Table 5.3). For the sake of clarity results are presented separately for each action performed in the experiment. The results are presented as the total amount of marks for each butchery process.

5.4.1. Defleshing

Meat from the fresh forelimb was easily removed, especially the muscles attached to the humerus. For the radius-ulna area, the flint flake was placed in an oblique angle in order to remove meat and tendons. Meat from the fresh hindlimb was easily removed by cutting in from the proximal and distal epiphysis from femur and tibia. In the case of the five dry limbs, the meat was completely attached to the bone. Cutting thought with a sawing motion allowed removing some meat. The rehydrated limb was similar to the fresh ones. The roasted limb was easily defleshed by hand since cooked meat was not adhered to the bone.

Table 5.2. Total number (NCM) and average value (NCM/NE) of butchery marks present in each skeletal elements.

Skeletal element	Nº CM	Average value
Scapula	69	5.3
Humerus	196	13
Radius	133	8.8
Ulna	88	5.8
Innominate	62	6.8
Femur	261	18.6
Tibia	118	8.4
Calcaneum	16	1.6
TOTAL	943	

Defleshing all 27 limbs, 13 scapulae and 9 innominates caused a total of 586 cut marks including incisions and sawing marks (62.1%). Such marks were transversal (57.6%) and oblique (42.3%) in orientation. (Table 5.4a). This results in an average value of 21.7 marks per limb. Defleshing cut marks are present in fresh, dried and rehydrated limbs that comprise our experimental sample and are located on all long bones, scapulae, innominates and one calcaneum. The femur and humerus are the most affected by marks caused while defleshing (Table 5.4a).

The morphology, orientation and intensity of the butchery marks vary depending on meat the conservation status. Results show that incisions resulting from cutting off muscle packs from fresh and rehydrated limbs were short in length, transversal (40.6%) and oblique (59.4%) in orientation, and of light or superficial intensity. In fresh limbs the majority of defleshing marks are located on proximal and distal epiphysis of long bones, specifically femur and humerus bones; while incisions resulting from cutting off meat from the rehydrated limbs were mostly located on long bone's shaft (Fig. 5.3) since meat is slightly attached to the bone in that area. The scapula, ulna and innominate are the elements less affected by defleshing cut marks in fresh status (Table 5.4b).

Incisions present in dried limbs were very numerous, also short in length, most transversal in orientation (80.8%) and sometimes displaying a zigzag pattern (oblique, 19.2%) due to the sawing motion needed to remove meat. Incisions range from moderate to strong intensity since much force is needed to remove dry muscle packs that are attached to the bone. Defleshing marks present in dried limbs are located in the whole surface (proximal and distal epiphysis, and shaft) of bones. In this category, all the skeletal elements present a high number of marks, however the most affected are the femur, humerus and scapula with a mean value of 22.3, 20, and 15 respectively (Table 5.4b).

5.4.2. Scraping

Scraping off meat from all 20 fresh limbs (10 forelimbs and 10 hindlimbs), 10 scapulae and 8 innominate caused a total of 342 scraping marks (36.3%). This results in an average value of 17.1 marks per limb.

Marks related to the scraping process are present in all 20 limbs, scapulae and innominates, and are mostly located on the whole surface of long bones (both epiphysis and shaft), and scapulae (fossa). Also innominates displayed scrape marks, mostly located on the illium and ischium (Table 5.4c and Fig. 5.4). All elements presented similar average number of marks but in femurs, the scapulae and innominates scrape marks were slightly more abundant.

Since long bones were scraped from the proximal epiphysis, down the shaft, and ending in the distal epiphysis, traces resulting from scraping meat and soft tissue off the bone were striae long in length, and longitudinal to the axis of the bone. Marks resulting from scraping off soft tissue were of superficial to moderate intensity.

5.4.3. Tendons removal

As consequence of Achilles tendons removal, the calcanei of four fresh hindlimbs were scraped down producing 15 marks of moderate to strong intensity (Table 5.4d and Fig. 5.5). Such marks were transversal to the axis of the bone. Calcaneum bones affected by the tendons removal activity display short transversal incisions of strong intensity in the proximal area and also transversal striae, of superficial and moderate intensity, originated as you try to scrape off tendons positioning the lithic tool perpendicularly to the axis of the bone.

5. 5. DISCUSSION

Within the archaeological record of prehistoric hunter-gatherer communities from Western Europe, leporid skeletal elements that show what it appear to be butchery marks but that have been difficult to interpret are quite common. This would be the case of some archaeological specimens from Maltravieso Santa Maira, Beneito, Cendres, Blaus or Tossal de la Roca sites (Canals et al., 2010; Pérez Ripoll, 2001); where rabbit remains, especially long bones, that present multiple probable “cut marks” have been described. For this reason it is important to know thoroughly the different types of marks that butchery activities may produce. Results from this experimental study show how the different butchery activities carried out (defleshing, scraping and tendons removal) leave characteristic types of marks that varied in frequency, location, orientation and intensity.

The number and type of marks produced during the defleshing of the rabbit carcasses clearly varies depending on the meat condition (fresh, dried, cooked). When rabbits are processed and consumed after being cooked, the incidence of marks are expected to be null or low, as seen in the roasted limb of our experimental sample were no marks were produced. This is coincident with observations made by Lloveras et al. (2009) who registered very few cut marks related to the defleshing of cooked rabbit carcasses. However, when rabbits are defleshed in raw the number of marks clearly increase. In this case marks consisted in several incisions mostly short, oblique and transversal in orientation, and superficial. Similar number and type of marks are observed also in rehydrated limbs. On the contrary, marks made while defleshing the dried limbs were clearly more abundant, mostly transverse, also short but continuous, sawing marks that almost resembles a zigzag pattern, and of moderate to strong intensity. In some cases, in order to remove dry meat, thin parts of cortical bone were lost. The locations of marks were similar in all cases, affecting the whole surface of bones but with more incidences in articular areas in fresh material. Lloveras et al. (2009) recorded a clearly lower number of defleshing marks on fresh rabbit carcasses, the reason is probably methodological as the occurrence of multiple parallel incisions were registered as a unique action by these authors whilst here the total number of marks have been counted. The location (shafts and epiphyses of long bones), the ischium and illium bones of the innominate, and intensity and orientation are similar in both studies.

A high number of marks were also produced when scraping bones in order to clean them from adhered soft tissue. However, in this case incisions consisted on long striations, running longitudinal across the entire shaft of long bones, the fossa of the scapulae, and the entire surface of innominates. Marks were oriented longitudinally, from the proximal to distal part, and of superficial to moderate intensity. Lloveras et al. (2009) observed the same increment of longitudinal marks of superficial intensity when scraping off meat of the bone.

Most butchery marks described by Pérez Ripoll (2001) from archaeological materials match well with observation made in this study. In Pérez Ripoll's archaeological sample (2001) defleshing marks were described as transversal and oblique in orientation, located on the proximal and distal end of bones were muscle packs were attached. In scapulae such marks were located at the neck and *fossa*, and long bone shafts. Scrape marks, long longitudinal striations oriented from proximal to distal part, were also recorded, mostly in scapulae (*fossa*), and long bone shafts. Tendons removal on rabbits has not been experimentally studied before. Our results have shown that as a consequence of Achilles tendon removal, marks are concentrated on calcanei. This type of marks are short, transversal to the axis of the bone, and of moderate to strong intensity. Mostly concentrated in the calcanean tuber and the proximal area of the calcaneum, in the plantar face. In contrast to our study, Pérez Ripoll (1992) recorded also traces of tendons removal in the distal epiphysis of the tibia.

When comparing cut marks resulting from the present experimental study to the ones found among the archaeological sample mentioned in the Introduction section (Balma del Gai, Cova de la Guineu and Font Voltada) we see that some were replicated (thus, they can be attributed to different activities within the butchery process) but others were not. This is the case of large sections of numerous transversal incisions scatter all around the bone surface, specifically the shaft area of long bones, seen in some of our archaeological samples (Fig. 1). These marks cannot be associated to defleshing because marks caused by this activity, even in the case of dry meat, when sawing in a continuous motion can result in numerous short transversal and oblique incisions of light to moderate intensity only small sections of the shaft of long bones are affected and it does never produce the high frequency of transversal cut marks covering large sections of the bone surface observed in the archaeological specimens. Scraping is clear to do not produce this type of marks, as we have seen that marks resulting from this process are long longitudinal striae of low or superficial intensity. Therefore, another activity than butchery and probably another agent than humans would be the responsible for this marks on leporid remains.

5.6. CONCLUSIONS

Experimental studies may provide the means to assess bone surface damage inflicted by lithic tools during the carcass processing under controlled conditions, and to reconstruct hunter-gatherers communities past behaviour. In this experimental study bone surface damage associated to the processing of the rabbit carcass in different states of conservation (fresh, dry, roasted and rehydrated limbs) has been analysed.

Table 5.3. A.Total numbers of cut marked skeletal elements (per limb) resulting from te experimental rounds (3a, 3b and 3c). Abbreviations: *CM*= Cut marks; **Skeletal elements**: *Sca* = scapula, *Hum* = humerus, *Rad* = radius, *Uln* = ulna, *IN* = innominate (pelvis), *Fem* = femur, *Tib* = tibia, *Cal* = calcaneus, *Ast* = astragals; **Side**: R = right, L = left; **Location**: *WS* = whole surface, *PE* = proximal epiphysis, *PES* = proximal epiphysis + shaft, *S* = shaft, *SDE* = shaft + distal epiphysis, *DE* = distal epiphysis, *GCN* = glenoid cavity + neck, *N* = neck, *NF* = neck + fossa, *F* = fossa, *IL* = ilium, *A* = acetabulum, *IS* = ischium, *Prox* = proximal; **Orientation**: *Long* = longitudinal; *Oblic* = oblique; *Trans* = transversal.

3a

Limb	Element	Side	Conservation	Nº CM	Location	Orientation
1	Sca	R	Fresh	6	WS	Long
	Hum	R	Fresh	3	DE, S	Long
	Rad	R	Fresh	10	S	Long, Obl
	Uln	R	Fresh	2	S	Long
2	Sca	L	Fresh	8	NF, F	Long, Obl
	Hum	L	Fresh	8	DE, S	Long, Trans
	Rad	L	Fresh	16	S	Long, Obl, Trans
	Uln	L	Fresh	6	S	Long
3	IN	R	Fresh	8	IL	Long, Obl
	Fem	R	Fresh	15	PE, S, DE	Long, Obl, Trans
	Tib	R	Fresh	6	PES	Long, Obl
	Cal	R	Fresh	5	Prox	Trans
4	IN	L	Fresh	5	IS	Long
	Fem	L	Fresh	33	PE, S, DE	Long, Obl
	Tib	L	Fresh	8	PE, S, DE	Long, Obl
	Cal	L	Fresh	/	/	/
5	Sca	R	Fresh	4	F	Long
	Hum	R	Fresh	4	WS	Long, Trans
	Rad	R	Fresh	4	S	Long
	Uln	R	Fresh	3	S	Long
6	Sca	L	Fresh	10	F	Long
	Hum	L	Fresh	4	S	Long
	Rad	L	Fresh	3	SDE	Long
	Uln	L	Fresh	2	S	Long
7	IN	R	Fresh	4	A, IL	Long, Obl
	Fem	R	Fresh	16	PE, S, SDE, DE	Long, Obl
	Tib	R	Fresh	10	S	Long
	Cal	R	Fresh	/	/	/
8	IN	L	Fresh	4	A	Trans., Obl.
	Fem	L	Fresh	17	PES	Long, Obl, Trans
	Tib	L	Fresh	8	S	Long
	Cal	L	Fresh	/	/	/
9	Sca	R	Fresh	6	F	Long
	Hum	R	Fresh	20	PES, S	Long
	Rad	R	Fresh	16	PES, S	Long, Obl
	Uln	R	Fresh	17	S	Long
10	Sca	L	Fresh	6	F	Long
	Hum	L	Fresh	22	PES, S	Long, Obl, Trans
	Rad	L	Fresh	10	PES	Obl
	Uln	L	Fresh	9	S	Long, Obl
11	IN	R	Fresh	5	IL,A	Long, Obl
	Fem	R	Fresh	25	PE, S, DE	Long, Obl
	Tib	R	Fresh	5	S	Long
12	IN	L	Fresh	9	IL	Long
	Fem	L	Fresh	29	PES, S	Long, Trans
	Tib	L	Fresh	8	PES	Long, Obl.
13	Sca	R	Fresh	2	F	Long
	Hum	R	Fresh	19	S, SDE	Long, Obl
	Rad	R	Fresh	18	PE, S, DE	Long, Trans
	Uln	R	Fresh	8	S	Obl
14	Sca	L	Fresh	7	F	Long, Obl
	Hum	L	Fresh	25	SDE	Long, Trans
	Rad	L	Fresh	10	PES	Trans
	Uln	L	Fresh	10	PES	Obl
15	Fem	R	Fresh	28	PE	Long, Trans
	Tib	R	Fresh	12	S, DE	Long, Obl, Trans
	Cal	R	Fresh	/	/	/
16	Fem	L	Fresh	2	PE	Trans
	Tib	L	Fresh	15	PE	Long, Obl, Trans
	Cal	L	Fresh	10	WS	Trans
17	Sca	R	Fresh	4	F	Long
	Hum	R	Fresh	32	S	Long, Obl
	Rad	R	Fresh	3	S	Long
	Uln	R	Fresh	3	S	Long
18	Sca	L	Fresh	1	NF	Trans
	Hum	L	Fresh	9	S	Trans
	Rad	L	Fresh	7	S	Obl, Trans
	Uln	L	Fresh	5	S	Long, Obl
19	IN	R	Fresh	15	IL	Long, Obl, Trans
	Fem	R	Fresh	9	PE	Long, Obl, Trans
	Tib	R	Fresh	/	/	/
20	IN	L	Fresh	3	IL	Long
	Fem	L	Fresh	20	PES, DE	Long, Obl, Trans
	Tib	L	Fresh	6	S	Long
				364		

Table 5.3. B. Total numbers of cut marked skeletal elements (per limb) resulting from the experimental rounds (3a, 3b and 3c). Abbreviations: *CM*= Cut marks; **Skeletal elements**: *Sca* = scapula, *Hum* = humerus, *Rad* = radius, *Uln* = ulna, *IN* = innominate (pelvis), *Fem* = femur, *Tib* = tibia, *Cal* = calcaneus, *Ast* = astragals; **Side**: R = right, L = left; **Location**: *WS* = whole surface, *PE* = proximal epiphysis, *PES* = proximal epiphysis + shaft, *S* = shaft, *SDE* = shaft + distal epiphysis, *DE* = distal epiphysis, *GCN* = glenoid cavity + neck, *N* = neck, *NF* = neck + fossa, *F* = fossa, *IL* = ilium, *A* = acetabulum, *IS* = ischium, *Prox* = proximal; **Orientation**: *Long* = longitudinal; *Oblic* = oblique; *Trans* = transversal.

3b

Limb	Element	Side	Conservation	Nº CM	Location	Orientation
21	Hum	L	Fresh	/	/	/
	Rad	L	Fresh	/	/	/
	Uln	L	Fresh	/	/	/
22	Hum	R	Dry	20	WS	Trans
	Rad	R	Dry	15	S	Trans
	Uln	R	Dry	8	SDE	Trans
23	Fem	R	Fresh	/	/	/
	Tib	R	Fresh	4	PE	Trans
	Cal	R	Fresh	/	/	/
24	Fem	L	Dry	25	PES, S, DE	Trans
	Tib	L	Dry	6	PE, S	Trans
	Cal	L	Dry	1	Prox.	Trans

3C

Limb	Element	Side	Conservation	Nº CM	Location	Orientation
25	Sca		Dry	15	NF	Obl, Trans
	Hum		Dry	20	PES, S, DE	Obl
	Rad		Dry	13	S	Trans
	Uln		Dry	10	PE, S	Trans
26	Sca		Roasted	/	/	/
	Hum		Roasted	/	/	/
	Rad		Roasted	/	/	/
	Uln		Roasted	/	/	/
27	Fem	R	Dry	30	S	Trans
	Tib	R	Dry	25	S	Trans
	Cal	R	Dry	/	/	/
28	Fem	L	Dry	12	PE, SDE, DE	Obl, Trans
	Tib	L	Dry	5	S, DE	Trans
	IN	L	Dry	9	IL, A, IS	Obl
	Cal	L	Dry	/	/	/
29	Sca		Rehydrated	/	/	/
	Hum		Rehydrated	10	S	Trans
	Rad		Rehydrated	8	S	Trans
	Uln		Rehydrated	5	S	Trans

Table 5.4. (4a)- Total number (NCM) and average value (NCM/NE) of butchery marks caused by defleshing. Abbreviations: *WS* = whole surface, *PE* = proximal epiphysis, *PES* = proximal epiphysis + shaft, *S* = shaft, *SDE* = shaft + distal epiphysis, *DE* = distal epiphysis, *NF* = neck + fossa, *F* = fossa and *IL* = ilium; (4b) Total number and average value of defleshing marks in fresh, dried, roasted and rehydrated limbs; (4c) Total number and average value of butchery marks caused by scraping meat out of bone. Abbreviations: *WS* = whole surface, *S* = shaft and F = fossa; (4d) Total number and average value of butchery marks caused by tendons removal. Abbreviations: *Prox*= proximal.

DEFLESHING MARKS

4a		***Transversal***			***Oblique***			***Total***	
Skeletal element	Nº elements	Location	Nº CM	Average Value	Location	Nº CM	Average Value	Nº CM	Average value
Scapula	13	/	6	0.4	NF, F	17	1.3	23	1.7
Humerus	15	WS	71	4.7	PES, SDE	69	4.6	140	9.3
Radius	15	PE, S, DE	67	4.4	WS	38	2.5	105	7
Ulna	15	PE, SDE	23	1.5	S	27	1.8	50	3.3
Innominate	9	IL	9	1	IL	22	2.4	31	3.4
Femur	14	WS	111	7.9	WS	62	4.9	173	12.3
Tibia	14	WS	50	3.5	WS	13	0.9	63	4.5
Calcaneum	10	WS	1	0.1	/	/	/	1	0.1
TOTAL			**338**			**248**		**586**	

4b	***FRESH LIMBS***						***DRY LIMB***			
Skeletal element	Nº elements	*Transversal*	*Oblique*	Nº CM	Average Value	Nº elements	*Transversal*	*Oblique*	Nº CM	Average Value
Scapula	10	1	7	8	0.8	1	5	10	15	15
Humerus	11	41	49	90	8.1	1	20	20	40	20
Radius	11	31	38	69	6.2	1	28	0	28	14
Ulna	11	0	27	27	2.4	1	18	0	18	9
Innominate	8	9	13	22	2.7	1	0	9	9	9
Femur	11	46	60	106	9.6	3	65	2	67	22.3
Tibia	11	14	13	27	2.4	3	36	0	36	12
Calcaneum	7	0	0	0	0	3	1	0	1	0.3
TOTAL		142	207	**349**			173	41	**214**	

Table 5.4. (4b) Total number (NCM) and average value (NCM/NE) of butchery marks caused by defleshing. Abbreviations: *WS* = whole surface, *PE* = proximal epiphysis, *PES* = proximal epiphysis + shaft, *S* = shaft, *SDE* = shaft + distal epiphysis, *DE* = distal epiphysis, *NF* = neck + fossa, *F* = fossa and *IL* = ilium; (4b) Total number and average value of defleshing marks in fresh, dried, roasted and rehydrated limbs; (4c) Total number and average value of butchery marks caused by scraping meat out of bone. Abbreviations: *WS* = whole surface, *S* = shaft and F = fossa; (4d) Total number and average value of butchery marks caused by tendons removal. Abbreviations: *Prox*= proximal.

	ROASTED LIMB			***REHYDRATED LIMB***			
Skeletal element	Nº elements	Nº CM	Average Value	Nº elements	*Transversal*	Nº CM	Average Value
Scapula	1	0	0	1	0	0	0
Humerus	1	0	0	1	10	10	10
Radius	1	0	0	1	8	8	8
Ulna	1	0	0	1	5	5	5
TOTAL		**0**				**23**	

SCRAPE MARKS				
4c	***Longitudinal***			
Skeletal element	Nº elements	Location	Nº CM	Average Value
Scapula	10	F	46	4.6
Humerus	10	WS	56	5.6
Radius	10	WS	28	2.8
Ulna	10	WS	38	3.8
Innominate	8	WS	31	3.8
Femur	10	S	88	8.8
Tibia	10	S	55	5.5
TOTAL			**342**	

TENDONS REMOVAL				
4d	***Tranversal***			
Skeletal element	Nº elements	Location	Nº CM	Average Value
Calcaneum	4	Prox	15	3.7
TOTAL	**4**		**15**	

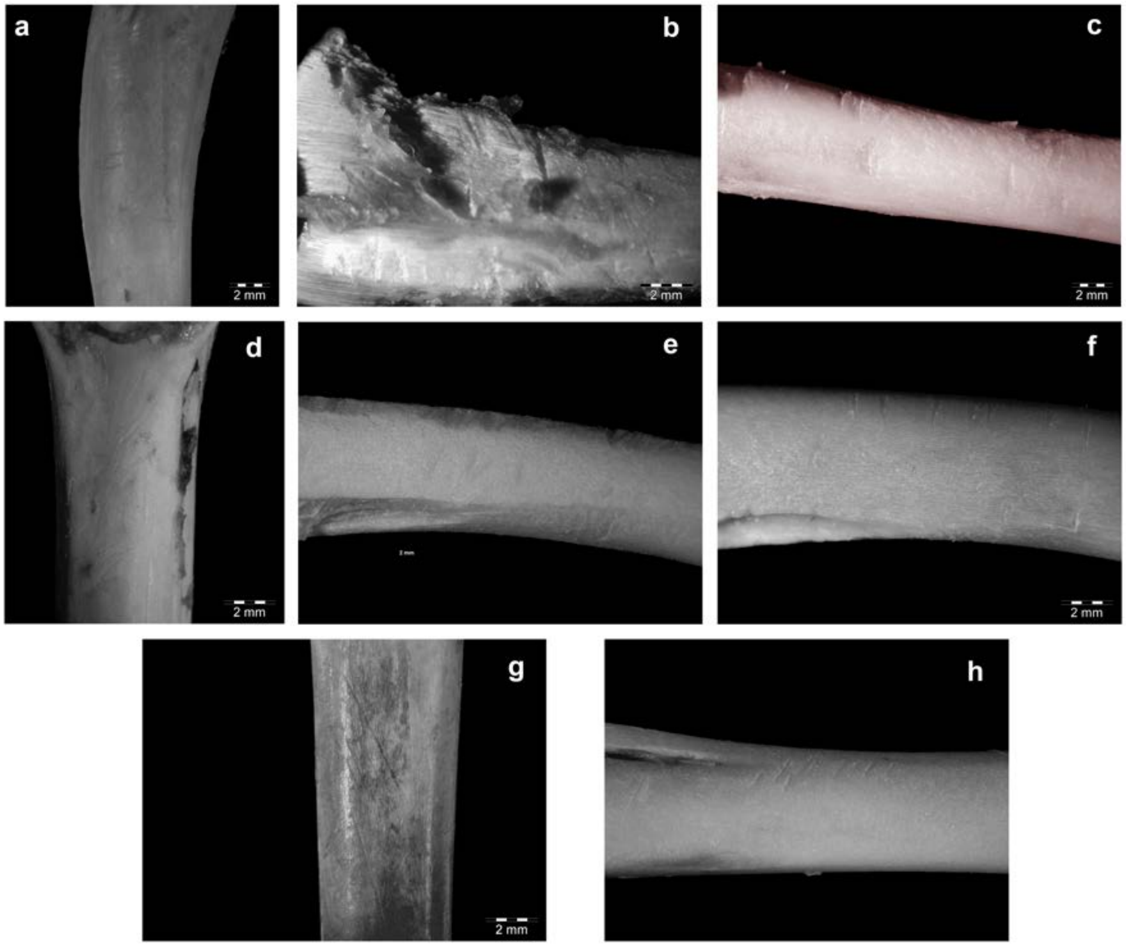

Figure 5.3. Cut marks caused by the defleshing process. (a) Fresh humerus, (b-c) dried humerus, (d) fresh femur, (e-f) dry femur, (g) fresh tibia, and (h) dry tibia.

Figure 5.4. Scrape marks. (a) Scapulae, (b) humerus, (c) radius-ulna, (d) tibia, and (e-f) femur

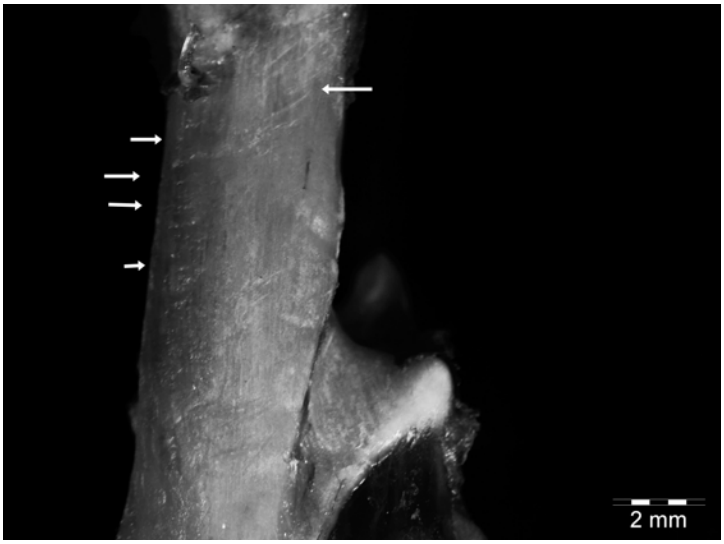

Figure 5.5. Tendons removal marks in calcaneus bone.

Identifying and associating cut marks with a particular butchery stage on archaeological leporid assemblages is not a straightforward process, since a same skeletal element may show similar marks that may be produced in different stages of the butchery process. For this reason, the type of marks, their location, orientation and the intensity of the marks should be taken into consideration. Based on our experimental study:

(1) Defleshing marks may vary depending on the state of meat conservation. On fresh carcasses some transversal and mostly oblique incisions of superficial intensity and mostly affecting long bones (shafts and epiphyses) were registered. On dry limbs marks are numerous, mostly transversal orientated, deep (strong intensity) and sometimes accompanied by bone loss.

(2) Scraping off meat, in order to clean the bone from remaining soft tissue, resulted into numerous long striae of superficial and moderate intensity, longitudinal orientated, running across the whole surface of the bone.

(3) Removal of the Achilles tendons produced short and transversal marks of moderate and strong intensity, mostly concentrated in the calcanean tuber.

These results can be an important tool to identify or exclude anthropogenic butchery activities when analysing archaeological leporid assemblages. Needles to say, that more than one variable must be taken into account in order to identify specific carcass processing activities, and to be cautious about how to interpret.

CHAPTER 6

ANALYSIS OF MODERN AND ARCHAEOLOGICAL BURNT BONES BY FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR – KBr).

6.1. INTRODUCTION

Burnt bones are quite frequent in the archaeological record and are indicative of use of fire in different activities. The analysis of burnt skeletal remains is a topic of transcendent importance as it provides information on paleoenvironment, paleodiet, paleoclimate, human and animal migrations among others (Berna et al., 2012; Britton et al., 2009; Lee-Thorp, 2002; Wang et al., 2008; Wrangham, 2010). Animal bones can be burned as a result of cooking practices, as fuel or inadvertently burned by a fire generated in close proximity (David, 1990; Bennett, 1999; Costamagno et a., 2005). According to Lyman (1994) the combustion process results from excessive heat, which can modify or damage the heated object. Alterations occur depending on the exposure to high temperatures during considerable period of time.

In fresh or unaltered bone the mineral phase is carbonated hydroxyapatite. Its crystal structure is poorly ordered, containing small crystals and therefore a low infrared splitting factor (IRSF) value, and particularly susceptible to substitutions of carbonate, chloride, fluoride, magnesium and other ions into its crystal lattice. These mineral substitutions introduce disorder at the atomic level, therefore destabilizing the mineral (Asscher et al., 2011). Carbonated hydroxyapatite crystals tend to become more ordered at the atomic level, either due to age related diagenesis or heat-induced transformations, displaying ordered crystal structures and an increase of crystal size, which results in a higher IRSF value (Thompson et al., 2011). The atomic disorder of carbonate hydroxyapatite can be monitored by Fourier Transform Infrared (FTIR) spectroscopy, which it is used to obtain information on the molecular structure of crystalline, amorphous and organic materials. It is currently used for the determination of materials and to characterize its atomic state (Weiner, 2010). According to Termine and Posner (1966), the extent to which the absorption at 603 cm^{-1} and 567 cm^{-1} are split in the infrared spectrum is indicative of the crystallinity of carbonated hydroxyapatite, “crystallinity” referring to the combination of the crystal size and atomic disorder.

Stiner et al. (1995) experimental research show that crystals in fresh bone have IRSF values of 2.7± 0.2, while calcined bone have values around 7, however an increase in the IRSF of fossil bones due to diagenesis has been recorded with values ranging from 6 to 7. Additional growth in size of the crystal can result in higher IRSF values (Trueman et al., 2004). The speed of the increase in the crystal order can also be augmented by weathering alterations (Stiner et al., 2001), but also there has been found that there is a correlation between colour change and the infrared spectrum (Table 6.1) since an increase in the IRSF have been shown to be the direct result of burning (Person et al., 1996; Thompson et al., 2009). Bones suffer a change in colour when burned due primarily to the loss of organic matter and also experiment changes in bone mineral and matrix (Shipman et al., 1984; Stiner et al., 1995). Colour has long been used to identify thermally modified bones; Stiner et al. (1995) introduced a colour code to visually evaluate the extension of thermo- alteration on bone (Table 6.1).

Due to the high incidence of thermo- altered material and the presence of colourations, possibly caused by diagenetic processes, mineral dyes and sedimentation, on the three archaeological sites discuss in this dissertation, we analysed a small sample of the leporid assemblage for each site using *Fourier transform infrared spectroscopy* (FTIR). One of the reasons to use the grinding curve method is that *cristallinity index* (CI) or *splitting factor* (SF) can change with each grinding of the sample (Surovell and Stiner, 2001). To avoid this problem we measured the CI in relation to the *full width half height* (FWHH) of the main dahllite peak. Asscher et al. (2011) showed that when the IRSF is plotted against the FWHM of the 1035 cm^{-1} peak of carbonated hydroxyapatite different trend lines, as a function of repeated grinding, are obtained. Recognizing the temperature at which the bone is burned, and quantifying the proportion of burnt bone in our assemblage, can contribute to the understanding the circumstances generated for each site.

Table 6.1. Changes in the infrared spectra and splitting factor of burned bones in relation to changes in colour as established by *Stiner et al.* (1995). Table extracted from *Weiner (2010)* and modified.

Burn code	Bone colour code	Splitting factor (SF)
0	Cream tan (not burned)	2.8
1	Yellow-ochre tonalities	2.9
2	Brown tonalities	3.3
3	Black	3.3
4-5	Grey tonalities	4.2
6	White	≥ 6.4

6.2. MATERIALS AND METHOD

Two sets of samples were used for this experiment: 1) the first set composed of two control samples consisting of modern and archaeological rabbit bones burned at different controlled temperatures and, 2) a second set composed of archaeological rabbit bones from the sites that are been discussed in this dissertation, corresponding to the different colour codes established by Stiner et al. (1995).

The control bone samples used for this study came from modern and archaeological *Oryctolagus cuniculus* bones. Fresh bones for our experiment consisted on a fresh tibia and a boiled femur while the archaeological samples consisted of two unburnt cortices of long bones recovered from Epipaleolithic level (unit I3) of the Balma del Gai site. Neither modern nor archaeological bones were chemically treated prior to burning or grinding. Since burning bones outdoors produce uncontrolled conditions that cannot be studied in an experimental approach, a muffle furnace was used to avoid uncontrolled variables, and produce repetitions of the same experiment to get statistically significant results. For this matter, the heating experiments with raw, boiled and archaeological pieces were carried out in a muffle furnace in which each piece was heated for two hours in temperatures ranging from 200 to 800 ºC. Visible stages of burning were classified by colour. A Munsell colour chart was used to reference the colour of each of the burnt fragments (Table 6.2). Evidence of burning damage was analysed using macroscopically and microscopically observable features such as bone colour and the *cristallinity index* (CI) or *infrared splitting factor* (IRSF). The mineral properties of burned modern and archaeological bones were compared to examine a possible overlap with the effect of weathering and other diagenetic processes.

The second set of samples consisted in 24 bone remains collected from Balma del Gai, Cova de la Guineu and Font Voltada archaeological sites, 5 of which (from Cova de la Guineu) are believe to be the result of diagenetic processes. The samples were extracted from calcanei, astragali, long bone cortices, phalanges, vertebrae and innominates. The bone remains were selected based on the corresponding to the different colour codes established by Stiner et al. (1995). As with the control samples, visible stages of burning were recorded by colour and using a Munsell colour chart to reference the colour of each of the burnt fragments (Table 6.3)

The microscopic structure of our bone samples was checked throughout the experiment by FTIR-KBr. Following the methodology established by Asscher et al. (2011), the sample was lightly ground by hand using a mortar and pestle, then a few tens of µg of the sample were mixed with potassium bromide (KBr) powder and pressed to form a transparent pellet under 2 tons pressure. The FTIR was obtained using an is-5 FTIR spectrometer from Thermo-Fisher Scientific, and the software used to analyse the Spectra was *Omnic 8.0*. After obtaining the spectrum, the pellet was reground and pressed for a second time to obtain another spectrum. This process was repeated until no significant change in peak shapes were obtained. Following Weiner and Bar Yosef (1990), the IRSF was calculated by summing the height of the 565 cm^{-1} and 603 cm^{-1} peak height and dividing the sum by the height of the valley between them. The full width at half maximum (FWHM) of the ν_3 absorption peak was measured directly off the spectrum.

Table 6.2. Temperature reached, time and exposure in the furnace, and Munsell colour chart reference for each of the burnt fragments that comprise the controlled modern and archaeological samples.

Modern	Temperature/ Time	Munsell colour reference
Boiled	200º C 2h	2.5Y, 7/4
Raw	200º C 2h	2.5Y, 6/6
Boiled	300º C 2h	10YR, 2/2
Raw	300º C 2h	7.5YR, 2.5/3
Boiled	400º C 2h	2.5Y, 7/2
Raw	400º C 2h	5Y, 3/1
Boiled	500º C 2h	2.5Y, 7/2
Raw	500º C 2h	2.5Y, 6/2
Boiled	600º C 2h	GLEY 1, 8N
Raw	600º C 2h	GLEY 2, 8/5PB
Boiled	700º C 2h	White
Raw	700º C 2h	White
Boiled	800º C 2h	White
Raw	800º C 2h	White

Archaeological	Temperature/ Time	Munsell colour reference
GAI 1825	200º C 2h	10YR, 6/4
GAI 1848	200º C 2h	2.5Y, 7/6
GAI 1825	300º C 2h	2.5Y, 5/3
GAI 1848	300º C 2h	10YR, 6/6
GAI 1825	400º C 2h	5Y, 8/2
GAI 1630	400º C 2h	5Y, 8/1
GAI 1825	500º C 2h	2.5Y, 8/1
GAI 1630	500º C 2h	GLEY 1, 8N
GAI 1825	600º C 2h	GLEY 1, 8/5GY
GAI 1630	600º C 2h	GLEY 1, 8/10GY
GAI 1825	700º C 2h	GLEY 1, 8/5GY
GAI 1630	700º C 2h	GLEY 1, 8/5G
GAI 1825	800º C 2h	GLEY 1, 8/5GY
GAI 1630	800º C 2h	GLEY 1, 8/5GY

6.3. RESULTS

Following Asscher et al. (2011), to decouple the particle effect from the effect of anatomic disorder, the IRSF values are plotted against the ν_3 FWHM as a function of repeated grinding, producing trend lines that document the grinding effect on the carbonate hydroxyapatite crystals.

Figure 6.1 shows grinding curves of the controlled samples, modern and archaeological rabbit (*Oryctolagus cuniculus*) bones, following exposure to increasing temperatures between 400-800°C. Monitoring the FWHM of the main peak shows that with each grinding it shifts toward lowed values. Monitoring the splitting factor index (SF), whose correlation trend with the grinding procedure characterizes the crystallinity of the specimen, shows modern and archaeological bones have similar trends. We distinguish between two different regimes of temperatures. The first regime, associated with bones that were exposed to 400-500°C, is characterized by grinding curves in which the SF index is independent of the FWHM, and therefore independent of grinding. A second regimen, associated with bones that were exposed to 600-800°C, is characterized by curves in which the changes of the SF index and FWHM are proportional. We note that the transition between regimes is continuous, and that increasing temperatures produce lower FWHM values and higher SF values, indicating larger crystallinity. Figure 6.1 shows that increasing the crystallinity of bones by exposing them to elevated temperatures, results in continuous inclination of the grinding curves slopes values.

Temperatures between 25-700°C is shown in Figure 6.2. Modern control samples show two regimes: between 25-500°C in which the slope is independent of the temperature, and between 500-700°C in which the slope value is proportional to the temperature. Archaeological control samples show similar behaviour, but with a shift to higher slope values in the range between 200-500°C. We speculate that the slopes differences between controlled archaeological and modern bones exposed to 200-500°C is associated with the absence of collagen in archaeological bones, which allows the crystals to growth more with heating than in modern bones. The change in slope values of modern and archaeological bones exposed to temperatures.

From figures 6.1 and 6.2 we conclude that the described sample crystallinity is similar to the SF index, but incorporates information on the change in FWHM with grinding (particle size effect). Also, the maximum value of the SF index (max SF index), which is associated to the lowest FWHM value, eliminates the influence of the particle size effect. Therefore, the slope and the max SF index of the grinding curves can be use to describe bones crystallinity changes with temperature.

Table 6.3. Munsell colour chart reference for each of the burnt fragments that comprises the archaeological samples from Balma del Gai, Cova de la Guineu and Font Voltada sites.

Balma del Gai	Colour code	Munsell colour reference
Gai 1629	Yellow-ochre tonalities	2.5YR, 6/4
Gai 1967	Yellow-ochre tonalities	2.5YR, 5/4
Gai1629	Brown tonalities	10Y, 3/1
Gai 30	Black	2.5Y, 4/1
Gai 218	Grey tonalities	7.5YR, 5/2
Gai 211	White	---

Cova de la Guineu	Colour code	Munsell colour reference
Gn 398	Cream (not burned)	10YR 8/3
Gn 597	Cream (not burned)	10YR 7/4
Gn 379B	Yellow-ochre tonalities	2.5YR 4/3
Gn 2929	Brown tonalities	7.5YR 3/1
Gn 1009D	Black	10YR 2/1
Gn 161	Grey tonalities	10YR 5/2
Gn 2928	White	---

Cova de la Guineu (Diagenesis samples)	Base colour	Munsell colour reference
Gn 1689	7.5YR 7/3	7.5YR 3/3
Gn 2157	7.5YR 7/3	7.5YR 4/4
Gn 2327	---	7.5YR 6/3
Gn 2469	10YR 8/3	10YR 4/2
Gn 4034	10YR 8/3	10YR 4/2

Font Voltada	Colour code	Munsell colour reference
FV	Cream (not burned)	7.5YR 7/4
FV 5055	Yellow-ochre tonalities	2.5YR 5/3
FV 1764	Brown tonalities	2.5YR 3/1
FV 2471	Black	GLEY1 2.5/N
FV F490	Grey tonalities	10YR 4/1
FV 3528	White	7.5YR8/2

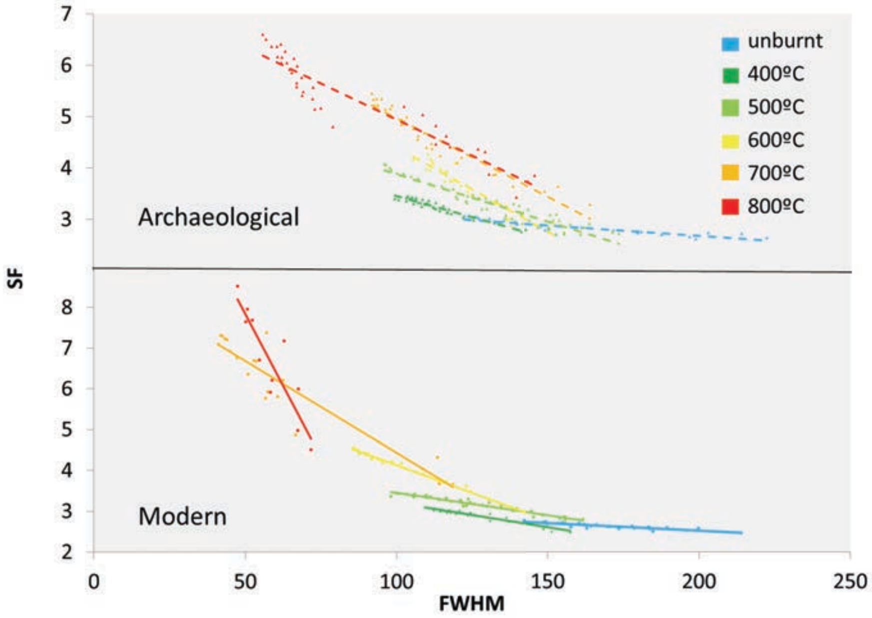

Figure 6.1. Grinding curves of modern and archaeological rabbit bones exposed to increasing temperatures between 400-800ºC. Modern and archaeological bones have similar trends with increasing temperatures, showing a shift to lower FWHM, larger SF. The agreement of the linear fits ranges between 80-95%.

The grinding curves of the archaeological rabbit bones recovered from each of the sites discussed in this dissertation and sorted according to the burning damage categories based on colour established by Stiner et al. (1995) are shown on Figures 6.3a, 6.3b and 6.3c. Using the grinding curve approach, we noted that the control (modern and archaeological bones) samples burned at different temperatures for 2 hours have similar trendlines to the archaeological sample recovered from Balma del Gai (6.3a), Cova de la Guineu (6.3b) and Font Voltada (6.3c). Similar, as already seen in the controlled samples (Figure 6.1), two different regimes of temperature can be distinguished in the three archaeological sites: one associated with exposure to temperatures between 400-500ºC and another associated with exposure to temperatures between 600-800ºC. The colour in each figure is associated to the expected temperature the bone was damage at (Table 6.4).

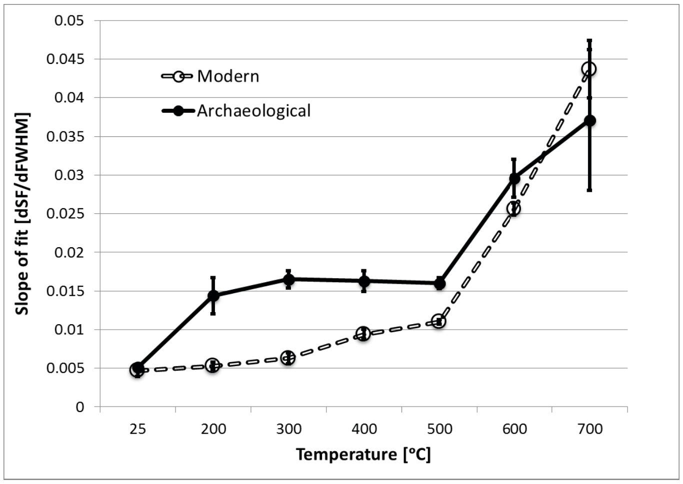

Figure 6.2. Slopes of the grinding curves of modern and archaeological rabbit bones that were exposed to increasing temperatures between 25-700°C. Modern and archaeological bones have similar trends with increasing temperatures, showing significant increase in slopes above 500°C. We note that archaeological bones slopes are higher than in modern bones between 200-500°C.

Table 6.4. Averaged values of grinding curves slopes and max SF indices of archaeological bones from Balma del Gai, Cova de la Guineu and Font Voltada that were exposed to different temperatures based on their coloration.

Temperature ranges *(Stiner et al. 1995)*	Colours	Slope	Max SF index
0-100 °C	*No alteration*	0.0077±0.0016	3.19±0.03
100-285 °C	*Yellow to ochre tonalities*	0.0084±0.0011	3.19±0.05
285-525 °C	*Brown tonalities*	0.0104±0.0019	3.33±0.25
300-500 °C	*Black*	0.0179±0.0055	3.75±0.47
500-650 °C	*Grey tonalities*	0.0216±0.0031	4.47±0.83
≥ 650 °C	*White*	0.0367±0.0046	5.8±0.97

In Balma del Gai, according to the grinding curves (Figure 6.3a), when monitoring the FWHM of the main peak, we see that with every grinding of the sample it shifts toward lower values, while the SP index shift toward higher values. Increasing temperatures produce lower FWHM values and higher SP index values, indicating the presence of larger crystals, and therefore a more stable structure. When monitoring the FWHM of the main peak of the grinding curves of bones samples recovered in Cova de la Guineu (Figure 6.3b) we see that with every grinding of the sample it shifts toward lower values, while the SP index shift toward higher values. However, bone samples under the *yellow-ochre, brown* and *black* categories, although the FWHM shift toward lowed values, the SF index shift to values below 3.5. In Font Voltada, according to the grinding curves (Figure 6.3c), like the previous archaeological samples, when monitoring the FWHM of the main peak we see that with every grinding of the sample it shifts toward lower values, while the SP index shift toward higher values, with the exception of the samples classified under the *yellow-ochre* and *brown* categories. The SF index of this two samples stayed below 3.3 values.

Figure 6.4 plots the max SF index and slopes of archaeological bones. The burning temperature is assessed based on coloration (empty symbols), with modern (black circles) and archaeological bones (black triangles) bones that were heated in controlled environments. Trend lines of modern and archaeological bones (dashed and solid respectively) of known temperatures overlap with the ranges of the slope and max SF index of archaeological bones that their burning temperature is assessed based on colorations.

The max SF index and the slope of the five bone samples from Cova de la Guineu (see Table 6.3), that were diagenetically altered due to chemical interaction with the environment, is plotted with modern and archaeological bones (control sample) that were heated to known temperatures (represented by an outline of the ranges according to temperature) are shown in Figure 6.5. Diagenetically altered bones were not altered by heating based on archaeological evidence in the site, however, their mineral fraction shows similar recrystallization and changes in the grinding curves similar to those of heated bones in the ranges 25-500°C.

6.4. DISCUSSION

Bones undergo important alterations when expose to a heat source, affecting its colour and surface texture. Frequently these macroscopic alterations are used to estimate the heating temperature at which the archaeological samples were exposed. However other taphonomic processes can affect bone colour during burial. Taphomomic research on archaeological bone has demonstrated that structure and chemical alterations occur during burial in sedimentary deposits. For instance, stains caused by iron and manganese oxides can give the appearance of brown and black colours, while diagenetic processes that take place during geological time can alter the bone's mineral phase by increasing its crystallinity.

The ability to identify bones that were exposed to heat or diagenetically altered in not possible based on the splitting factor (SF) index alone. Understanding alterations based on heating is done using the grinding curve method, and figures 6.1 and 6.2 show that it is difficult to distinguish between bones that were exposed to temperatures up to 500^{o}C, since the FWHM and SF ranges overlap greatly.

When comparing the resulting grinding curves of the control samples (modern and archaeological) with the grinding curves obtained from bones samples recovered from Balma del Gai, we noted that they are quite similar (Figure 6.3a). The two regimes associated to 400-500^{o}C and 600-800^{o}C temperatures are present, it also show a shift in FWHM and SF index values. The FWHM shift toward lowed values, while the SF index shift toward high values with the increase of temperature. Also the transition between temperatures is continuous. The increase of the SF index due to the exposure to high temperatures results in the inclination of the trend lines slopes values. According to data obtained from the control sample, these results show that Balma del Gai archaeological samples, in each of the established colour categories, indeed are burnt.

The results are somewhat uncertain in the case of Cova de la Guineu and Font Voltada (Figures 6.3b and 6.3c). Both archaeological sites, like Balma del Gai, show the two regimes associated to 400-500^{o}C and 600-800^{o}C that were identified in the control samples. We also see a shift in FWHM toward low values and an increase in the SF index, but the transition between temperatures is not continuous. The increase in the SF index, due to the exposure to high temperatures results in the inclination of the trend lines slopes values corresponding to samples classified as white and grey in Cova de la Guineu's archaeological sample, and samples classified as white, grey and black in Font Voltada's archaeological sample. By comparing the results of the samples classified as yellow-ochre, brown and black obtained from the control samples (modern and archaeological) and the samples collected from Cova de la Guineu and Font Voltada, we can see some discrepancy between the FWHM and SP index values. In the control samples the FWHM values ranges between 150 to 100, meanwhile the SF index values for samples burned at

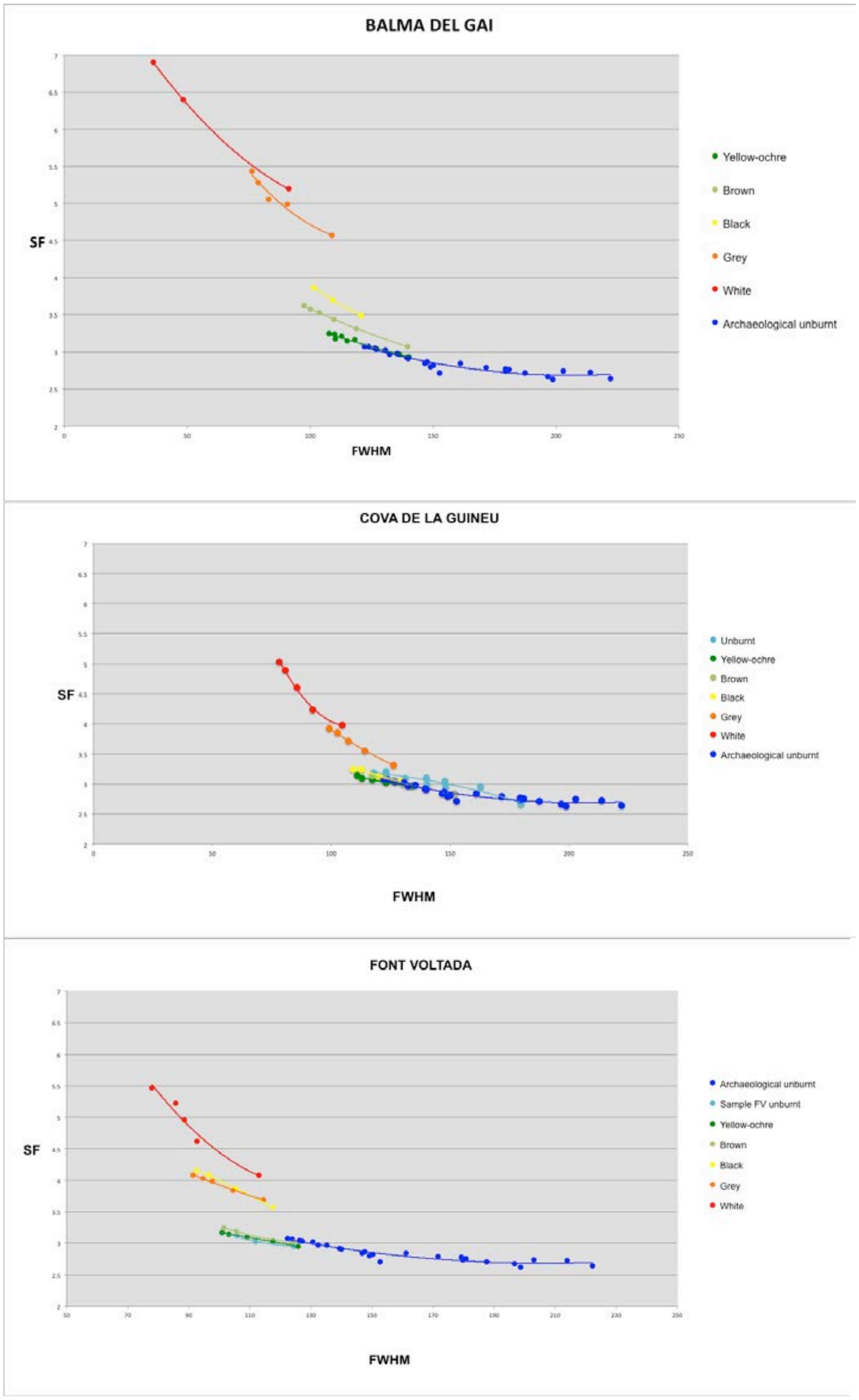

Figure 6.3. Grinding curves of the archaeological rabbit bones recovered from each of the site discussed in this dissertation: **a.** *Balma del Gai*, **b.** *Cova de la Guineu* and **c.** *Font Voltada*, and sorted according to the burning damage categories based on colour established by Stiner et al. (1995).

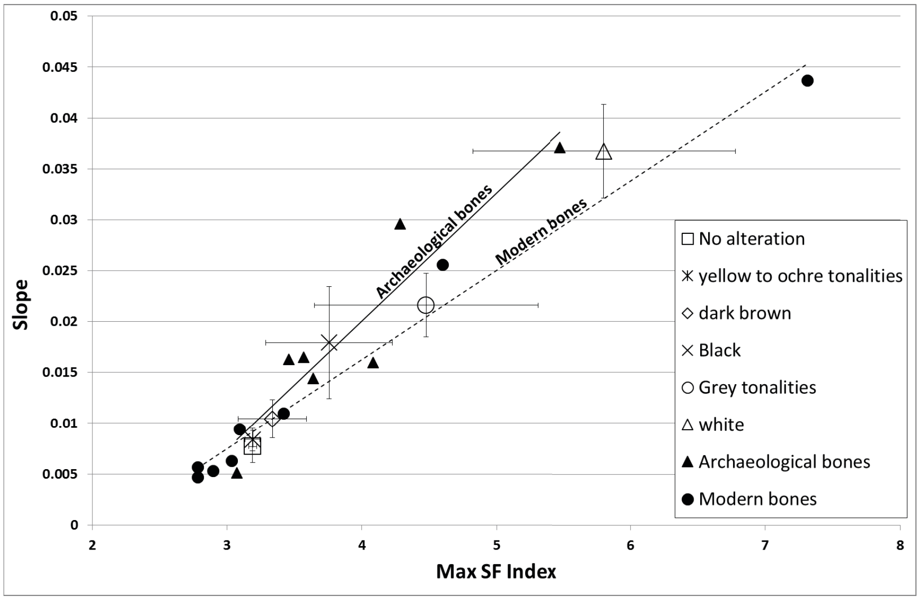

Figure 6.4. Max SF index and slopes of bones that were altered by temperatures (solid symbols): modern bones and archaeological bones that were heated in controlled environments, and archaeological bones that their burning temperature is assessed based on coloration (colours shown in empty symbols).

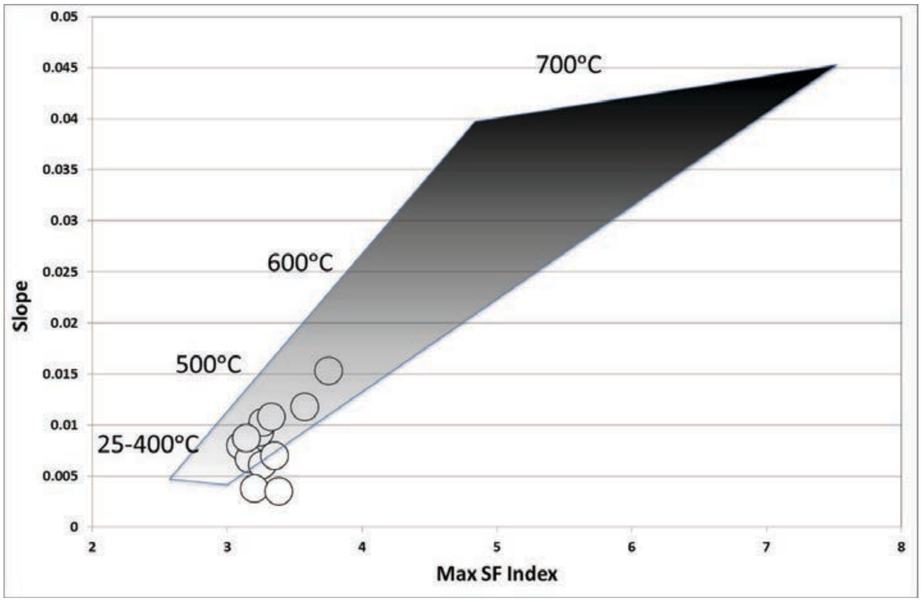

Figure 6.5. Max SF index and slopes of archaeological bone samples collected from Cova de la Guineu site that were altered by diagenesis. Also plotted is the range of modern bones and archaeological bones that were heated in controlled environments. Diagenetically altered bones show similar recrystallization to bones that were heated to temperatures between 25-500°C.

400°C range between 2.8 - 3, samples burned at 500°C range between 3 - 3.3, and the samples burned at 600°C range between 3 – 4.

In Cova de la Guineu, bones corresponding to yellow-ochre, brown tonalities and black categories all present FWHM values between 150 – 100 and a SF index between 3.2 – 3. As mentioned before, there is no inclination of the trend lines slopes values. The same pattern occurs in Font Voltada's sample. According to data obtained from the control samples, burnt bone within the yellow-ochre categories have a SF index ranging between 3.3 – 3, while SF index for brown and black coloured bone ranges between 3.9 – 3.3 and 4 – 3.5 respectively. The FWHM and SF index values between these three colour categories overlap.

Discrepancies between FWHM and SF index values within the yellow-ochre, brown and black categories in Cova de la Guineu, and yellow-ochre and brown categories in Font Voltada leads us to assume that bone samples within this colour categories are not really burnt, but altered by other agents such as manganese oxides and mineral dyes found in the sedimentary deposits.

6.5. CONCLUSIONS

The identification of burnt bones in the archaeological record is not a straightforward matter. While dark browns and black colourations may be indicative of thermo-alterations it could also be due to staining by manganese and/or iron oxides (Marín-Arroyo et al., 2008; Shahack-Gross et al., 1997). The results of the FTIR – KBr analysis of 24 archaeological bones recovered from Balma del Gai, Cova de la Guineu and Font Voltada shows that at least 46% of them are indeed burnt. This leads us to conclude that a colour-based identification of burnt bone is not reliable.

All of the work presented in this chapter can be used directly. We have established some distinctive patterns, and prepared a reference collection of modern and archaeological rabbit bones. Furthermore, with a single FTIR it is possible to place any rabbit bone from archaeological sites in our reference collection graph and immediately know if it is burnt or not, and to what extent. All of this can be done within a matter of seconds and using small amounts of samples. Also, this research presents the opportunity to study other types of bones/animals using this approach.

The real mechanics behind the relation between burnt bone and an increase in crystallinity is still not well understood. Additional experimentation is needed to better understand this phenomenon.

PART II. B

APPLIED METHODOLOGY FOR THE TAPHONOMICAL ANALYSIS AND ARCHAEOLOGICAL SITES

The leporid accumulations studied for this PhD dissertation come from the archaeological sites of Balma del Gai (Moià, Barcelona), Cova de la Guineu (Font Rubí, Barcelona), and Font Voltada (Montbrió de la Marca, Conca de Barberá), located in the Northeast of the Iberian Peninsula. Just as we point out at the introduction, these sites were selected due to the presence of Epipaleolithic levels corresponding to the *Geometric* (Filador type) and *Microlamina*r (Epimagdalenian).

The end of the Pleistocene entails a major climate change at a global scale, which is directly related to the disappearance of the pleniglacial hunter-gatherers groups' lifestyle. This event it is clearly linked to ecological changes derived from weather conditions, and manifests itself into an ecological diversification by hunter-gatherers groups. The analysis of these archaeological sites seeks to highlight the importance of variables, such as the environment and the functionality of these enclaves, in relation to the presence of leporid accumulations and the activities developed by prehistoric hunter-gatherers populations within such enclaves.

CHAPTER 7

APPLIED METHODOLOGY

In this chapter we discuss the methodology used in the taphonomic analysis of leporid remains from our archaeological sample. It follows that applied in previous works carried out with modern leporid assemblages originated by different predators (Lloveras et al., 2008a, 2008b, 2009a, 2009b, 2012a, 2012b) and leporid remains from archaeological assemblages (Lloveras et al., 2010, 2011; Rosado-Méndez et al., 2015). The information is divided into the following sections: material processing and the creation of a database, taxonomic determination, age of death, anatomic representation, breakage patterns and type of fractures, bone surface alterations, quantification of the remains, and experimental research.

7.1. MATERIAL PROCESSING AND DATA RECORDING

The leporid remains analysed for this dissertation were recovered from three archaeological sites in the northeast of the Iberian Peninsula: Cova de la Guineu, Font Voltada and Balma del Gai. The analysed material was recovered using different methods according to the excavation plan proposed by the excavation team that intervened in each archaeological dig. The specific methods will be described in the chapters assigned for each archaeological site. The remains were collected manually during fieldwork and in the process of: 1) dry sieving through 5 to 1 mm superimposed meshes in Font Voltada and Cova de la guineu, and 2) wet sieving through 5 to 0.5 mm meshes in Balma del Gai. Remains from the Font Voltada archaeological site came from the *Museu Comarcal de la Conca de Barberà* (Montblanc) and were already clean and ready for analysis. Remains from Cova de la Guineu were provided by Artur Cebrià. While leporid remains from Balma del Gai, due to the presence of some sediment concretions, were carefully cleaned with a soft brush and water, and left to dry before the taphonomic analysis. Using the Filemaker Pro Advanced 13 and Windows Excel software, a database was created based on the information extracted from the visual analysis (reference, location, taxonomic determination, anatomic representation, left or right side, age of death, bone surface alterations, type of fractures, length in millimetres and observations) for every one of the analysed remains. The SPSS Statistic programme was used for the analysis of differential conservation.

7.2. TAXONOMIC DETERMINATION

In the past, taxonomic distinction between genera *Oryctolagus* (rabbits) and *Lepus* sp. (hares) was based on body size and the morphology of the first inferior premolar (P_3). Presently, there are several studies in which biometric and morphological criteria are proposed in order to distinguish between rabbits and hares (Callou, 1997; De Marfà, 2009; Llorente, 2010; López-Martínez, 1989). For this study on archaeological leporid assemblages, we have relied on size difference and on the criteria established by Callou (1997). Callou's study provides information about diagnostic traits present on different skeletal elements; see for example Fig. 7.1 and Fig. 7.2, being an useful criteria to distinguish between from rabbits and hares. In the cases when there has been certain doubts about the taxonomic determination of a particular remain, we referred to the reference collections from the archaeology laboratory of the University of Barcelona.

7.3. DETERMINATION OF AGE OF DEATH

There are two methods to establish age of death. The first method is based on leporid bone growth and stages of fusion of skeletal elements (Hale, 1949; Rogers, 1982; Taylor, 1959), taking into account that epiphyses of long bones do not fuse to its corresponding bone shaft until the end of the growing period. The same occurs with the rest of skeletal elements such epiphyses of metapodials, ilium, ischium and pubis, which are elements that correspond to the innominate, and the coracoid and acromial processes in the scapulae. Based on work done previously, Hale (1949), Taylor (1959) and Rogers (1982) compiled the ages of epiphyseal fusion of the primary long bones. It was established that individuals over 9 months should be classified as adults, individuals between 5 and 9 months be considered as sub-adults, and individuals less than 5 months classified as infantile and/or kitten. The other method consists in the analysis of teeth eruption and wear (Jones, 2006).

The estimation of age of death for the leporid assemblages studied for this dissertation was based on the epiphyseal fusion of long bones, metapodials, scapulae and innominate; in that way establishing two categories: adults (with fused elements) and immature individuals (sub-adults and infantile). Age of death was recorded as *fused* (F) and *not fused* (NF) and the percentage of adults was calculated based on the total of fused remains over total amount recorded remains (Fig. 7.3).

7.4. ANATOMIC REPRESENTATION AND DIFFERENTIAL CONSERVATION

Recovered remains were identified anatomically, whenever possible. Remains that could not be associated to any skeletal element were considered as indeterminate, and though they were counted, they were left out of the analysis. The code used to record each skeletal element appears in Table 7.1. To evaluate the anatomical representation of our sample the number of determined remains (NDR) was counted, and its percentage calculated relatively to the total sample. The minimum number of elements (MNE) was calculated for each element as well as the minimum number of individuals (MNI), based on the highest number for any element and taking into account laterality (right/left), age of death (F/NF) and size (Lyman, 1994; Reitz and Wing, 2008).

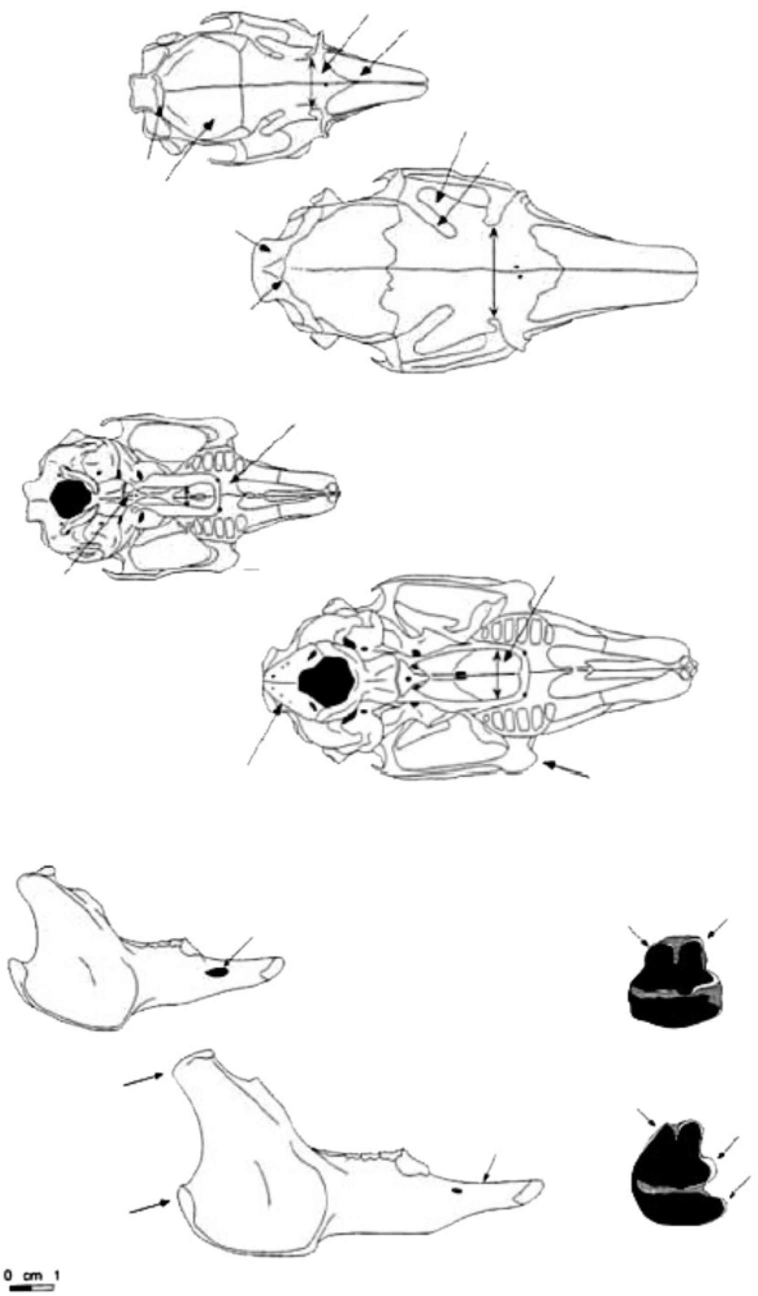

Figure 7.1. Morphological differences between cranial remains from rabbit (superior) and hare (inferior). Illustration modified from Callou (1997).

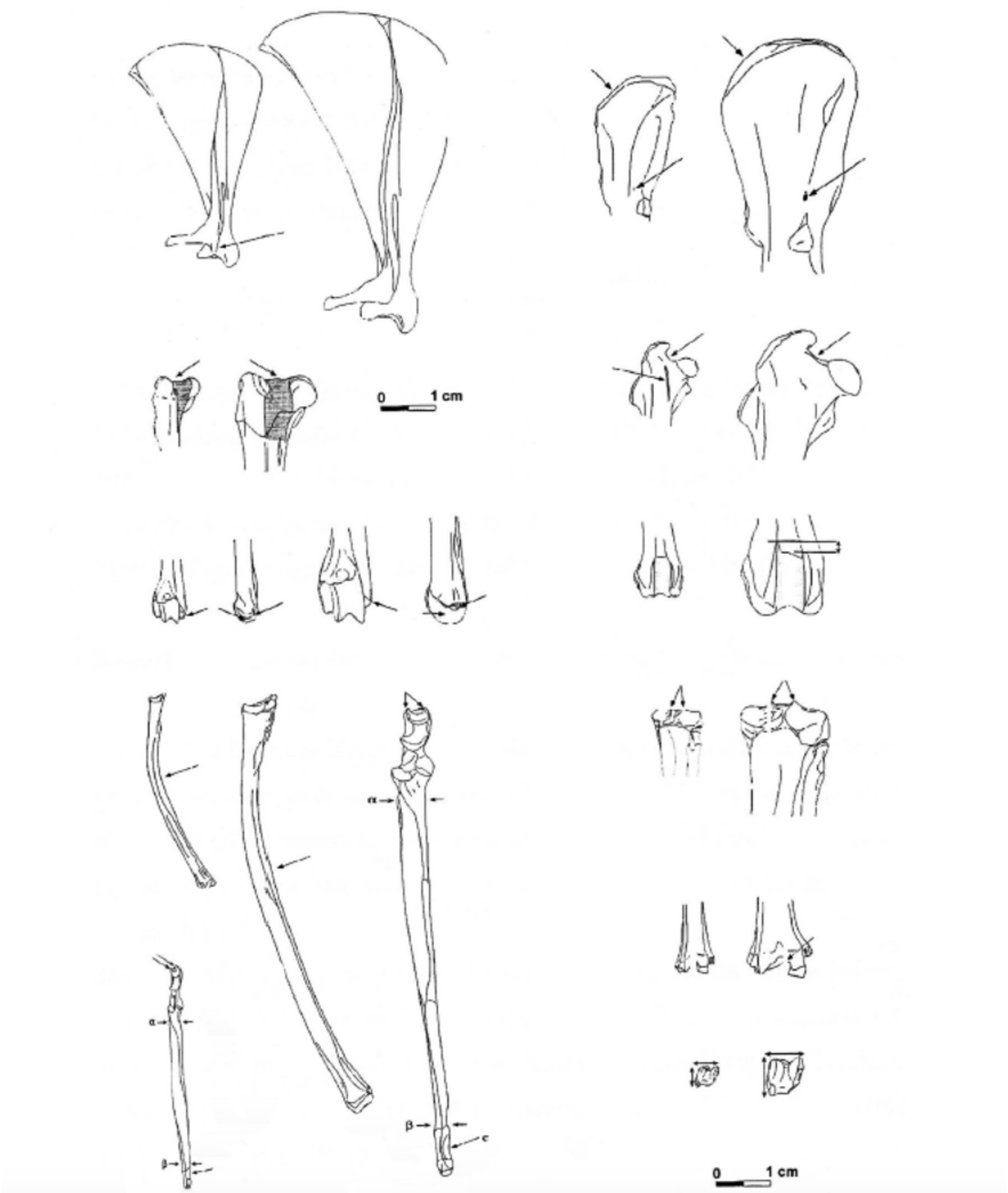

Figure 7.2. Morphological differences between postcranial remains from rabbit (superior) and hare (inferior). Illustration modified from Callou (1997).

Figure 7.3. (A) Humerus bone of an adult rabbit (fused) and (B-C) a sub-adult and infantile individuals (not fused). Modified from Lloveras (2011).

Table 7.1. Codes used in the determination of skeletal elements.

Skeletal element	Code	Skeletal element	Code
Cranium	Cr	Ribs	Rib
Mandible	Md	Innominate	IN
Upper molar	UM	Femur	Fem
Lower molar	LM	Tibia	Tib
Incisors	Inc	Metacarpals	Mtc
Scapulae	Sca	Metatarsals	Mts
Humerus	Hum	Calcaneum	Cal
Radius	Rad	Astragalus	Ast
Ulna	Uln	Patella	Pat
Carpal/Tarsal	C/T	Phalanges ½	Phal ½
Vertebrae	Ver	Phalanges 3	Phal 3

The relative abundance (RA) of each element was also calculated using the formula proposed by Dodson and Wexlar (1979). It relates the observed MNE for any given element and the theorical number of remains that one might expect to find in the sample as from the MNI. In Dodson and Wexlar (1979) formula, RA_i: relative abundance of element *i*, MNE_i: minimum number of skeletal element *i*, MNI: minimum number of individuals based on the highest number of any skeletal element, and E_i: the number of elements *i* present in the leporid skeleton.

$$RA_i\,(\%) = \frac{MNE_i}{E_i\,(MNI)}\,(100)$$

In addition, anatomic representation has also been evaluated taking into consideration the proportions of skeletal elements. Because of this, proportions of skeletal elements were evaluated using several indices for the study of micro mammals (Andrews, 1990) and leporids (Lloveras, 2011).

Proportions between postcranial and crania elements have been assessed applying the following indexes:

- PCRT/CR- the total number of postcranial elements was compared with the total number of crania elements (cranium, mandibles, maxillae and teeth) (Fig. 7.4a).
- PCRAP/CR- the total number of appendicular skeleton elements (long bones, scapulae, innominate, patellae, metapodials, carpal, tarsals and phalanges) was compared to crania elements (cranium, mandibles, maxillae and teeth) (Fig. 7.4b).
- PCRLB/CR- the total number of long bones (humerus, radius, ulna, femur and tibia) was compared to crania elements (cranium, mandibles, maxillae and teeth) (Fig. 7.4c).

The loss of distal elements was assessed applying the following indexes:

- AUT/ZE- the number of elements corresponding to the autopodium (metapodials, carpals, tarsals, phalanges, calcanei and astragals) compared to elements corresponding to the zigopodium and stylopodium (tibia, radius, ulna, humerus, femur and patellae) (Fig. 7.4d).

- Z/E- the number of elements corresponding to the zigopodium (tibia, radius and ulna) compared to elements corresponding to the stylopodium (femur and humerus) (Fig. 7.4e).

The proportion between elements from the anterior and posterior extremities was assessed applying the following index:

- AN/PO- the number of elements corresponding to the anterior extremities or forelimbs (humerus, radius, ulna and metacarpals) compared to elements corresponding to the posterior extremities or hind limbs (femur, tibia and metatarsals) (Fig. 7.4f).

In all the cases, calculations were done using the MNE. To compensate for the difference between the numbers of skeletal elements that are being compared it is necessary to apply a correction factor (Lloveras, 2011) (Table 7.2).

Differential conservation in relation to bone density was evaluated using the bivariate Spearman’s rho correlation (Grayson, 1984), taking into account the data provided by Pavao and Stahl (1999) independent measures of rabbit bone density, in which the maximum density of each skeletal elements is checked against its relative abundance percentage. When results are deemed positive, bone loss within the assemblage may be related to post-depositional processes; on the other hand, if the results are negative, it may be accounting for other factors such as predation or differential transport of different parts of the carcasses.

7.5. BREAKAGE PATTERNS AND TYPES OF FRACTURE

The breakage patterns have been described from the maximum length identified skeletal elements. The mean value and the percentage of remains under 1 mm were calculated. We also estimated the percentage of complete bones, isolated teeth and articulated remains. Long bones cylinders, which are fragments of long bones with snapped ends as a result of consumption, were also counted and registered. Anatomically determined bones have been classified in accordance to the part of the represented fragment. Different breakage categories were used depending on bone type (Lloveras, 2011; Lloveras et al., 2008a):

- Long bones such as humerus, radius, ulna, femur, tibia, metacarpus and metatarsus were classified as: complete (C), proximal epiphysis (PE), proximal epiphysis + shaft (PES), shaft (S), shaft + distal epiphysis (SDE) and distal epiphysis (DE) (Fig. 7.5).

- Innominate elements were recorded as: complete (C), acetabulum (A), acetabulum + ischium (AIS), acetabulum + ischium + ilium (AISIL), acetabulum + ilium (AIL), ischuium (IS) and ilium (IL) (Fig. 7.5).

- Scapulae remains were registered as: complete (C), glenoid cavity (GC), glenoid cavity + neck (GCN), neck (N), neck + fossa (NF) and fossa (F) (Fig. 7.5).

- Elements composing the skull were registered separately. Bones corresponding to the cranium were classified as complete (C), incisive bone (IB), incisive bone + maxilla (IBM), maxilla (M), zygomatic arch (AZ) and neurocranium (NC). On the other hand, mandible fragments were registered as complete (C), incisive part (IP), mandible body + incisive part (MBI), mandible body (MB), mandible body + branch (MBB), branch (B) and condylar process (CP). Dental pieces were recorded as: complete (C) and fragments (F). Following the methodology proposed by Andrews (1990), and Fernández- Jalvo and Andrews (1992), breakage of teeth was calculated separately for isolated and in situ pieces. They were classified as complete (C) and fragment (F) (Fig. 7.5).

- Skeletal elements such as carpals, tarsals, patellae, calcanei, astragals, phalanges 1/2, phalanges 3 and ribs were recorded as: complete (C) and fragment (F).

- Vertebrae fragments were classified as: complete (C), vertebral body (VB), vertebral epiphysis (VE) and spinous process (SP).

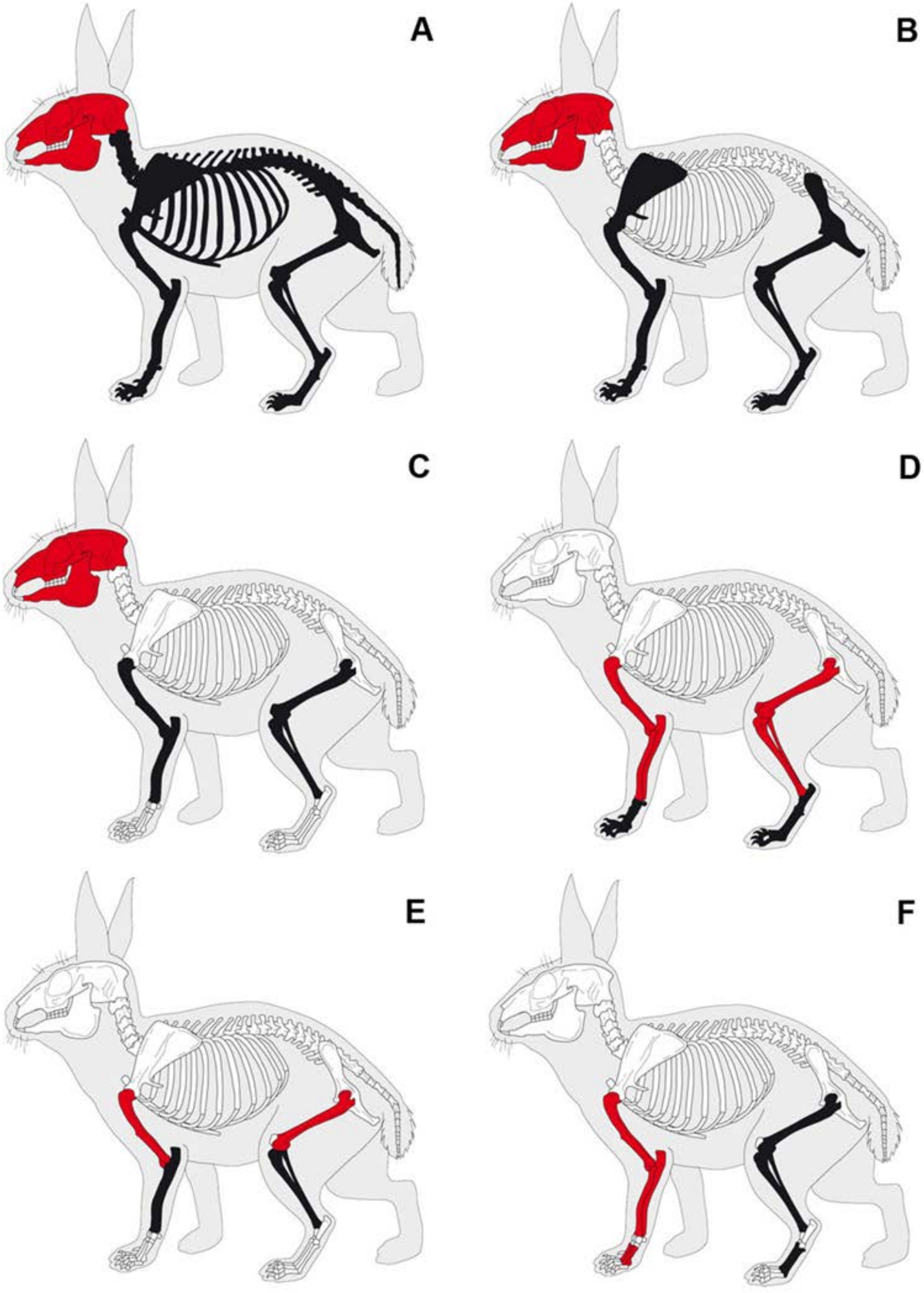

Figure 7.4. Elements compared within the anatomical representation indexes. (A) PCRT/CR index- cranial elements (red) and postcranial elements (black); (B) PCRAP/CR index- cranial elements (red) and appendicular elements (black); (C) PCRLB/CR index- cranial elements (red) and long bones (black); (D) AUT/ZE index- autopodium elements (black), and zygopodium and stylopodium elements (red); (E) Z/E index- zygopodium elements (black) and stylopodium elements (red), and (F) AN/PO index- anterior elements (red) and posterior elements (black).

Table 7.2. Correction factors applied to the calculus of anatomic representation indexes.

INDIXES	Correction factor
PCRT/CR	32/165
PCRAP/CR	32/114
PCRLB/CR	32/10
AUT/ZE	12/98
Z/E	4/6
AN/PO	12/16

Long bones were also analysed while attempting to distinguish between green (fresh) and dry fractures (Johnson, 1985; Villa and Mahieu, 1991). Fractures were recorded as: dry fractures (DF), green or fresh fractures (FF) and modern fractures (MF). Differences between different types of fractures were distinguished (angle, profile, line of fracture, circumference, width, and length of the fractures). Fresh bone (FF) fractures exhibit oblique and acute angles, with a curve and spiral fracture profile (V form), and smooth borders. Dry fractures (DF) tend to have straight angles, with longitudinal and transverse profiles, irregular fracture line, and rugged border. In the case of modern fractures (MF), the fracture lines displays a white colour.

7.6. BONE SURFACE ALTERATIONS

Damage to the surface of the bone was examined both macroscopically and microscopically. All of the skeletal remains were observed under an Olympus light microscope S261 (x10 – x45) and Olympus KL 1500 compact light source. The material was photographed using Olympus microphotography systems: SZ61-TR/KL 1500/SC20/CELL^B.

7.6.1. Digestion

The assessment of bone surface damage caused by digestion was based on methods proposed by Andrews (1990), and Fernández- Jalvo and Andrews (1992) for the study of micromammals, and later on modified by Lloveras *et al*. (2008a; b) for the study of leporid remains. Five degrees of digestion were recorded:

- *Null (0)-* No traces were observed.

- *Light (1)-* Less than 25% of the bone surface is lightly altered. Digestion damage is concentrated in specific bone areas, there is the presence of pitting and the edges of the bone may be slightly rounded.

- *Moderate (2)-* Between 25 and 75% of the bone surface are altered. The effects of pitting increases with the occurrence of localized destruction to the bone. Bones with moderate damage may suffer splitting and rounding of edges.

- *Heavy (3)-* The entire surface of the bone is affected with extensive pitting and the presence of small holes. Bone destruction might show in more than 50% of the bone surface. At this point it shows splitting, cracking and extensive rounding of edges.

- *Extreme (4)-* There is a significant damage to the bone surface and structure due to corrosion. Anatomical identification of the skeletal element is difficult at this point.

7.6.2. Tooth/Beak marks

Mechanic alterations caused by the action of teeth/beak, from humans and non-human predators were identified, noted and counted. Skeletal element and the area were the mark was situated was also registered (Landt, 2007; Lloveras et al., 2009b). Following the methodology developed for the study of macrofauna remains (Binford, 1981; Haynes, 1980,1983) and considering the data provided by other studies dealing with tooth/beak marks on small prey (Landt, 2007, Lloveras et al., 2008a, 2008b, 2009a,b, 2012a,b; Sanchis Serra et al., 2011; Rodríguez-Hidalgo et al., 2013b) tooth marks were classified as:

- *Tooth punctures (TPU)-* punctures that breaks through the cortical bone leaving the edges intact. This type of mark leaves an impression in circular or oval shape. In the interior of the impression flattening of cortical layers occur (Fig. 7.6a).

- *Tooth pits (TPI)*- depressions or notches that shows flattening of the cortical layers around the impression margins. It's a shallow and oval shape impression (Fig. 7.6b).

- *Scores (SCO)*- scoring or elongated impressions with rounded sections in the cortical matrix. Sometimes it exhibits internal flattening along the edges (Fig 7.6b).

- *Crenulated edges (CRE)*- split edges that divide into two bone layers. These marks leave internal flattening along the split edges and are associated with indicators such as: localized force, punctures, notches and superficial scoring (Fig 7.6c).

- *Notches (NO)*- a dent that breaks into the bone due to compression, which results into a dissected margin. Flattening of the cortical layer and spongy bone may occur (Fig 7.6d).

The presence of damage related to carnivores gnawing with multiple types of alterations (punctures, pits and scoring) in the same specimen was taken into consideration. The location of marks (part and side of the bone) was also registered.

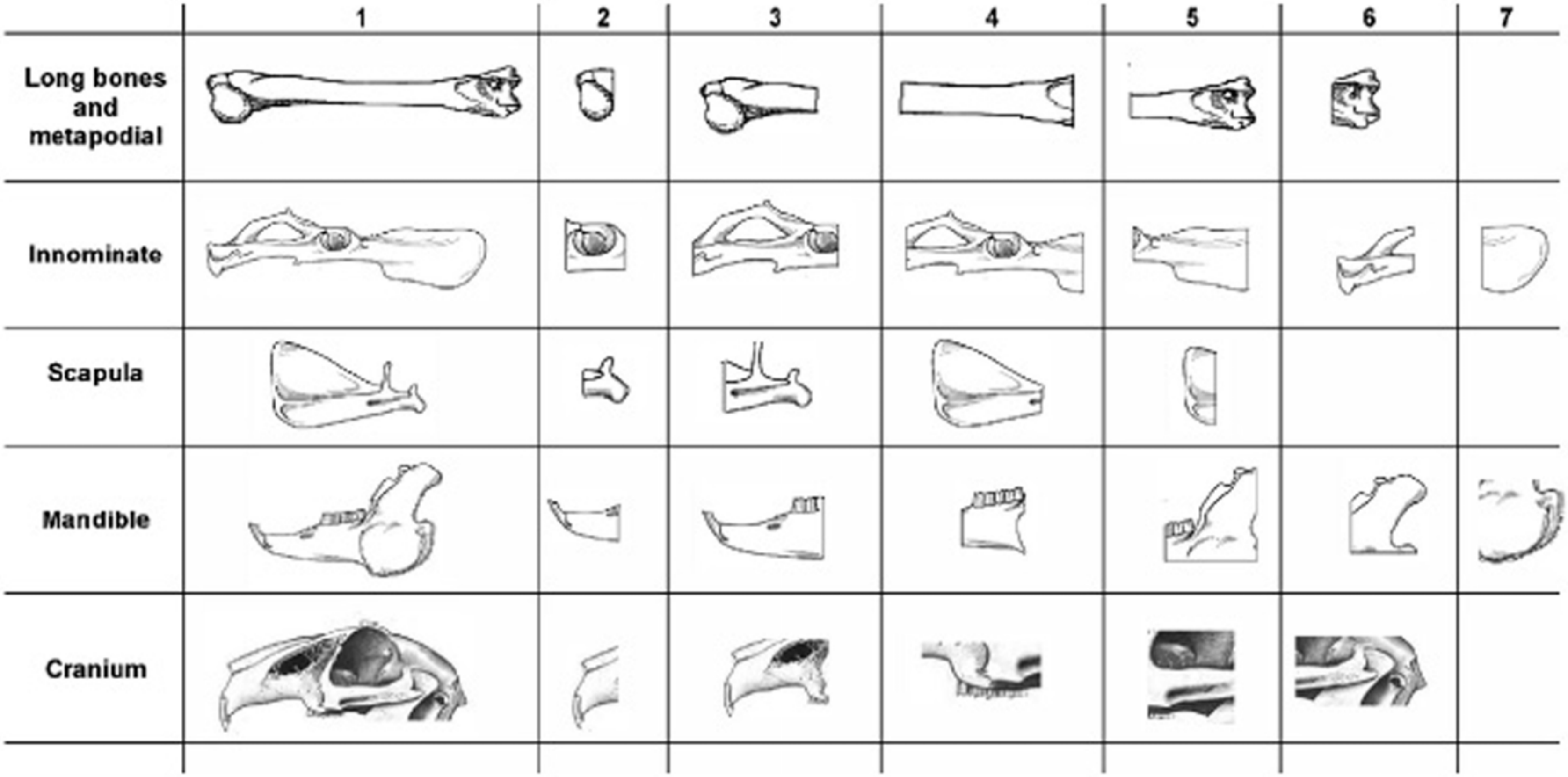

Figure 7.5. Long bones and metapodials were classified as: 1 Complete (C); 2 Proximal epiphysis (PE); 3 Proximal epiphysis + shaft (PES); 4 Shaft (S); 5 Shaft + distal epiphysis (SDE); and 6 Distal epiphysis (DE). **Innominate** as: 1 Complete (C); 2 Acetabullum (A); 3 Acetabullum + ischium (AIS); 4 Acetabullum + ischium + ilium (AISIL); 5 Acetabullum + ilium (AIL); 6 ischium (IS); and 7 ilium (IL). **Scapula** as: 1 Complete (C); 2 Glenoid cavity (GC); 3 Glenoid cavity + neck (GCN); 4 Neck + fossa (NF); 5 Fossa (F); and 6 Glenoid cavity + neck + fossa (GCNF). Modified from Lloveras et al., 2008a.

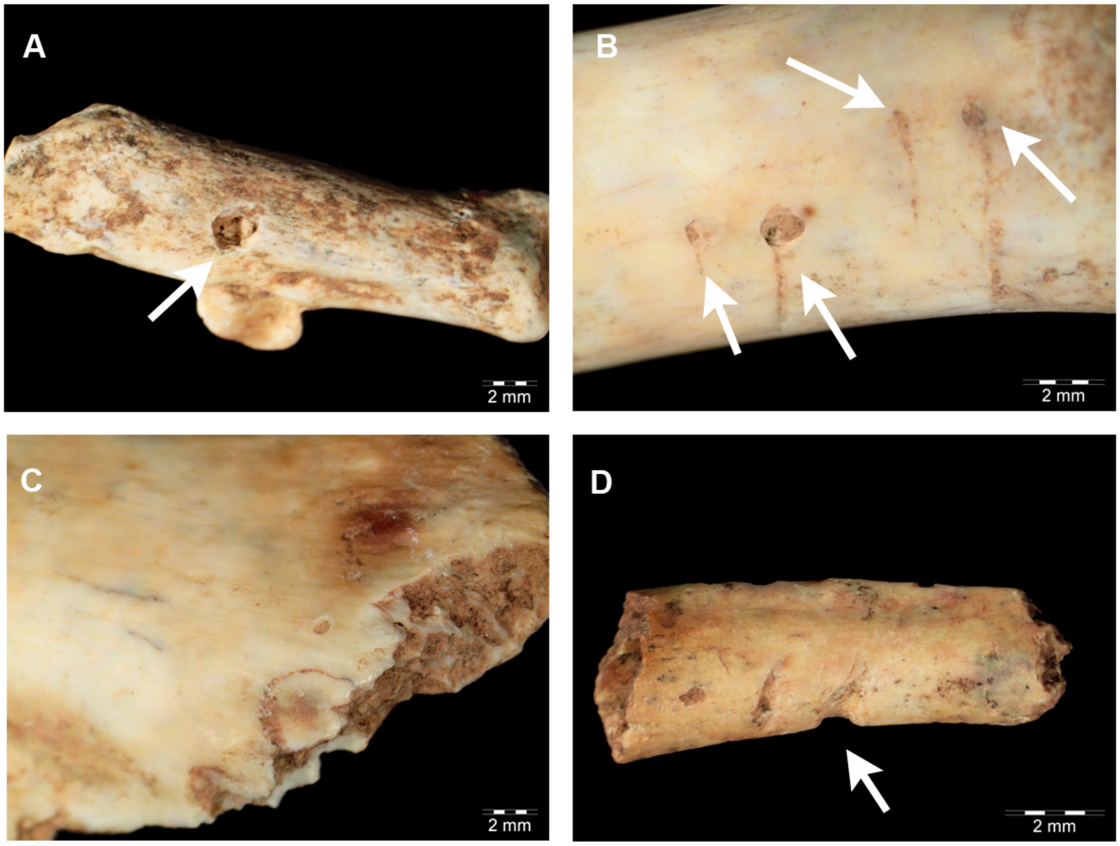

Figure 7.6. (A) Puncture located on the calcaneus bone, (B) Pits and scoring marks on the shaft of a tibia bone, (C) Crenulated edges on an innominate (ilium), and (D) Notches on a rib.

7.6.3. Cutmarks

Leporid remains recovered from the archaeological sites included in this study have been examined in order to detect the presence of possible cutmarks left by human activity during the processing of the carcass (Fig. 7.7). For this matter, it has been taken into account the criteria established for the study of macromammals (Binford, 1981; Bromage and Boyde, 1984; Shipman and Rose, 1984), which are:

- Shape of the striae. Transversal section in a “V” shape and micro striation background.
- The presence or absence of a barb, which is the shallower end of the groove slightly curved to the side in the form of an open hook (Domínguez- Rodrigo et al. 2009).

- The presence of the *shoulder effect* and its associated striae (Shoulder effect is defined as the striae that occur in association with the main groove or cutmark in a distance not farther than 0.2 mm from the edge of the groove) that frequently occur parallel to the groove.

Obtained results from previous studies on cutmarks in archaeological leporid remains (Pérez Ripoll, 2004) have been taken into consideration. Following the methodology posed by Lloveras et al. (2009b), cutmarks orientation, along the main axis of the skeletal element (longitudinal, transversal and oblique), intensity and location have been recorded. Due to the difficulty in differentiating cutmarks from marks caused by trampling, reference data from experimental research on distinguishing cutmarks from pseudo-marks have been used (Blasco et al., 2008, de Juana et al., 2010; Domínguez- Rodrigo et al., 2009; Domínguez- Rodrigo et al., 2010; Fernández-Jalvo and Cáceres, 2010; Gaudzinski-Windheuser et al., 2010).

Also, to correctly evaluate this type of alteration, as well as the activities associated with it (skinning, butchering and defleshing), we have conducted an experimental study on leporid carcass processing. Our results have been applied in our study of archaeological remains. For more detail please refer to Chapter 5 in Part II of the thesis.

7.6.4. Burnt marks

Burnt marks occur when bone come in contact with fire. As a consequence of anthropic activity, especially those derived from cooking practices for example roasting and cooking directly over ember, accidental exposure, bone remains may present traces. This type of activity may cause changes in bone coloration not to mention its internal structure. According to Stiner et al. (1995), depending on temperature and time of exposure the remains may acquire a characteristic coloration, from yellowish to ochre tones when lightly burnt, to brown tones when exposed to more intense temperatures, to a black colour when charred, and finally grey and white tones when exposed to temperatures above 800º C.

Figure 7.7. Tibia bone from *Oryctolagus cuniculus* displaying cut marks located in the shaft close by the distal epiphysis.

The presence of burnt bones was acknowledged for our archaeological sample. Burnt remains were recorded according the part of the skeletal element affected by fire. The intensity of the damage cause by fire was recorded following the methodology develop by Shipman et al. (1984) and Stiner et al. (1995), based on colour: cream to tan/ not burned, light yellow to ochre/ light, brown tones/ moderate, black/ heavy, grey/ extreme and white/ calcinate.

To correctly evaluate this type of alteration, as well as the activities associated with it, we have conducted an experimental study on burning temperatures and it characteristic coloration. Our results have been applied in our study of archaeological remains. For more detail please refer to Chapter 6 in Part II of the thesis.

7.6.5. Other alterations

Beside bone surface alterations caused by humans and non-human predators, leporid remains may suffer from other alterations caused by other agents, before or during the depositional process. This type of alterations may occur as a result of biotic (bioturbation, plants, microorganism etc.) and abiotic factors (as a consequence of non biological processes). Modifications cause by both biotic (trampling, gnawing cause by rodent activity, bioerosion caused by microorganism activity and root etching) and abiotic agents (weathering, abrasion and diagenetic alterations) were identified and recorded.

7.6.5.1. Trampling

Trampling occurs when pressure is applied to the surface of the sediment, due to human and animal transit (Lloveras, 2011). This type of alteration can generate spatial disturbance, fragmentation and surface alterations on the remains (Andrews and Cook, 1985; Behrensmeyer et al., 1986; Cochard, 2004; Fiorillo, 1989, Nielsen, 1991; Olsen and Shipman, 1988). Alterations may vary depending on factors such as intensity, type of sediment, size and morphology of the remains, and the depth at which they were buried (Courtin and Villa, 1982). In addition to fragmentation and abrasion marks, trampling can cause a substantial vertical dispersion of the remains and horizontal displacement of bone remains located at the surface (Andrews and Cook, 1985; Courtin and Villa, 1982; Gifford-Gonzáles et al., 1985; Nielsen, 1991; Reitz and Wing, 2008). Skeletal elements that are most affected by trampling fragmentation are cranium elements, mandibular symphysis, scapulae, and fragile parts of bones such as apophysis and the spinous process of vertebrae. Alterations caused by trampling reflect the depositional history of a determined site, and in many cases it may be confused with intentional marks that are related to the different phases of carcasses processing (Reitz and Wing, 2008), which can lead to misinterpretation on whether there has been anthropic activity or not. Pseudo cut marks make result from the pressure, dragging and friction between the bone surface and the sediment. Not only they may mimic cut marks but also are difficult to distinguish at a microscopic level (Dominguez-Rodrigo et al., 2009).

Experimental research done over the past few years (Andrews and Cook, 1985; Barisic et al., 2007; Behrensmeyer et al., 1986; Blasco et al., 2008; Domínguez- Rodrigo et al., 2009; Fiorillo, 1989, Nielsen, 1991; Olsen and Shipman, 1988) show that striations mark cause by trampling may appear isolated or in clusters of straight lines. Unlike marks left by lithic tools, this type of striations does not present a narrow section that may indicate directionality and, furthermore, they do not exhibit the “shoulder” effect, which are parallel striations associated to a cut mark.

7.6.5.2. Rodent Gnawing

Rodent activity can also leave marks on the bone surface. It also can give away information on bioturbation. Many rodents of different sizes such as squirrels, mice, rats, or porcupines gnaw bones. They gnaw on bones with their 4 incisors, which grow throughout life and a way to keep them aligned is to gnaw, also they consume bone in order to obtain minerals or soft tissue and marrow in fresh bone (Lloveras et al., 2016; Munuhe Kibii, 2009; Pokines, 2013). This activity leaves parallel marks, closely spaced and flat-bottomed on the bone surface (Brain, 1981; Lyman, 1994; Reitz and Wing, 2008; Shipman and Rose, 1984).

Bone surface alteration caused by rodents gnawing can vary depending on the condition of the bone:

- Dry bone- it has been documented in porcupines and small sized rodents. Gnawing occurs because of the movement of the incisors teeth onto the bone surface in order to reduce hard fibrous substances. According to Haglund (1997), during this activity the superior incisors press hard into the bone freeing the mandible, which allow the inferior incisors to perform a repetitive movement, up and down, like a chisel. This process leaves marks, which can be easily identified: short striae, parallel in orientation, and displaying different widths depending on the rodent species. Rodent gnawing marks normally are concentrated on the edges of skeletal elements. A repetitive gnawing in a same element may end up affecting its surface, leaving irregular areas (Fig. 7.8).

- Fresh bone- small sized rodents, like mice and rats, may carrion on fresh remains. This behaviour often produces important damage on bone tissue, normally on the thin edges of bones, especially epiphyses of long bones (Haglund, 1997; Lloveras et al., 2016; Pokines, 2013). In this case, pieces of bone may disappear in the epiphyses area, and striae situated on the cortical area may be present (Fig. 7.9).

7.6.5.3. Modifications by microorganisms

Microorganism such as bacteria and fungi, which are present during decomposition of organic matter or present on the depositional sediment, can cause bioerosion; thereby degrading bone remains (Jans, 2008; Jans et al., 2004; Nielsen- Marsh et al., 2007; Reitz and Wing, 2008). Bioerosion happens when microorganisms modify, chemically or mechanically, hard tissue (bone) as a consequence of microbial activity (Blumenschine et al., 2007; Davis, 1997). According to Bell and colleagues (1996) bioerosion is controlled by environmental factors like temperature, water, presence of light and oxygen, and type of soil (Davis, 1997; Turner-Walker, 2008). Contrary to the chemical deterioration that can be accelerated by lower pH and high temperatures, microbial activity is optimal in neutral pH. The main organisms involved in this process are fungi, cyanobacteria (aquatic environments) and bacteria; each of them creates a distinctive type of bone surface alteration (Blumenschine et al., 2007; Davis, 1997; Jans, 2008).

Fungi and cyanobacteria dissolve the bone creating tunnels in order to consume its collagen. In general, fungi don't damage the microstructure of the bone, which means that several species of fungi might use bone material as a medium (Jan, 2008). Fungi alterations are common in animal remains, which can be related to the fact that fauna remains in archaeological sites are often buried without meat as a result of food processing (Jans et al., 2004; Jans, 2008; Turner-Walker, 2008.). Cyanobacteria alterations are only seen in remains that have been deposit in marine and lacustrine environments (Davis, 1997), and they are very similar to the Wedl type tunnels caused by fungi (Davis, 1997; Jans, 2008), with an approximate diameter of 5-7μm and only affecting the superficial area (Fig. 7.10). Davis (1997) and Jans (2008) have observed that by covering the remains in sediment, bioerosion by cyanobacteria activity can be prevented. The other main organisms that can cause bone surface alterations are bacteria, which can create focalize destruction and exhibits a complex morphology (Fig. 7.11). Bacteria attack can cause an increment in bone porosity, consequently causing a substantial degradation of organic matter (Jans, 2008). Hackett (1981) described three types of microscopically focal destruction: (1) lineal longitudinal, (2) budded, and (3) lamellate. Bacterial alterations in bone may initiate right after death (Bell et al., 1996) and may last to 100-500 years (Dixon et al. 2008, Hedges et al., 1995).

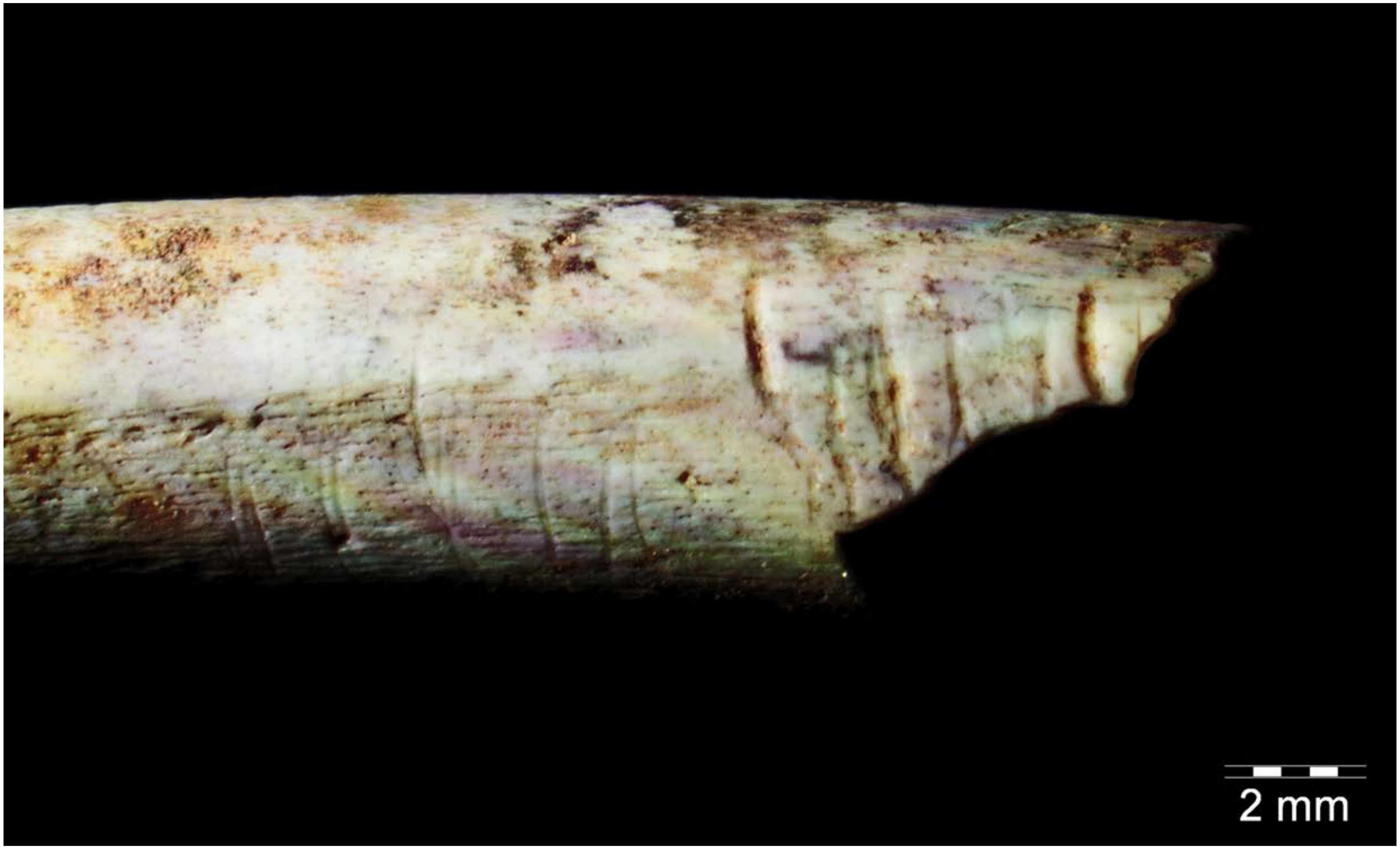

Figure 7.8. Rodent gnawing in dry bone. Archaeological femur shaft from *Oryctolagus cuniculus* displaying rodent gnawing.

Figure 7.9. Alterations caused by gnawing of a small rodent (*Mus spp.)* in *Oryctolagus cuniculus* fresh long bones. Modified from Lloveras et al., 2016.

Since it is difficult to identify which microorganism cause each alteration, Pirrone et al. (2014) propose to classify each alteration according to morphology, taking into consideration: general morphology (from a top view), site of emplacement (profile view), pattern of occurrence, morphology of bioglyphs, morphology of the filling, branching and location.

7.6.5.4. Root marks

Flora activity can have important effects over remains deposited on the surface, creating different types of chemical and mechanic alterations. On the other hand, plant growth over skeletal remains may indicate the time of deposition. Among the alterations caused by plant growth root etching is the most common. Evidence of root etching indicates the history of the bone's sedimentary environment. The roots of plants can cause bone surface alteration as a consequence of humic acid associated with the growth and decay of roots or fungus (Lyman, 1994). Bones, rich in nitrogen (N) and phosphate (PO_4^{3-}), are a nutrient resource for plants. Even though this kind of alterations occurs once the remains have been covered in sediment, it must be taken into account that it could also happen during the biostratinomic phase as a result of moss activity. Roots can contribute to the taphonomic history of a set of remains by:

- *Producing fractures and altering the spatial distribution*- on the one hand, root growth can alter the organization of the remains, modifying its original position. On the other hand, it can cause bone destruction upon contact. Roots can pass through the bone foramens and fissures present in the remains; when roots grow and become bigger it fractures and destroy the bone tissue from the inside out.

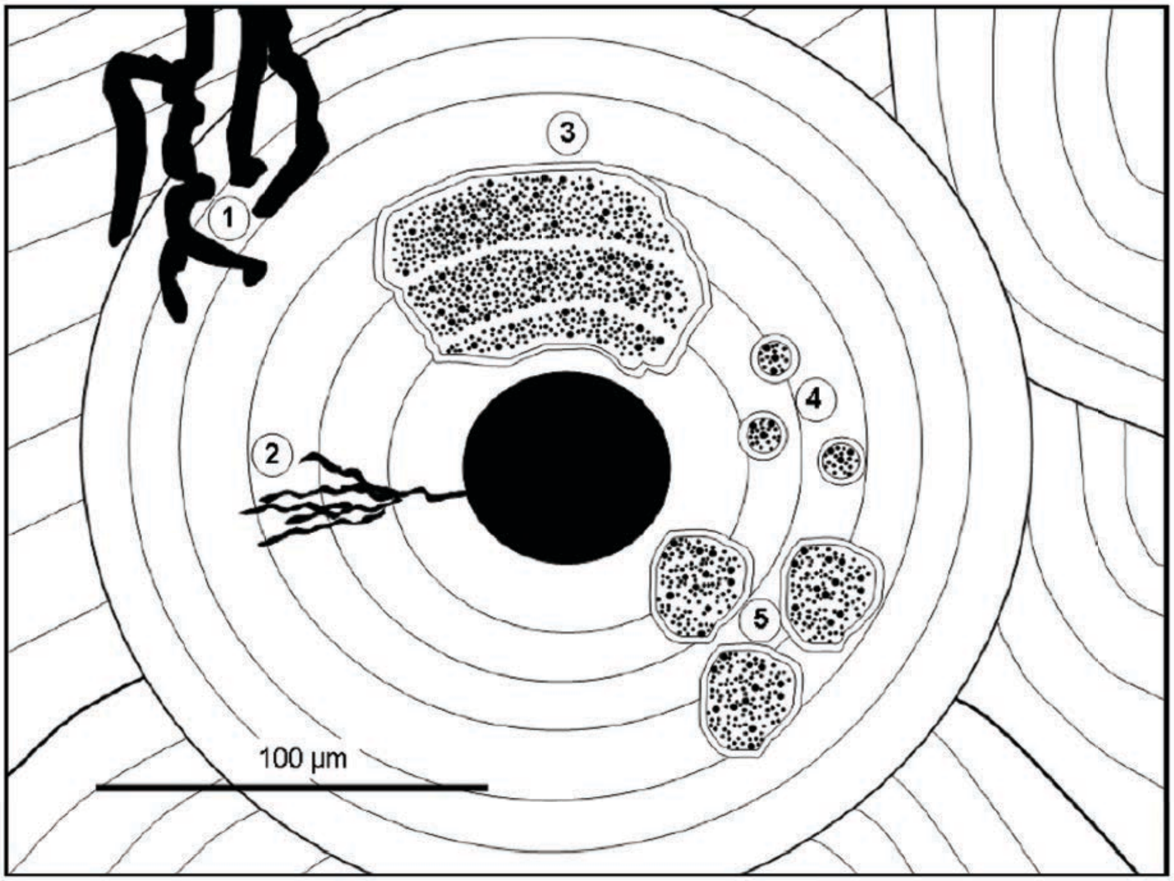

Figure 7.10. Schematic representation of a transversal section of bone showing an osteone with the different types of tunnels produced by microorganisms: (1) Weld tunnels Type 1, (2) Weld tunnels Type 2, (3) MFD *Lamellate*, (4) MFD lineal longitudinal and (5) MFD *Budded*. Modified from Jans (2008).

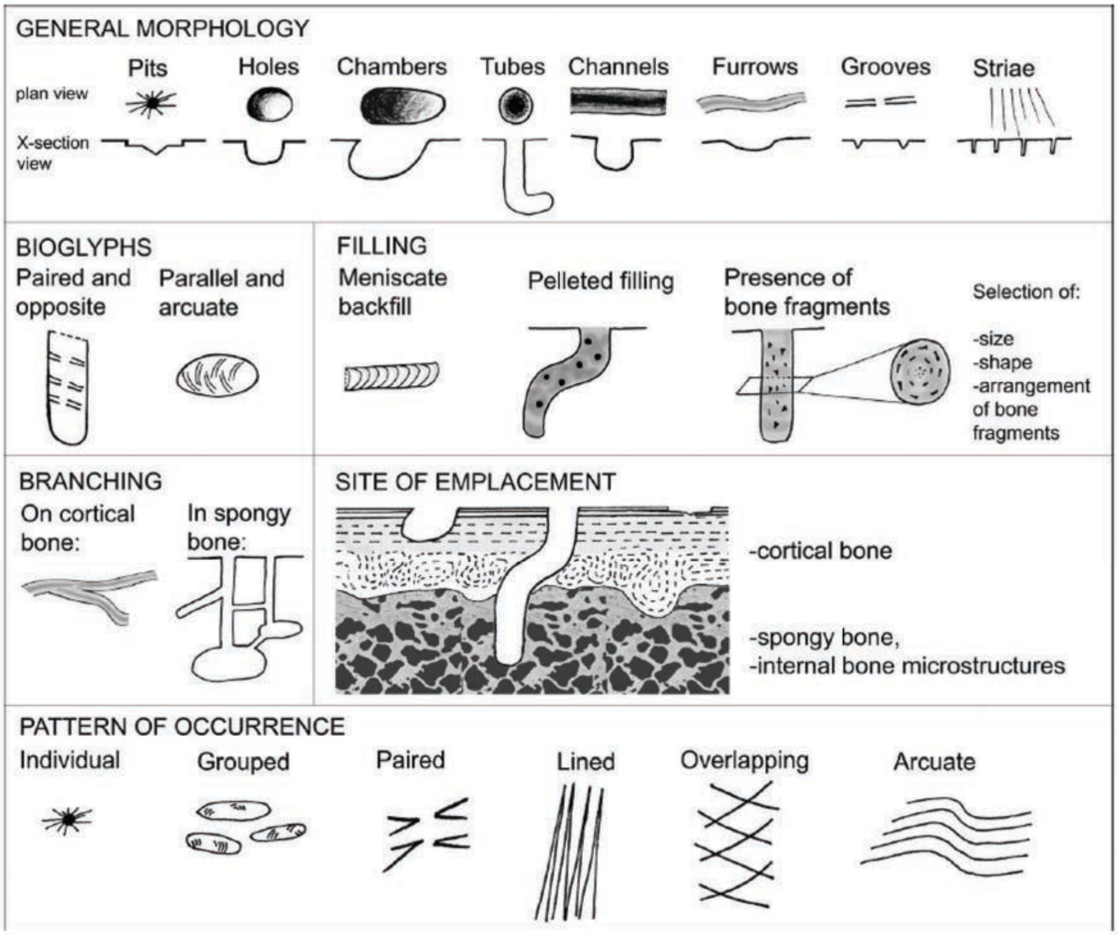

Figure 7.11. Schematic from Pirrone et al. (2014) showing the different characteristic traits to consider when the most common alteration due to bioerosion activity.

- *Root etching*- roots can cause destruction of the bone from touching the surface of the bone, leaving a pattern of marks called “root etching”. Besides humic acid, plants also secrete citric, malic and oxalic acid, all of which allow increasing the quantity of phosphorus (P) available for absorption (Bais et al., 2006). This acid compounds can dissolve the mineral content of the bone upon contact. Root marks are visible at a macroscopic level and are characterized by the presence of ramified grooves on the surface of the remains (Fig. 7.12).

Figure 7.12. Radius bone from *Oryctolagus cuniculus* displaying surface damage caused by root etching.

7.6.5.5. Weathering

The exposure of remains out in the open may result into the gradual decomposition of bone tissue due to chemical and mechanical transformation caused by different agents such as: exposure to sunlight, wind and water, as well as variations in temperature, humidity and soil conditions. Weathering is the process through which organic and inorganic components of bone are separate, and altered by physical and chemical agents (Behrensmeyer, 1978). It is a natural process, which involves the decomposition and destruction of bone tissue, so thus nutrients are recycled onto the soil (Behrensmeyer, 1978; Lyman, 1994; Reitz and Wing, 2008). This process reflects climatic variables in specific habitats, body size and age, and also help identifying between human and nonhuman accumulations (Behrensmeyer, 1978; Reitz and Wing, 2008). Bones affected by weathering are characterized by bleaching and exfoliation of the bone surface, longitudinal and parallel fractures extending from the proximal to distal end, the presence of a crackle effect in joint areas, and rounded edges, fragmentation, and total loss of the bone (Fig. 7.13).

Since one of the main factors of weathering is exposure to sunlight, and changes in humidity and temperature, the bleaching of the bone appears as a consequence of solar radiation. The bone progressively loses its natural colour until it acquires a whiter tone. Beary (2005) found a significant relation between duration of exposure to UV rays and the change of colour. Another important cause of degradation is the loss in humidity. The continuous exposure of the periosteum, a membrane adhered to the bone, results in the loss of water content and a gradual decrease of fat content (Junod and Pokines, 2013). Also, daily changes in temperature may provoke the bone to expand and contract. Damage cause by widening and contraction accumulates over time causing localized damage to the bone structure.

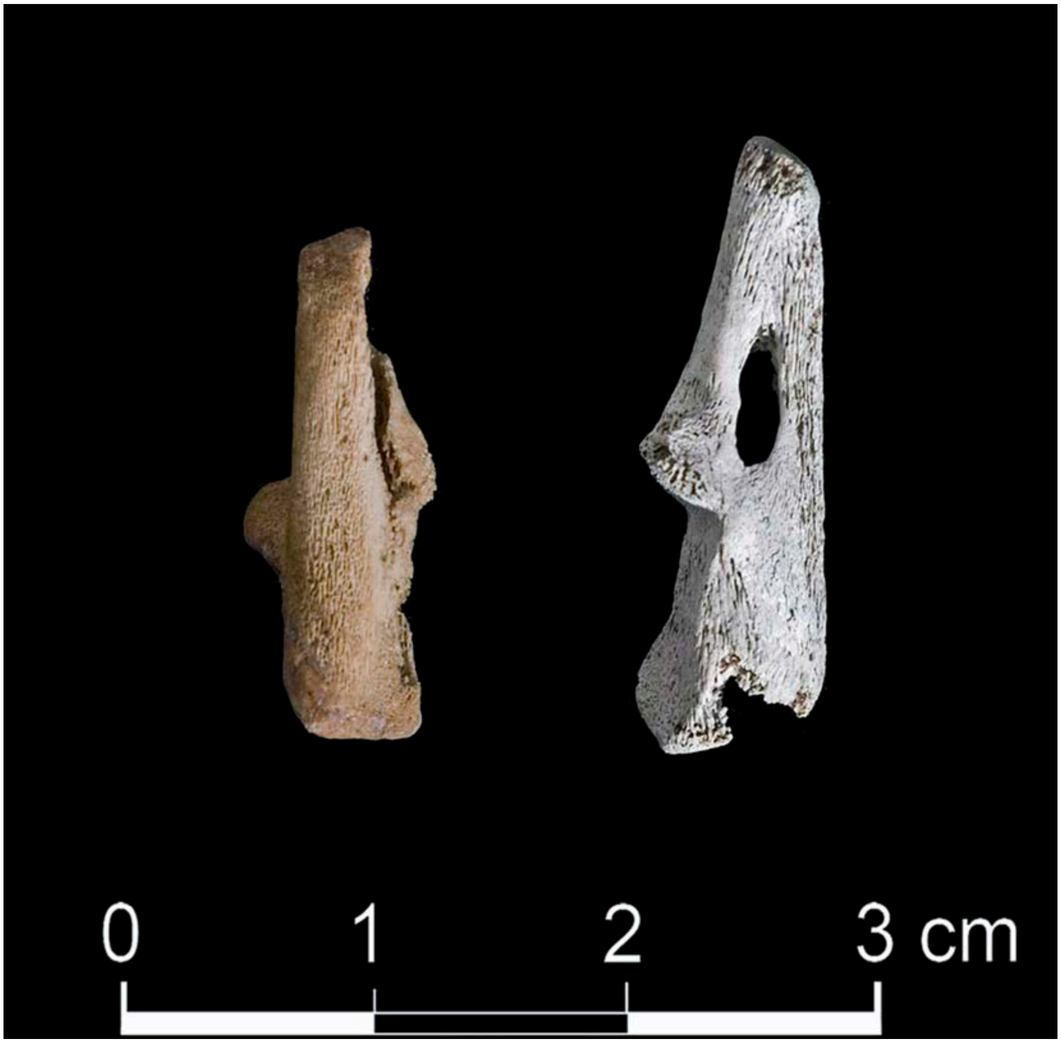

Figure 7.13. Anterior and posterior view of two rabbits' calcaneum bones affected by different stages of weathering. Modified from Lloveras (2011).

7.6.5.6. Abrasion

According to Bromage and Boyde (1984), abrasion is defined as the result of any agent, which through the application of physical force may erode the bone surface. Bone remains from archaeological sites tend to suffer abrasion caused by natural phenomena such as sand particles transported by wind, fluvial transport and sediment movement etc. Bone exposed to fluvial transport suffers damage on the entire surface. Such rough abraded surfaces result from flow of particles and water through the bone under pressure (Brains, 1967).

7.6.5.7. Dissolution

Dissolution can be defined as the loss of the mineral component of the bone through the action of water (Turner-Walker, 2008), this being one of the most important mechanisms responsible for bone destruction (Mays, 2010). As water penetrates through the bone tunnel system it dissolve and leach the mineral component (hydroxyapatite). The bone's durability it's related to the stability of its mineral components, however the degree of durability depends on the effective surface of skeletal elements. Parameters such as the increment in bone porosity, crystallinity, and ions uptake serve as indicators of dissolution. The solubility of the hydroxyapatite in water is conditioned by the pH and the presence of exogenous ions diluted on the soil. Once the dead bone is deposit in the sediment, the soil stands as some kind of open system with a determined chemistry. The dissolution of the mineral phase may occur through the external surface (in contact with soil) or bone porosities (Mays, 2010). If the soil's pH is low (acidic soils) calcium phosphates become soluble. Acidic soils dissolve bone creating small *pitts* that can increase in numbers and diameter altering the bone surface, and in the worst case destroying the bone completely (Andrews, 1990; Denys, 2002). It must be kept in mind that the degree of alteration raises with the increase acidity (Lower pH) of the soil (Nielsen-Marsh et al., 2007). Once the chemical dissolution begins the porosity of the bone increases permitting the entrance of water, which promotes more mineral dissolution incrementing even more bone porosity, until it disappears completely.

7.6.5.8. Concretions

This type of alteration is quite common in caves and rock shelters located in karst formations, where dissolved calcium carbonate ($CaCO_3$) is transported and precipitated by water. They can extensively affect the remains, and although bone do preserve well, it been proven difficult to separate bone from the carbonate concretions, and thus interfere with taphonomic analysis (Lyman, 1994).

7.6.5.9. Manganese oxide staining

Manganese oxide stains mostly occur in environments with a high percentage of humidity and the presence of puddles of water. This type of chemical alteration, due to the decomposition of organic matter, can cause a colour (from browns to black) change in bones and teeth, and its one of the most common taphonomic alterations seen in rock shelters and caves sites (Shipman et al., 1984; Stiner et al., 1995; Weiner et al., 1998; Weiner and Bar-Yosef, 1990).

CHAPTER 8

BALMA DEL GAI

8.1. LOCATION AND ARCHAEOLOGICAL BACKGROUND

The archaeological site of Balma del Gai is located in the municipality of Moià (Moianès, Barcelona), in the Northeast of the Iberian Peninsula (2º 08' 19'' E; 41º 49' 00'' N; UTM: 31TDG284297) (Fig. 8.1a and Fig. 8.1b). It is a small rockshelter 10.5 m long and 5.5 m wide. The surrounding landscape is conditioned by farming activities (Fig. 8.1c). Geographically, it is part of the Moià Plateau, at the southeast margin of the Ebro Depression. The site is 50 km inland from the present day coastline at 760 m above sea level. The Moià Plateau is constituted by sandstone and limestone from Eocene and Oligocene epochs, and wedges of conglomerate material in the southern area disposed horizontally which, from a morphological point of view, gives the appearance of a tabular landscape (Bergadà, 1998).

Joan Surroca discovered the archaeological site in 1975, and the first archaeological excavations took place between 1977-1978 under the supervision of Miquel Llongueras and Jean Guilaine (Estrada et al., 2011; García-Argüelles et al. 1997; Mangado et al., 2006). The fieldwork was focused on two areas: downstream and the exterior of the rockshelter (Estrada et al., 1990, Bergadà, 1998). Over the course of 1994 excavation works were reinitiated under the supervision of Pilar García-Argüelles, Jordi Nadal and Alicia Estrada to contrast the archaeological possibilities the site offered. Archaeological fielwork was re-iniciated in 2009 by Lluis Lloveras and Jofre Costa.

8.2. STRATIGRAPHIC UNITS

A preliminary stratigraphic sequence was determined following archaeological criteria (Llongueras and Guilaine, 1982):

- Superficial layer- 20 to 30 cm thick, composed by yellow, muddy and compact sediment.
- Layer 1- 25 cm thick, composed by yellow, muddy and compact sediment with limestone fragments.
- Layer 2- 10 to 15 cm thick, composed by a darker tone of yellow sediment.
- Layer 3- 19 cm thick, crumbly sediment with abundant amount of charcoal remains.
- Layer 4- it corresponded to a level of blocks and limestone fragments detached from the shelter's wall due to the effects of cold.

In this stratigraphic sequence the archaeological material was documented in levels 1,2, and 3. At that time, the lithic industry corresponded to the Epipaleolithic with the presence of facies related to the Azilian complex (Sant Gregori type) and some Sauveterrinian elements (Filador type) (Llongueras and Guilaine, 1982).

In 1992 a new stratigraphic study was conducted by Maria Mercè Bergadà, which establishes a definite sedimentation process for the site (Fig. 8.2):

- **Superficial level-** it shows a maximum thickness of 30 cm. The stratigraphic unit is formed by a matrix of fine sands of brown color (5 YR 6/4) with a 13% of coarse fractions of sub-rounded limestone between 1 and 2 cm in size. It displays a laminar/granular type structure; it also shows a lot of actual biological activity. Even though it is considered archaeologically sterile, it presents mixed archaeological remains from prehistoric, mainly Neolithic and Bronze Age, to modern occupations

- **Level I-** it displays a maximum thickness of 52 cm. The stratigraphic unit is formed by a matrix of silty sands of brown color (5 YR 6/2). It's composed of 60% of coarse fraction of limestone (gravel), sub-angular in shape, 1 to 10 cm in size, with no signs of concretions. It displays a granular type structure. Between the heights of 30-40 cm it shows a high amount of coarse fraction, whereas in 43-64 cm height a large concentration of charcoal and bone remains were found. Archaeologically, this level covers a large chronological period of what is now called *Epimagdalenian* (lower level) and *microlaminar Sauveterroide* (upper level).

- **Level II-** it shows an undetermined thickness of 15 cm. It is a sterile level composed exclusively of gravel of 2 to 13 cm in size, and blocks that result from the weathering effects on the rockshelters' wall and ceiling due to cold climate.

The thickness for the different levels was obtained within the archaeological site, where the stratigraphic study was conducted. Once the excavation surface was extended, we see the thickness varied in certain sectors. At this moment, the thickness of level II is unknown. The excavation processes consisted of digging a relatively large surface to analyze stratigraphic dynamics, chronocultural evolution, and the spatial distributions of the remains. To this date, 16 m^2 located in the contact zone to the rockshelters's wall have been excavated (Fig. 8.3). The Méroc-Laplace method was used during the excavation process to locate remains three dimensionally in space. A grid was established, where each 1 m^2 was given a letter and a number according to their coordinates. Organic remains were systematically recovered *in situ* during the excavation process, and during the dry and wet sieving of the remains. The wet sieving method consist first, a process of floatation of all the recovered sediment, and secondly, sieving the material through 5 mm, 2 mm and 0.5 mm wide sieves.

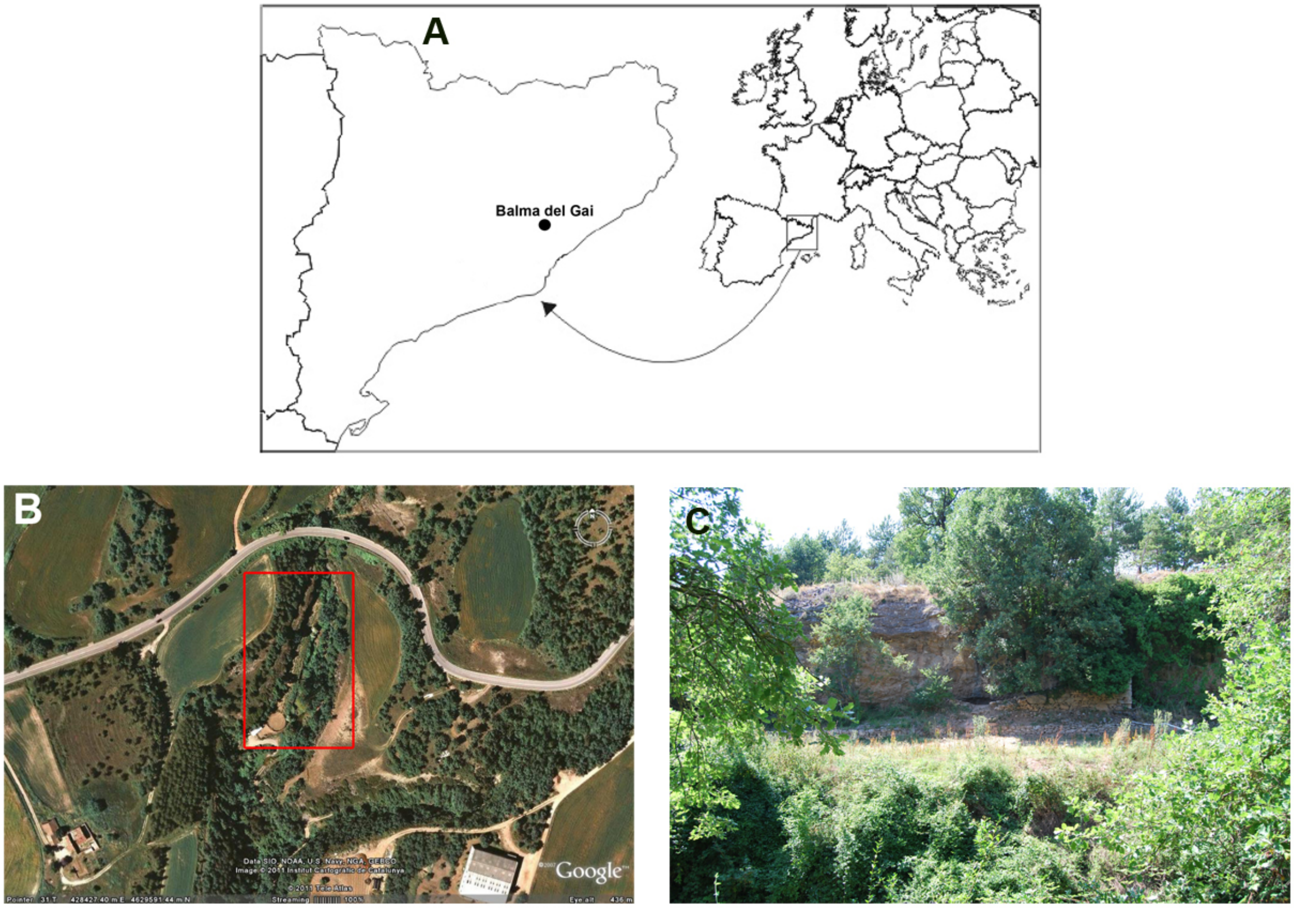

Figure 8.1. (A-B) The archaeological site of Balma del Gai is located in the municipality of Moià (Bages, Barcelona), in the Northeast of the Iberian Peninsula (2º 08’ 19’’ E; 41º 49’ 00’’ N; UTM: 31TDG284297. (C) Photo of the natural surroundings of the rockshelter.

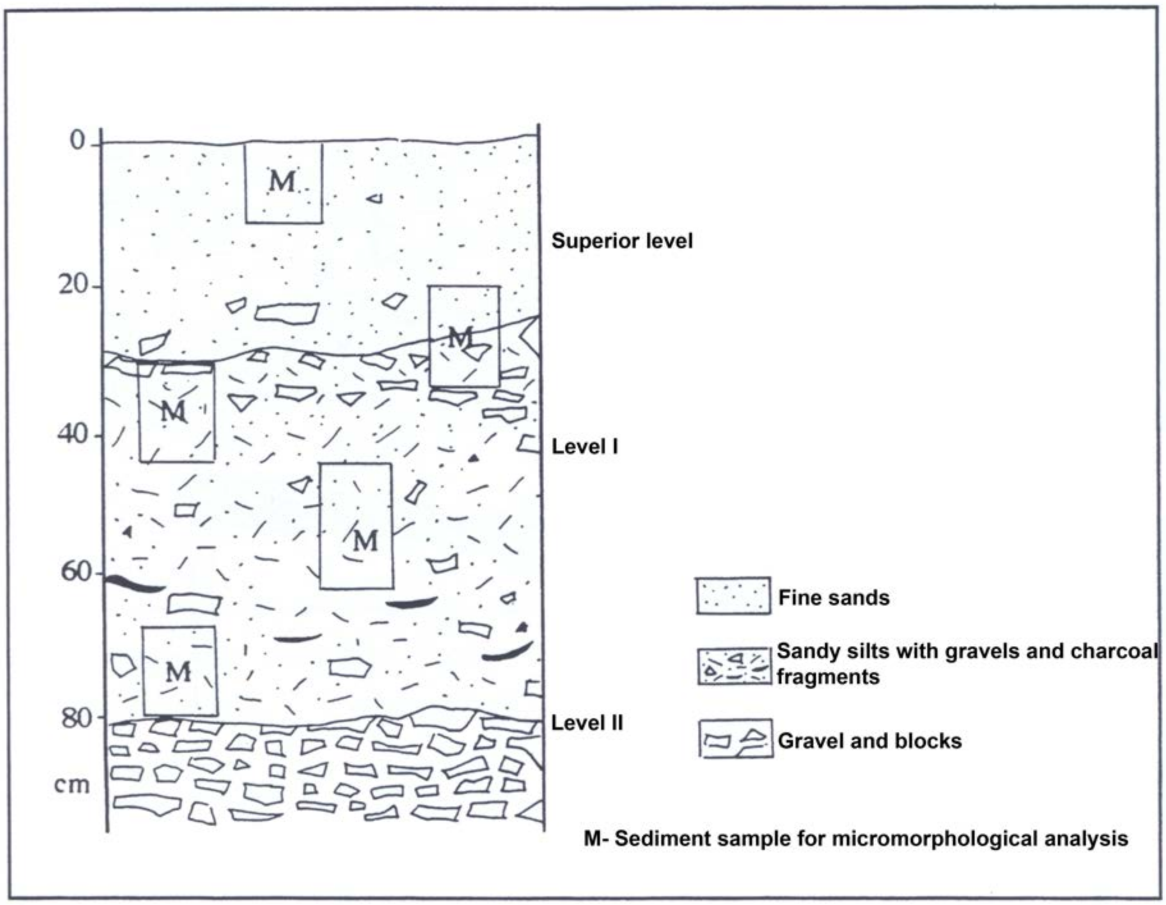

Figure 8.2. Stratigraphic sequence for Balma del Gai. Modified from Bergadà (1998).

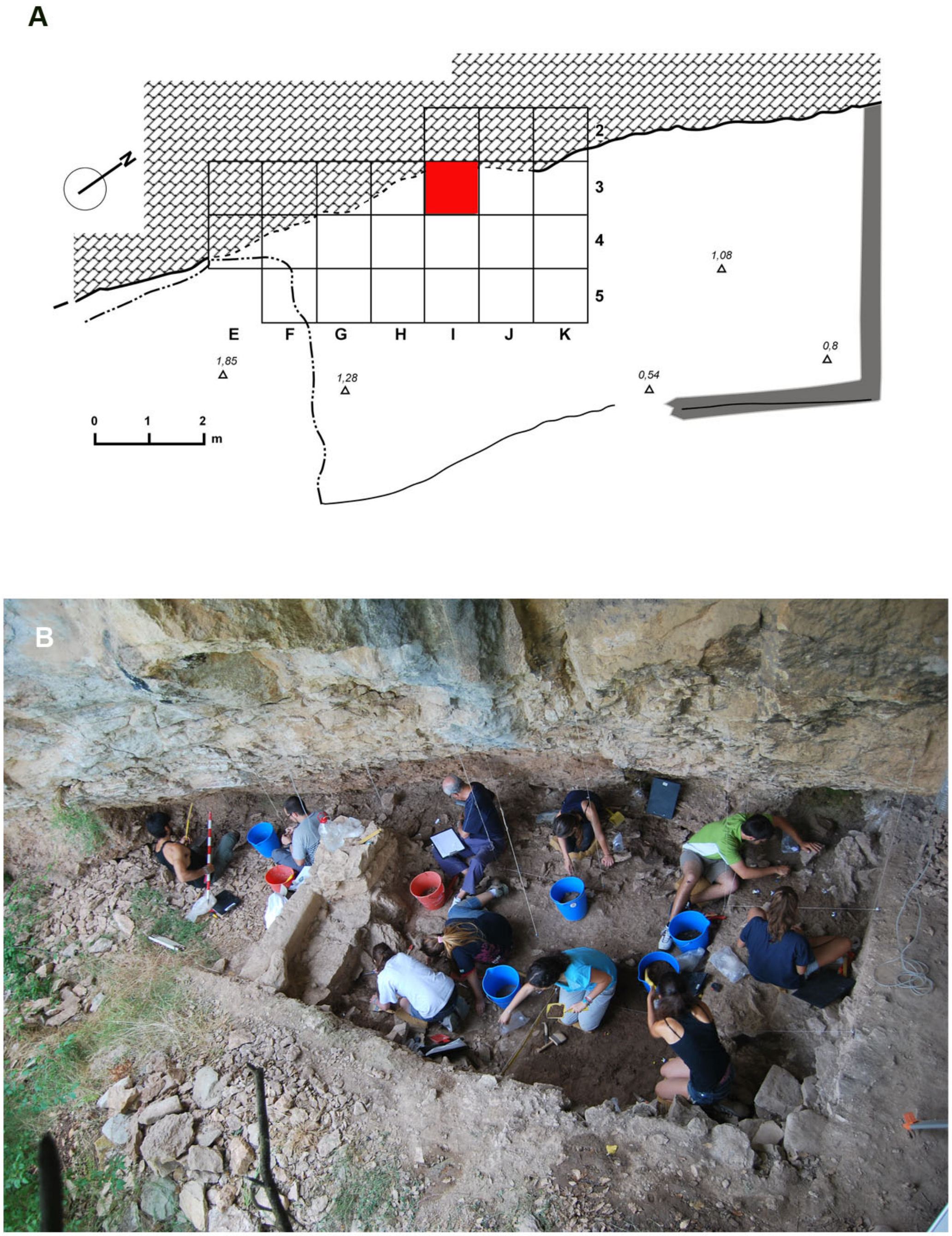

Figure 8.3. (A) Illustration of the location of unit I3, where the leporid sample studied in the present work comes from (marked in red), and (B) photo of the excavated areas in Balma del Gai.

8.3. CHRONOLOGY AND MATERIAL CULTURE

Level I, from an archaeological point of view, reflect a major occupation of Epipalaeolithic hunter-gatherers evidenced by its lithic sequence. The distribution of the material across the entire level indicates diverse habitation layers, which can be difficult to differentiate since both occupations succeeded each other.

The occupation (mid and lower layer of level I) belongs to the *microlaminar Epipalaeolithic*, similar to the chronology and material culture of the *Azilian complex* in France and northwestern Spain. This layer contains bladelets, points and endscrapers (Fig. 8.4a), and also contains artifacts elaborated in bone and red deer antler (Fig. 8.5), it can be related to the end of the GI-1 and specially GS-1. The upper layer of level I belongs to the *Filador geometric complex,* according to the terminology established by Fortea (1973), which is parallel to the *Sauveterrian* French Mesolithic. It is defined by the presence of triangular microliths made by the microburin technique (Fig. 8.4b) (Lloveras et al., 2011), and it is related to the early Holocene period. Flora and fauna remains, mostly leporid remains, were also recovered.

Several charcoal samples were collected for radiocarbon dating. The dates were calibrated using OxCal online version 4.1, with a range of 2σ. 95.4%. The lower layer, corresponding to the *microlaminar Epipalaeolithic complex* was dated by three radiocarbon dates: 1) the first one from the 77-78 archaeological campaing, Mc-2140 layer 2: 11.050±160 BP (12,817-13,150 cal. BP), 2) Gif-10029: 11.170±160 BP (12,891-13,247 cal. BP) and 3) OxA-29608 Level I (Z: 150 cm): 11.440±50 BP (13,233-13,480 cal. BP). The upper layer, corresponding to the *geometrict type Filafor complex* was dated by three radiocarbon dates: 1) Mc-1418 layer 1: 9.840±400 BP (10,760-12,028 cal. BP), 2) Mc-2141 layer 1: 10.030±160 BP (11,349-11,934 cal. BP) and 3) Gif-10028 level I (Z: 125-130 cm): 8.930±140 BP (9,786-10,189 cal. BP). These dates are consistent with other Epipalaeolithic sites in Northeastern Spain were both chronocultural traditions are present (García-Argüelles et al., 2009, 2010).

8.4. RECOVERED REMAINS

The archaeological site of Balma del Gai shows a wide range of material culture; is very rich in organic remains (flora and fauna) in comparison to other sites located in the same region, and also shows a wide array of lithic industry, and bone industry. The most numerous remains recovered at the site are faunal remains, although malaco-faunal and plant remains can also be found. Fauna and plant remains not only permit researchers to reconstruct the climate conditions and the landscape evolution of the region, it also helps us to understand the subsistence habits, and the mechanism used by epipalaeolithic communities to exploit different food resources, since most of the remains are the result of hunting activities, gathering and consumption.

8.4.1. Lithic industry and habitation features

According to Mangado (2002), the lithic industry from Balma del Gai is mainly composed of flint, although other raw materials including calcareous rock, quartz, hyaline quartz, Lydian stone, rhyolite, and jasper have been identified. The lithic industry found at Balma del Gai may be defined as "microlithic". All the stages of chipped stone production have been found and identified on the site.

A total number of 5,545 elements have been recovered during fieldwork, 343 of which correspond to retouched pieces and 69 cores (García-Argüelles et al., 2010). The industry is quite homogeneous throughout the entire archaeological sequence, only the upper layers of level I display Geometric elements, such as endscrapers and geometric pointed bladelets.

8.4.2. Antler and bone industry

A scarce but significant set of artifacts made out of bone was recovered. Even tough this type of material is most frequent during the Magdalenian period we still find them among the industries of Epipaleolithic hunter-gatherers groups. The specific piece, showed in Figure 8.5, is made out of deer antlers and its functionality is currently unknown.

8.4.3. Flora remains

During the first excavation in the 70's J. L. Vernet conducted an anthracologic study based on the taxonomic identification of charcoal remains recovered in archaeological sequences, in which diverse taxa were identified in all three stratigraphic units. On level II (base), *Pinus sylvestris/nigra* and *Betula verrucosa* were identified. While *Prunus amygdalus, Pinus sylvestris/nigra, Pinus nigra* sp*. Salzmanni, Prunus mahaleb, Prunus spinosa, Buxus sempervirens, Phillyrea* cf*. angustifolia, and Rammus cathartica saxatilis* were recorded in level II. On the superficial level, *Prunus amygdalus, Pinus sylvestris/nigra, Juniperus* sp*., Prunus spinosa,* and *Acer monspessulanum* were present.

A recent study based on anthracological data obtained from the analysis of 1171 charcoal remains from Balma del Gai, and conducted by E. Allué show that the most abundant taxa were *Pinus sylvestris/nigra, Acer, Juniperus, Prunus, Rammus cathartica/saxatilis,* and *Maloideae* (Allué et al., 2007)*.* This study allowed reconstructing the evolutions of the ecosystems around the site from a landscape dominated by open grassland with small patches of pine forest, and a gradual increase in Mediterranean species.

8.4.4. Faunal remains

Faunal remains are diverse; mostly composed of mammals' remains and continental land snails. This record refers essentially to elements discarded by human consumption, however, a small number of recovered remains, like small snails and microvertebrates, might not be of anthropogenic origin. On the other hand, a few but significant numbers of specimens of marine mollusks may have been provided for ornamental purposes or as instruments (Estrada et al., 2010).

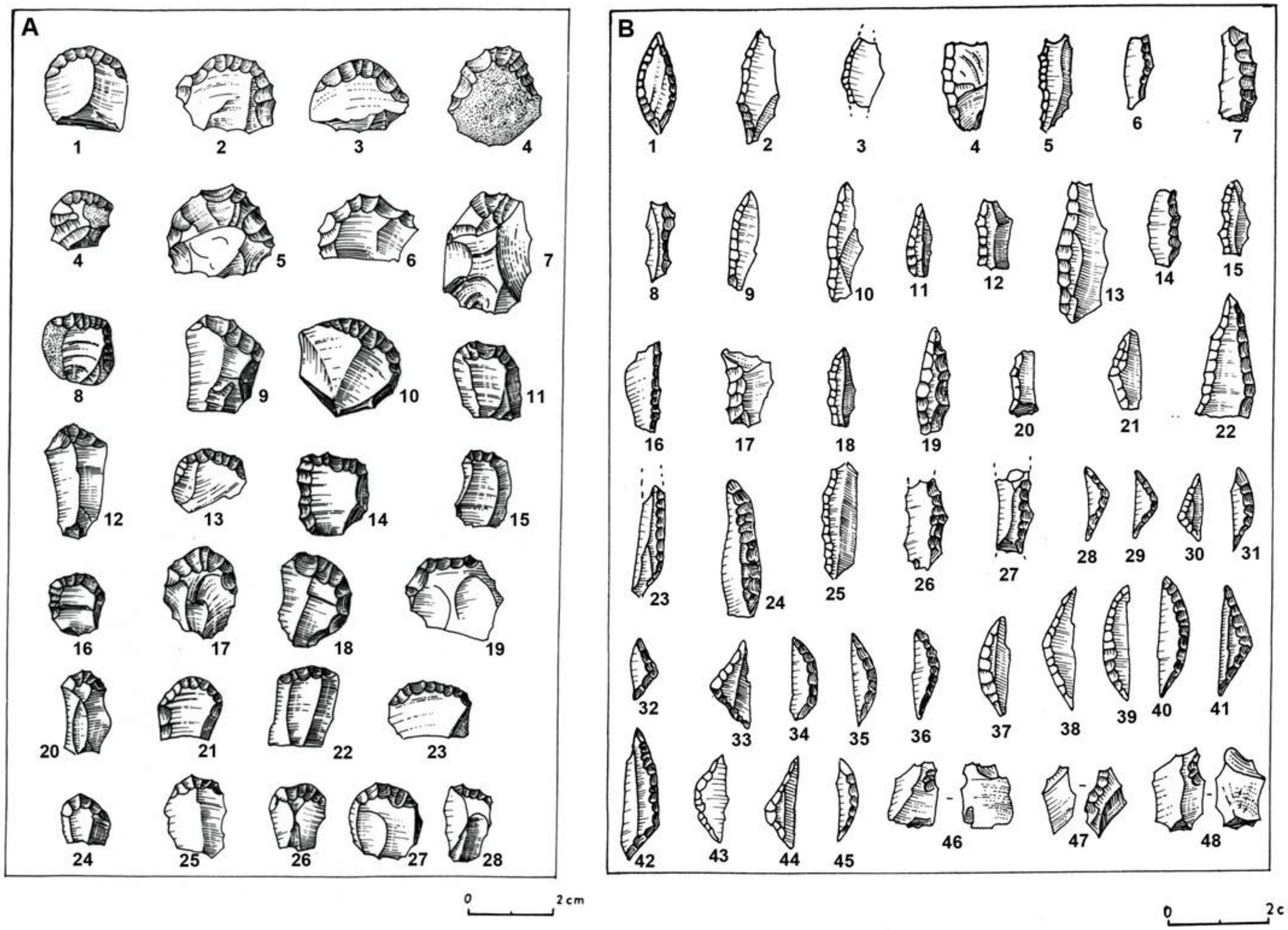

Figure 8.4. (A) Endscrapers from level I; (B) microlithic industry from level I: bladelets, pointed bladelets, geometric arrow points and retouched debris (the so-called "microburins" in specialized literature).

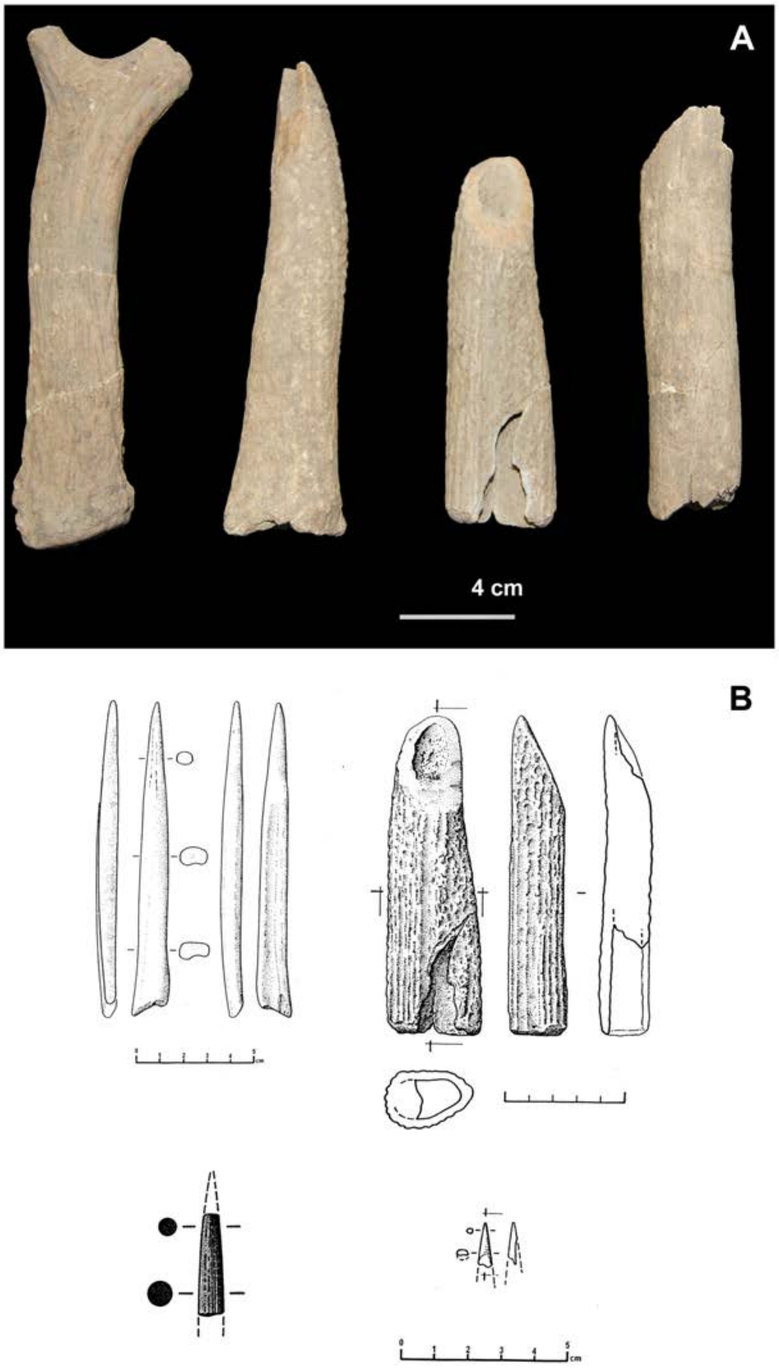

Figure 8.5. Antler and bone artifacts (Illustrations by R. Álvarez)

Among the terrestrial and marine mollusks we see: 1) Scaphopods represented by 7 specimes from the species *Dentalium vulgare* and *Dentalium dentale*; 2) a total of 29 specimens of the taxon Bivalvia were recorded, and they belong to the species *Pecten jacobaeus, Mytilus galloprovinciallis, Glycymeris nummaria, Glycymeris glycymeris,* and *Glycymeris* sp.*;* and 3) Gastropods represented by the species *Cyclope neritea, Hinia costulata, Hinia reticulate, Collumbea rustica* (Estrada et al., 2010), and 6,738 (MNI) of *Cepaea nemoralis* (Lloveras et al., 2011).

Among the remains of large mammals one can find red deer (*Cervus elaphus*), wild board (*Sus scrofra*) and small bovids like the chamois (*Rupicapra rupicapra)* and the wild goat (*Capra pyrenaica*). Also, terrestrial carnivore remains, such as the Iberian lynx (*Lynx pardina*), the wildcat (*Felis silvestris*), red fox (*Vulpes vulpes*), and a large canid (probably wolf, *Canis* sp.*)* have also been recorded.

Small size prey remains such as hedgehogs (*Erinaceus europaeus*) and diverse species of birds (wood pigeon - *Columba palumbus*, red-legged partridge – *Alectoris rufa*) have also been recovered. However, the mammal species most represented among the faunal assemblage in Balma del Gai is the wild European rabbit (*Oryctolagus cunniculus*) with thousands of remains recorded. The elevated number of leporid remains comprises the 95% of the minimum number of individuals (MNI) in the fauna assemblage.

8.5. ANALYSIS RESULTS

The analyzed material consisted on leporid remains recovered from unit I3 from level I. Before we present our results, two things must be mentioned.

First, a total number of 39,012 of leporid bones and teeth were recovered from unit I3, only 38% of the sample, which corresponds to 14,875 remains, was considered for the taphonomical analysis, since the remains were anatomically determinable. Only the material recovered directly during the excavation and material recovered from 5 mm mesh sieving was taken into consideration. Remains from the 2 mm mesh sieving were not taken into account due to the large volume of the sample and because they were not anatomically determinable. However, to evaluate the loss of elements that this could suppose we decided to analyze all the bone fragments 2 mm in size from 120-125 cm level. By doing so we encountered a significant number of small skeletal elements, for example 3rd and 2nd phalanges, carpals/tarsals, patellae, as well as fragments of 1st phalanges, upper molars, lower molars, incisors teeth, calcanei and astragali. This show that the entire skeleton is well represented, the only reason we are lacking small sized skeletal remains are clearly due to the study techniques of the samples applied in this dissertation and not because of differential conservation within the archaeological site.

Second, as explained in section 8.2, level I was divided into two periods of occupation: Epimagdelenian (microlaminar Epipaleolithic; ≥ 140 cm) and microlaminar Sauveterroide (geometric Epipaleolithic; ≤ 139 cm). For this reason, individual analysis of the leporid assemblages for each occupation was performed. After comparing the results of the taphonomical and statistical analysis for each occupation, no significant differences were found. For this reason, we considered it would be better to treat it as one unique sample and present the results as a whole, since we could not find any evidence of differential treatment, in terms of anatomical representation and carcasses processing, between both. The results corroborate the cultural interpretations that arise between these two moments (Román, 2012).

Based on the cranial elements count, the estimated minimum number of elements (MNE) and the minimum number of individuals (MNI) is 195.

8.5.1. Taxonomic determination

According to Callou’s (1997) criteria to differentiate between wild European rabbit and hare, 14,874 remains were classified as rabbit (*Oryctolagus cuniculus*). Only one bone remain, an innominate, was identified as hare (*Lepus* sp).

8.5.2. Age of death

In accordance to the epiphyseal fusion of long bones, metapodials, scapulae, and innominates, the percentage of adult individuals is 92.3 while a 7.7% correspond to juvenile individuals (Table 8.1).

8.5.3. Anatomical representation and differential conservation

In order to present the information in an organized way, we have elaborated a table showing the anatomical composition of the leporid remains, as well as the relative abundance percentage for each element (Table 8.2). The entire skeleton is well represented. According to the NDR%, the most numerous remains are cranial elements, upper and lower molars, ribs, phalanges, innominates, and mandibles while patellae, carpal/tarsal elements, astragali, calcanei, ulna and metacarpal were the scarcest.

Table 8.1. Age of death. F fused and NF not fused.

Skeletal elements	F	NF	TOTAL
Humerus	389	28	417
Radius	161	27	188
Ulna	257	36	293
Femur	393	28	421
Tibia	323	39	362
Metacarpal	348	19	367
Metatarsal	405	9	414
Innominates	699	60	759
Scapulae	347	31	378
Total	3322	277	3599
%	92.3	7.7	

In Table 3 the RA% for each element are presented; according to these percentages the most represented elements are cranial elements, mandibles, scapulae, femora, humerus, tibia, innominate, and ulna. Skeletal elements with the lower RA% are phalanges (1/2 and 3), carpal/tarsals, vertebrae, ribs, and patellae (Fig. 8.6). The calculated mean value for this sample is 47%, which indicates an important loss of skeletal elements. However, it should be taken into account, as already explained at the beginning of section 8.5, the lack of small sized skeletal remains are due to the study techniques applied to the analysis of the samples discussed within this dissertation and not due to differential conservation.

Table 8.2. Leporid skeletal remains identified in level I from Balma del Gai.

Skeletal elements	N	N%	MNE	RA%
Mandible	798	5.4	348	89.2
Crania	1984	13.3	195	100
Incisor	752	5.1	600	51.3
Upper molar	1359	9.1	1223	52.3
Lower molar	1359	9.1	1131	58
Humerus	554	3.7	293	75.1
Radius	476	3.2	231	59.2
Ulna	406	2.7	240	61.5
Femur	636	4.3	321	82.3
Tibia	612	4.1	258	66.1
Patella	31	0.2	31	7.9
Scapula	488	3.3	335	85.8
Innominate	858	5.8	242	62
Metacarpal	451	3	333	17.1
Metatarsal	687	4.6	427	27.4
Phalanges 1/2	848	5.7	752	11.3
Phalanges 3	129	0.9	118	3.4
Calcaneum	280	1.9	230	58.9
Astragal	182	1.2	182	46.6
Carpal/Tarsal	168	1.1	168	3.6
Vertebrae	623	4.2	469	5.2
Rib	1194	8	309	6.6
TOTAL	14875			

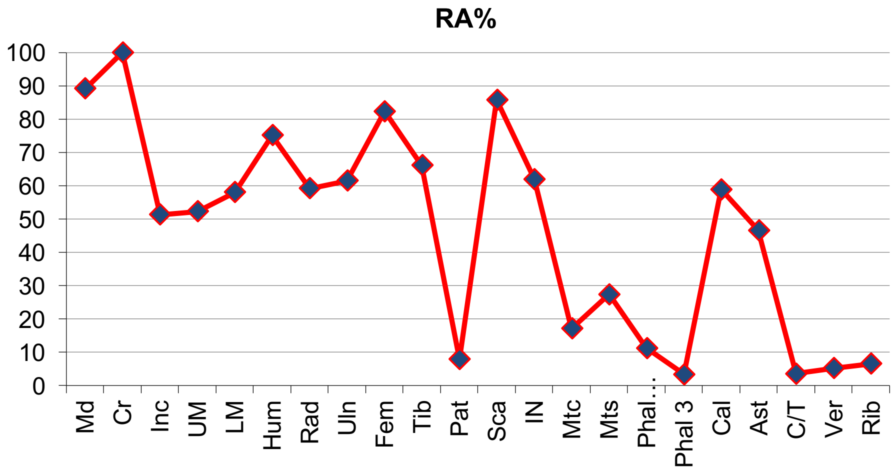

Figure 8.6. Relative abundance of the different parts of the skeleton in Balma del Gai leporid remains sample. Relative abundance (RA) of every element presented. *Md* mandible, *Cr* cranium, *Inc* incisors, *UM* upper molar, *LM* lower molar, *Hum* humerus, *Rad* radius, *Uln* ulna, *Fem* femur, *Tib* tibia, *Pat* patella, *Sca* scapula, *IN* innominate, *Mtc* metacarpals, *Mts* metatarsals, *Phal ½* first and second phalanges, *Phal 3* third phalanges, *Cal* calcaneum, *Ast* astragalus, *C/T* carpal and tarsals, *Ver* vertebrae, and *Rib* ribs.

The corresponding values of the different anatomical indexes, that allows us to assess the proportions in which the different parts of the skeleton are represented, are shown in Table 8.3.

Table 8.3. Portions of different parts of the skeleton.

Index	Value %	Representation
PCRT/CR	26.5	+ Cranial
PCRAP/CR	32.2	+ Cranial
PCRLB/CR	119	+ Long bones
AUT/ZE	16.8	+ Proximal (ZE)
Z/E	79.1	+ Proximal (*Fem* and *Hum*)
AN/PO (1)	81.8	+ Hindlimbs
AN/PO (2)	100.4	= Equilibrated
AN/PO (3)	89.2	+ Hindlimbs

A calculation approximating to the 100% implies a balance (equilibrium) between the represented elements, while a calculation under or above the 100% entails a lower or higher representation of the skeletal elements. Results show the following:

- The relatively low value obtained for the PCRT/CR index shows that for every 100 cranial elements (CR) there are only a 26.5% of postcranial elements, which means that postcranial elements are underrepresented. The same occurs with the PCRAP/CR; in this case the appendicular elements are also underrepresented (32.3%). When cranial elements are compared to long bones (PCRLB/CR), the sample shows a deficit of cranial elements (119%), indicating a good representation of long bones.

- When comparing the proportions between distal and proximal elements (16.8%), the AUT/ZE index indicates that there is a low representation of skeletal elements that comprises the autopodium in comparison to elements belonging to the zigopodium + stilopodium, which implies an important loss of distal elements.

- The value for the Z/E index (79.1%) shows a mayor representation of skeletal elements that correspond to the stilopodium.

- When calculating the proportion between AN/PO, three results were obtained. Calculation for 1 and 3 resulted in lower values, 81.8% and 89.2% respectively, which suggest a greater representation of elements corresponding to the hindlimbs in comparison to elements that comprise the forelimbs, as opposed to calculation 2, 100.4%, that indicated an equilibrated proportion between forelimbs and hindlimbs. This suggests that the differences in proportions are due to the different values obtained for the metapodial elements.

According to Pavao and Stahl's (1999) criteria, there was no statistically significant correlation between the frequency of rabbit skeletal portions and their density (rho= 0.437, P= 0.091). This indicates that the preservation of rabbit remains within the Epipaeolithic level of Balma del Gai was generally unaffected by density-mediated attrition.

8.5.4. Breakage patterns and types of fracture

The maximum length of the analyzed remains is variable with measures ranging between 2.6 to 84.7 mm. The average maximum length was 16.6 mm and more than 82.2% of the remains present length values over 10 mm, while the length of 17.8% of the remains were under 10 mm (Fig. 8.7).

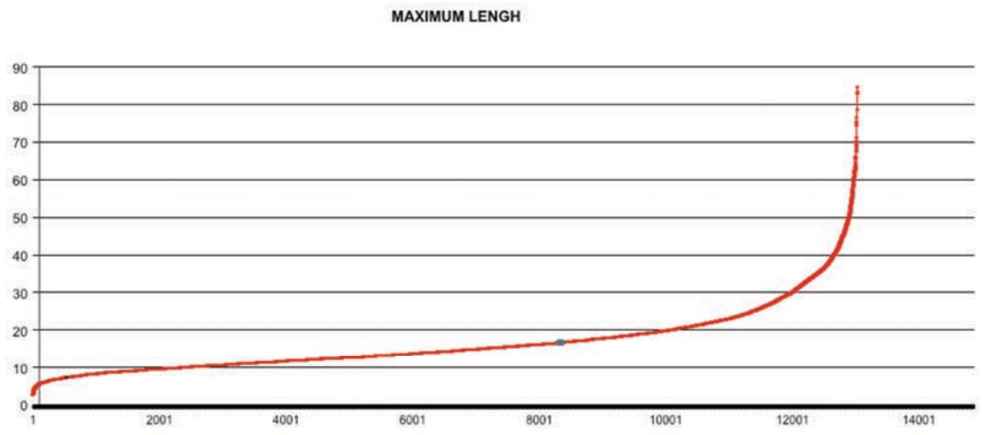

Figure 8.7. Mean length of fragmented *Oryctolagus cuniculus* remains. The blue dot denotes the sample's mean value (16.6 mm).

A total of 4,304 remains (29%) were complete (Table 8.4), if we consider solely long bones remains the percentage of complete bones it is reduced to 0.5%. As might be expected, the obtained value vary according to size of the skeletal remain, being the smaller remains, such as teeth, patellae, phalanges, astragals and carpal/tarsal, that appear less fragmented (Table 8.5 of breakage categories).

Breakage categories of the skeletal elements show that cranial elements never appeared complete, mainly identified by fragments comprising the neurocranium (NC), maxillae (M) and the zygomatic arch (AZ). Mandibles were mostly represented by mandibular body + incisive part (MBI), mandibular body (MB), incisive part (IP) and condylar process (CP). For the innominates, it was common to find parts belonging to the isquium (IS), illium (IL), and fragments containing the acetabulum (AIL and AIS). Only 1 scapula remain appeared complete. Most scapulae fragments contained the glenoid cavity + neck (GCN) and glenoid cavity + neck + fossa (GCNF) parts. Vertebrae were complete in 27.8% of the cases, but the most represented fragments were vertebrae body (VB) and the spinous process (SP). Ribs were always fragmented in a 98.8% of cases. Regarding the teeth, 42% of isolated and *in situ* incisors were complete, the 68.6% isolated and 64.3% *in situ* teeth (upper molars and lower molars) were also complete.

Table 8.4. Number and percentages of complete elements. *N* number of skeletal remains, *C* number of complete elements, and *C%* percentage of complete elements.

Skeletal elements	N	C	C%
Md	798	7	1
Cr	1984	0	0
Inc	752	315	42
UM	1359	1098	81
LM	1359	1054	77.5
Hum	554	5	0.9
Rad	476	3	0.6
Uln	406	1	0.2
Fem	636	4	0.6
Tib	612	2	0.3
Pat	31	31	100
Sca	488	1	0.2
IN	858	5	0.6
Mtc	451	228	50.5
Mts	687	97	14.1
Phal 1/2	848	678	80
Phal 3	129	118	91.4
Cal	280	160	57.1
Ast	182	149	82
C/T	168	161	96
Ver	623	173	27.8
Rib	1194	14	1.1
TOTAL	14875	4304	

Table 8.5. Number and percentage of parts of the skeleton included in each breakage category.

Long bones and metapodials												
	C		**PE**		**PE+S**		**S**		**S+DE**		**DE**	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Humerus	5	0.9	96	17.3	20	3.6	145	26.1	58	10.4	230	41.5
Radius	3	0.6	32	6.7	196	41.1	131	27.5	100	21	14	2.9
Ulna	1	0.2	108	26.6	131	32.3	98	24.1	56	13.7	12	2.9
Femur	4	0.6	256	40.2	61	9.6	203	32	8	1.2	104	16.3
Tibia	2	0.3	123	20.1	14	2.3	282	46	39	6.3	152	25
Metacarpal	228	50.5	5	1.1	100	22.2	5	1.1	108	24	5	1.1
Metatarsal	97	14.1	16	2.3	314	45.7	16	2.3	236	34.3	8	1.2

Mandible	*N*	*%*	*Vertebrae*	*N*	*%*	*Innominate*	*N*	*%*
C	7	0.9	C	173	27.8	C	5	0.6
IP	124	15.5	VB	296	47.5	IL	196	22.8
MBI	217	27.2	VE	10	1.6	AIL	134	15.7
MB	168	21	SP	144	23.1	A	35	4.1
MBB	71	9	Rib	*N*	*%*	AISIL	70	8.1
B	94	11.7	C	14	1.2	AIS	122	14.2
CP	117	14.6	F	1,180	98.8	IS	295	34.4
Cranium	*N*	*%*	Patellae	*N*	*%*	*Phalanges 1/2*	*N*	*%*
IB	267	13.4	C	31	100	C	678	79.9
M	376	19	F	0	0	F	170	20
AZ	365	18.4						
NC	976	49.2						

Scapula	*N*	*%*	Calcaneum	*N*	*%*
C	1	0.2	C	160	57.1
GC	56	11.5	F	120	43
GCN	162	33.2			
GCNF	116	23.7	*Astragalus*	*N*	*%*
N	38	7.8	C	149	81.9
NF	83	17	F	33	18.1
F	32	6.5			
Phalanges 3	*N*	*%*	*Carpal/Tarsal*	*N*	*%*
C	118	91.5	C	161	95.8
F	11	8.5	F	7	4.2

Teeth	*In situ*					
	Incisors		UM		LM	
	N	*%*	*N*	*%*	*N*	*%*
C	138	41.8	458	91.2	841	82.6
F	192	58.1	44	8.8	177	17.4

Isolated					
Incisors		UM		LM	
N	*%*	*N*	*%*	*N*	*%*
177	41.9	640	74.7	213	62.5
245	58	217	25.3	128	37.5

Long bones and metapodials were classified as complete (C), proximal epiphysis (PE), proximal epiphysis + shaft (PES), shaft (S), shaft + distal epiphysis (SDE), and distal epiphysis (DE). Mandibles were classified as complete (C), incisive part (IP), mandible body + incisive part (MBI), mandible body (MB), mandible body + branch (MBB), branch (B), and condylar process (CP). Cranium elements were classified as complete (C), incisive bone (IB), maxillae (M), zygomatic arch (AZ), and neurocranium (NC). Innominates were classified as complete (C), illium (IL), acetabulum + illium (AIL), acetabulum (A), acetabulum + ischium +illium (AISIL), acetabulum + ischium (AIS), and ischium (IS). Scapulae were classified as complete (C), glenoid cavity (GC), glenoid cavity + neck (GCN), glenoid cavity + neck + fossa (GCNF), neck (N), neck + fossa (NF), and fossa (F). Vertebrae were classified as complete (C), vertebral body (VB), vertebral epiphysis (VE), and spinous process (SP). Ribs, patellae, phalanges, calcanei, astragali, carpals and tarsals, and teeth were classified as complete (C) and fragment (F).

All the breakage categories were represented in limb bones and metapodial elements. Humeri, femora and tibiae remains are best represented by fragment belonging to the proximal epiphysis (PE), shaft (S) and distal epiphysis (DE). For the radii remains, the most abundant fragments are the ones composing the proximal epiphysis + shaft (PES), shaft (S) and shaft + distal epiphysis (SDE). Metacarpals and metatarsals bones are the most complete elements with an average value of 50.5% and 14.1% respectively. Patellae were all complete. Carpal/Tarsal were almost always complete (95.8%), and so were also 3 phalanges and 1/2 phalanges (91.5% and 80% respectively), astragali (81.9%), and calcanei (57.1%).

A total number of 379 (30.6% of long bones fragments) were identified as long bone cylinders. Fresh fractures were the most abundant (55.1%) among long bones and metapodial elements (Fig. 8.8 and 8.9), whereas that 18.3% of remains show dry fractures. Finally, a total of 26.5% of the remains displayed modern fractures, possibly due as a consequence of the excavation process, transport and packaging of the remains (Table 8.6).

Figure 8.8. Image of the proximal epiphysis of a radius bone with evidence of fresh (green) fractures.

Figure 8.9. Image of long bones diaphysis (long bones cylinders).

Table 8.6. Types of fractures. *FF* fresh fractures, *DF* dry fractures, and *MF* modern fractures.

Skeletal elements	FF	DF	MF
Humerus	397	51	77
Radius	209	119	145
Ulna	219	67	116
Femur	426	80	91
Tibia	396	81	103
Metacarpal	60	58	104
Metatarsal	161	166	262
TOTAL	1868	622	898
%	55.1	18.3	26.5

8.5.5. Bone surface alterations

8.5.5.1. Digestion

A detailed study of the remains under a light microscope was conducted to detect the presence of damage caused by digestion. Almost all remains (99.9%) were not affected, only 10 cases (0.07%) from our sample presented digestion corrosion damage (Table 8.7). The altered remains were the scapula, vertebrae, ribs, calcanei and astragali. Among them there were no dental remains. Of the 10 cases, 6 cases present a moderate degree of damage (0.04%), 3 cases (0.02%) show strong degree of digestion, while 1 case (0.007%) shows a light degree of digestion (Fig. 8.10 and 8.11).

8.5.5.2. Cut marks

A total of 175 bones (1.2%) display cut marks, mostly observed in innominates (26), humerus (22), ulna (20), radius (17), mandibles (16), and tibia (11). All orientations were recorded but most of the marks were transversal (107) to the principal axis of the bone (Table 8.8).

A total number of 62 marks are associated to the skinning process. Mandibles and metatarsals display the highest frequency of cut marks. In the mandibles, marks are mostly located on the incisive part and mandibular body + incisive part, especially on the lateral faces. Most of the marks were transversal in orientation, ranging from light to moderate intensity. A total number of 18 marks were associated to the disarticulation of the carcass. Innominates (ischium and acetabulum bones), followed by scapulae (articular end), display the highest frequency of cut marks, although innominate remains tend to display both disarticulation and defleshing marks. As far as the orientation of the cut marks is concerned, transversal marks are dominant, ranging from light to moderate intensity. A total number of 95 marks are associated to the defleshing process. These are mostly located in long bones, especially in diaphysis. Humeri, ulnae and radii display the highest frequencies of cut marks. A great variation in orientation was recorded, with an increase in oblique marks, while longitudinal marks were often seen in long bones shafts and the whole surface of innominates (Fig. 8.12).

8.5.5.3. Tooth marks

A total number of 133 remains with tooth marks (0.9%) were recorded during the taphonomic analysis. The skeletal elements that show the greater number of marks were tibiae (29 cases) followed up by mandibles (24 cases), innominates (23 cases), and femora (15 cases). A number of 50 (37.6%) remains displayed punctures (TPU), while a 23.3% showed pit marks (TPI), a 1.5% of the remains presented scoring marks, 20 cases (15%) exhibit crenulated edges (CRE), and a 22.5% of the remaining cases (30) displayed notches (Table 8.9). Punctures marks (TPU) are mostly seen in long bones (tibiae, femora, and humeri) and mandibles, whereas that pit marks (TPI) are mainly seen in tibiae. Scoring marks were recorded in mandible, scapula, humerus, innominate, and tibia. Crenulated edges are more perceptible in the illium area of innominate remains, and the branch area of mandible remains. Notches marks were noticeable in mandibles, innominates, and tibiae remains (Fig. 8.13). The majority of the remains displaying tooth marks show more than one type of mark. It should be noted that most of the remains presented multiple punctures and pits in the same bone, for example long bones may display pits (TPI) and scoring (SCO) marks across the shaft, while it is common to find innominates showing crenulated edges (CRE) and scoring (SCO) marks across the ilium.

Table 8.7. Number and percentages of *Oryctolagus cuniculus* remains included in each digestion category.

Elements	Null		Light		Moderate		Heavy		Extreme		TOTAL
	N	%	N	%	N	%	N	%	N	%	
Mandible	798	100	0	0	0	0	0	0	0	0	798
Cranium	1984	100	0	0	0	0	0	0	0	0	1984
Incisors	752	100	0	0	0	0	0	0	0	0	752
Upper molar	1359	100	0	0	0	0	0	0	0	0	1359
Lower molar	1359	100	0	0	0	0	0	0	0	0	1359
Humerus	554	100	0	0	0	0	0	0	0	0	554
Radius	476	100	0	0	0	0	0	0	0	0	476
Ulna	406	100	0	0	0	0	0	0	0	0	406
Femur	636	100	0	0	0	0	0	0	0	0	636
Tibia	612	100	0	0	0	0	0	0	0	0	612
Patellae	31	100	0	0	0	0	0	0	0	0	31
Scapula	487	99.8	1	0.2	0	0	0	0	0	0	488
Innominate	857	100	0	0	0	0	0	0	0	0	857
Metacarpus	451	100	0	0	0	0	0	0	0	0	451
Metatarsus	687	100	0	0	0	0	0	0	0	0	687
Phalanges 1/2	848	100	0	0	0	0	0	0	0	0	848
Phalanges 3	129	100	0	0	0	0	0	0	0	0	129
Calcaneum	275	98.2	0	0	3	1	2	0.7	0	0	280
Astragalus	181	99.4	0	0	1	0.5	0	0	0	0	182
Carpal/Tarsal	168	100	0	0	0	0	0	0	0	0	168
Vertebrae	622	99.8	0	0	1	0.1	0		0	0	623
Ribs	1192	99.8	0	0	1	0.08	1	0.08	0	0	1194
TOTAL	14864		1		6		3		0		14874

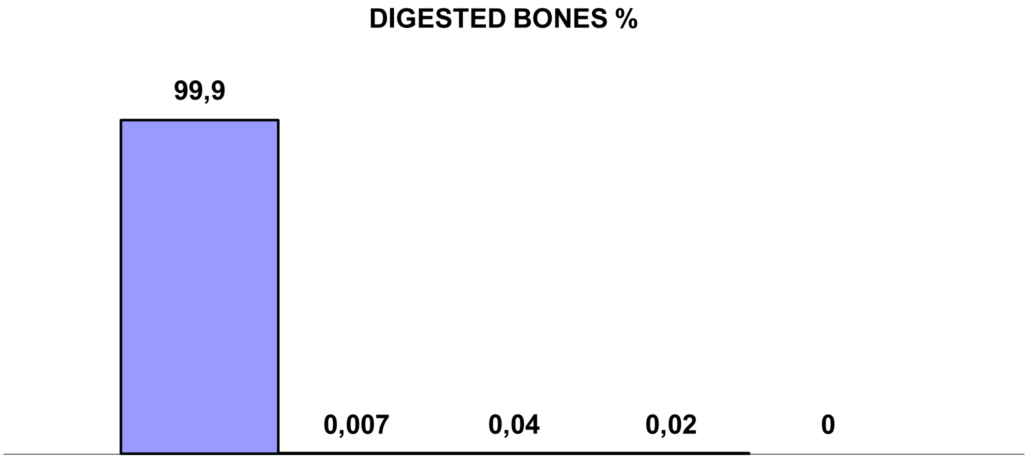

Figure 8.10. Percentage of skeletal remains included in each digestion category. 99.9% corresponds to the *Null*, 0.007% corresponds to *Light*, 0.04% corresponds to *Moderate*, and 0.02% corresponds to the *Heavy* categories.

Figure 8.11. Image of a calcaneum and an astragalus affected by digestion corrosion (5 mm scale).

It is quite complex to distinguish between teeth marks made by non-human and human predators. Experimental research about human toothmarks suggest that the range of damage is as extensive as that most likely to be produced by carnivores. This damage includes furrowing, scooping-out, crenulated and sawtoothed edges, longitudinal cracking, crushing, peeling and tooth marks (Landt, 2007; Saladié et al., 2013; Sanchis Serra et al, 2011). Other papers suggest the characteristics that define the model of human chewed bones are: bent ends, crenulated edges or chewed ends, and punctures and linear marks on the bone surfaces (Fernández-Jalvo and Andrews, 2011). For it features and comparisons with reference collections of materials consumed by different type of non-human predators (Lloveras, 2011) and with materials resulting from experimental research on human tooth marks (Fernández-Jalvo and Andrews, 2011; Landt, 2007; Saladie et al., 2013; Sanchis Serra et al., 2011), teeth marks recorded in Balma del Gai archaeological sample, in general, could be associated to both human and carnivores' activity. Remains that we consider are a result of human activity usually are proximal or distal epiphysis (60.9%) produced by a fresh fracture due to bite (Fig. 8.13), while remains with toothmarks caused by carnivores' activity display small punctures, pits and scores; especially in ribs, scapulae, calcanei and metapodials (15.7%) (Fig. 8.14). The rest of the 23.3% of the registered marks are undetermined.

8.5.5.4. Burnt marks

3,480 remains, a 23.4% of the studied sample, exhibit damage due to burning. Damage due to burning was not located on any particular part of the skeletal elements and it affected different kinds of bones. The most affected skeletal elements were cranial elements (cranium fragments, upper molars, lower molars, incisors, and mandibles), innominates, and ribs (Table 8.10). The intensity of the burning damage in the remains ranges between light and calcined. A 50.1% of the remains show light (light yellow and reddish) burning, 32.6% display moderate (brown to dark brown) damage (Fig. 8.15), 10.1% presented a strong (black) degree of burning damage, while a 5.9% and 1.2% of the remains show a extreme (grey) and calcined (white) degree of damage. It must be noted that most of the sample is homogeneously burnt, however a few specimens, corresponding to proximal epiphysis + shaft (PES) and shaft + distal epiphysis (SDE) of long bones show two colour categories.

8.5.5.5. Other bone surface alterations

A total of 1,533 skeletal elements display bone surface alterations caused by other biotic and abiotic agents, and comprises 10.3% of our archaeological sample (Table 8.11). The most common of this type of alteration are root-etching marks with a total of 912 cases (59.5%), followed by calcium carbonate concretions (14.7%), manganese oxide stains (12.2%) (Fig. 8.16), rodent gnawing marks (5.7%) (Fig. 8.17), and weathering (4.7%) (Fig. 8.18).

8.6. DISCUSSION

As evidenced by the results from research carried out on leporid archaeological assemblages from different geographic areas, an elevated percentage of adult individuals, which actually constitute more than 80%, is normally associated with human procurement strategies (Brugal, 2006; Cochard, 2004a; Guennoini, 2001; Hockett, 1991; Hockett and Bicho, 2000; Martínez-Valle, 1996; Lloveras et al. 2016; Rillardon and Brugal, 2014; Sanchis Serra and Fernández Peris, 2008). The frequency of adult individuals in Balma del Gai (92.3%) is placed within the range. Additionally, comparisons with data from taphonomic studies analysing remains recovered from nest and pellets from nocturnal and diurnal raptors, and scats and non-ingested remains from small terrestrial carnivores, show that the percentage of adult individuals consumed may vary depending on the abundance of prey (Tables 8.12 and 8.13). For instance, actualistic taphonomic studies on leporid assemblages produced by the red fox (*Vulpes vulpes*) (show that the percentage of adult individuals may vary from 50% (Cochard, 2004b) to 87 % (Cochard, 2004b; Lloveras et al., 2011), which it comes near to the results obtained for Balma del Gai. Also, the percentage of adult individuals in assemblages accumulated by the Egyptian vulture (*Neophron percnopterus*) ranges from 41.7 to 100 % (Lloveras et al., 2014; Sanchis et al., 2013).

Table 8.8. Total number of cutmarks recorded in *Oryctolagus cuniculus* remains recovered from the Balma del Gai.

Skeletal elements			Transversal		Oblique		Longitudinal	
	N	%	*N*	%	*N*	%	*N*	%
Mandible	16	9.1	8	7.5	8	14	0	0
Cranium	4	2.3	3	2.8	1	1.8	0	0
Vertebrae	2	1.1	0	0	2	3.5	0	0
Rib	3	1.7	2	1.9	1	1.8	0	0
Scapula	3	1.7	2	1.9	1	1.8	0	0
Humerus	22	12.6	10	9.3	10	17.5	2	18.1
Radius	17	9.7	10	9.3	4	7	3	27.3
Ulna	20	11.4	9	8.4	10	17.5	1	9.1
Innominate	26	15	11	10.3	12	21	3	27.3
Femur	9	5.1	5	4.7	2	3.5	2	18.1
Tibia	11	6.3	8	7.5	3	5.3	0	0
Patellae	0	0	0	0	0	0	0	0
Calcaneum	9	5.1	8	7.5	1	1.8	0	0
Astragalus	0	0	0	0	0	0	0	0
Carpal/Tarsal	0	0	0	0	0	0	0	0
Metacarpus	5	2.9	4	3.7	1	1.8	0	0
Metatarsus	20	11.4	19	17.7	1	1.8	0	0
Phalanges 1/2	8	4.6	8	7.4	0	0	0	0
Phalanges 3	0	0	0	0	0	0	0	0
TOTAL	175	100	107	99.9	57	100.1	11	99.9

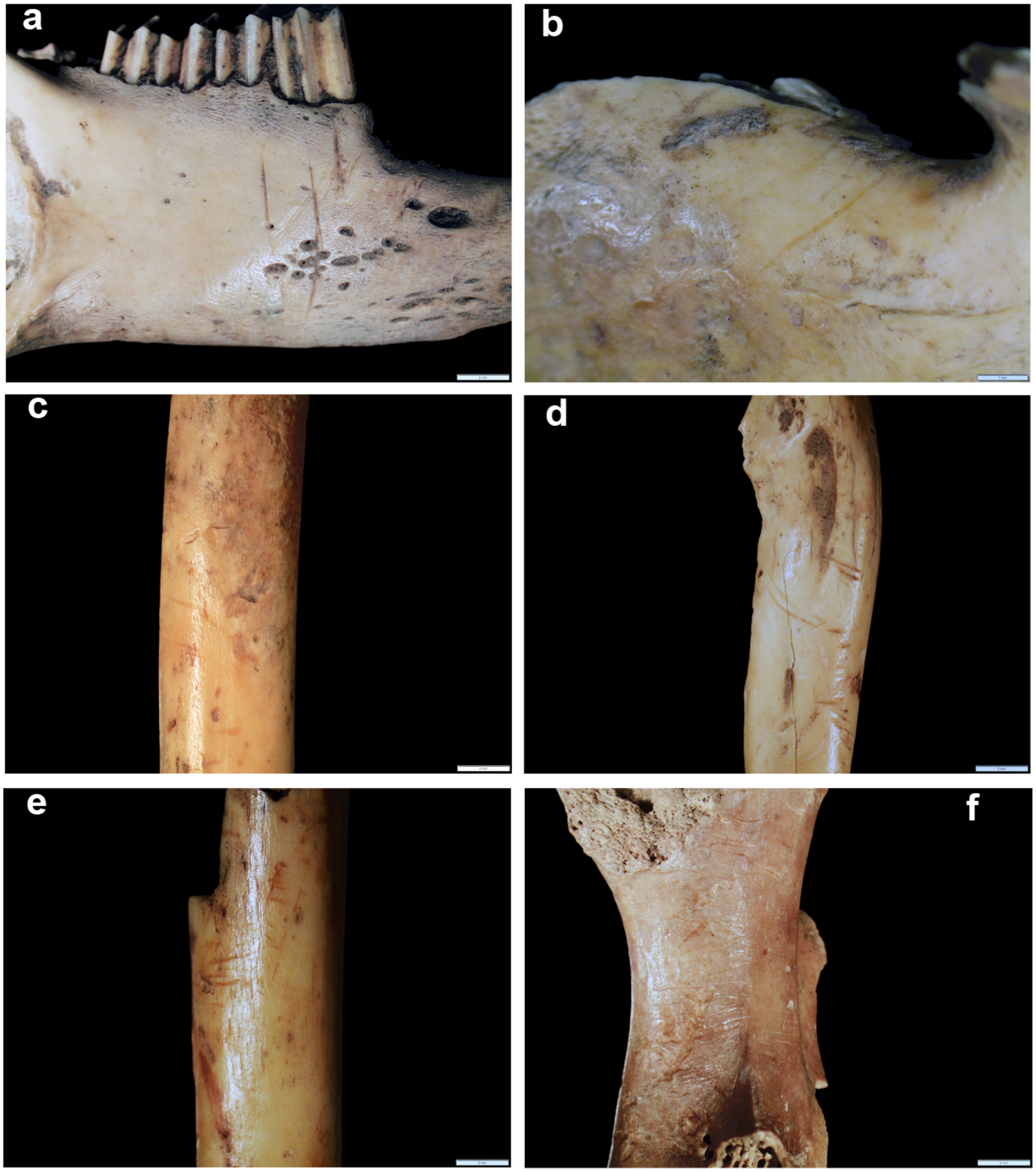

Figure 8.12. Example of cutmarks from leporid remains recovered in Balma del Gai. Mandible (a), cranium (b), radius (c), ulna (d), tibia (e), and innominate (f) (2 mm scale).

Table 8.9. Number of tooth marks counted in leporid remains recovered at the Balma del Gai.

Skeletal elements	TPU	TPI	SCO	CRE	NO	TOTAL
Mandible	6	0	1	6	11	24
Cranium	0	0	0	0	0	0
Vertebrae	1	0	0	0	0	1
Rib	2	1	0	0	2	5
Scapulae	5	3	1	1	2	12
Humerus	8	1	0	0	1	10
Radius	1	0	0	0	0	1
Ulna	1	1	0	1	0	3
Innominate	4	3	0	10	6	23
Femur	8	4	0	0	3	15
Tibia	11	11	0	2	5	29
Calcaneum	0	3	0	0	0	3
Astragalus	0	0	0	0	0	0
Carpal/Tarsal	0	0	0	0	0	0
Patellae	0	0	0	0	0	0
Metacarpus	1	1	0	0	0	2
Metatarsus	0	3	0	0	0	3
Phalanges 1/2	2	0	0	0	0	2
Phalanges 3	0	0	0	0	0	0
TOTAL	50	31	2	20	30	133
%	34.3	23.9	3.7	16.4	21.6	

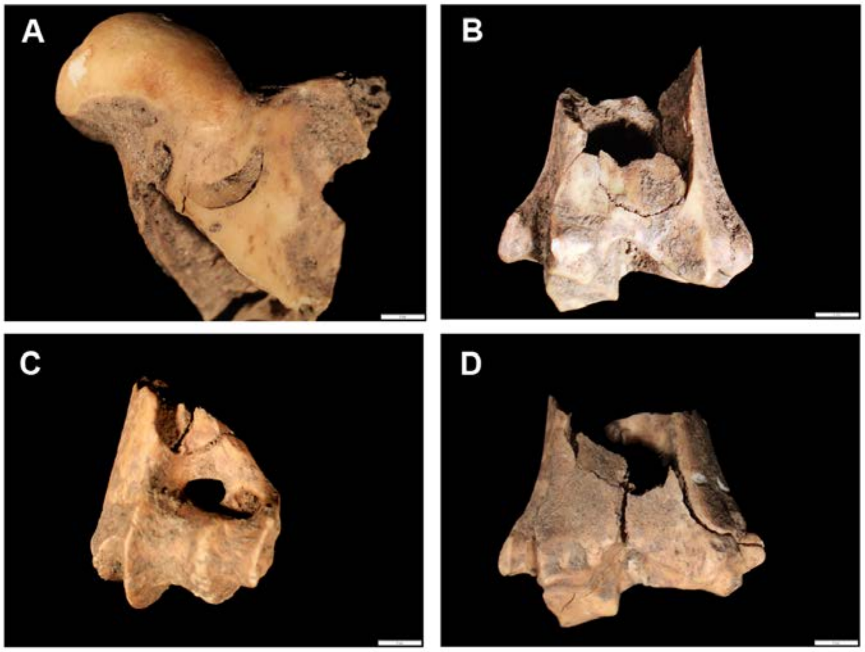

Figure 8.13. Examples of tooth marks on leporid remains recovered from Balma del Gai. Toothmarks associated to human consumption displaying fresh (green) fractures due to bite (2 mm scale).

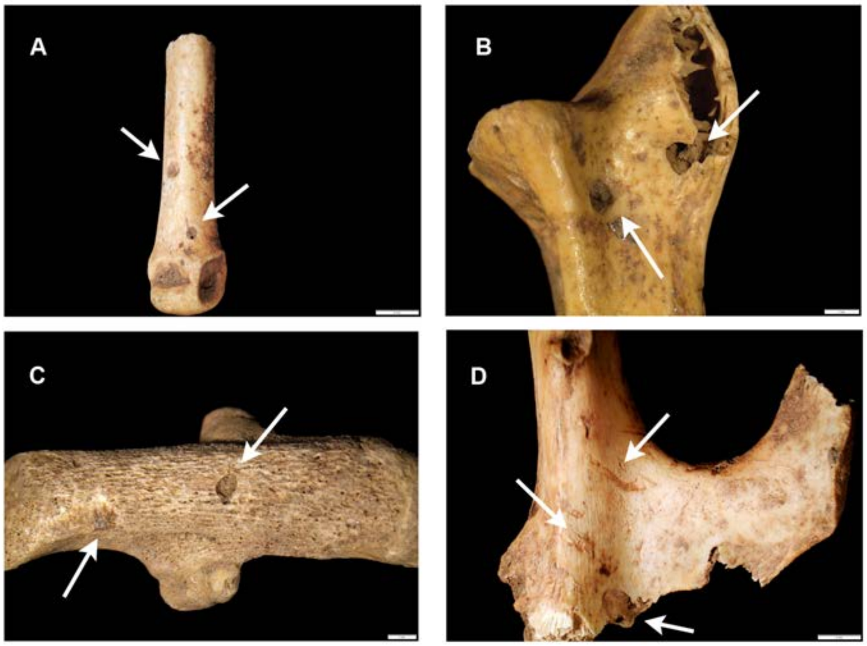

Figure 8.14. Examples of tooth marks on leporid remains recovered from Balma del Gai. Toothmarks associated to carnivores' activity displaying punctures and pits (A, B and C), and scores (D) (2 mm scale).

Table 8.10. Total number of burnt marks remains according to colour categories.

Skeletal elements	Light	Moderate	Strong	Extreme	Calcined	TOTAL
Mandible	108	79	28	11	2	228
Cranium	216	141	40	19	3	419
Upper mol +Inc	154	60	22	4	1	241
Lower mol + inc	223	85	7	1	0	316
Vertebrae	78	29	6	2	0	115
Rib	123	91	16	8	3	241
Scapulae	59	42	25	24	1	151
Humerus	71	60	21	17	3	172
Radius	54	55	19	14	3	145
Uln	48	53	19	6	0	126
Innominate	104	107	43	20	2	276
Femur	91	52	15	12	5	175
Tibia	65	84	12	8	2	171
Patellae	12	2	1	0	0	15
Calcaneum	48	29	13	16	6	112
Astragalus	40	13	11	2	2	68
Carpal/Tarsal	24	19	8	1	0	52
Metacarpus	49	29	10	8	2	98
Metatarsus	65	40	18	7	3	133
Phalanges 1/2	98	62	17	23	3	203
Phalanges 3	15	3	1	3	1	23
TOTAL	1745	1135	352	206	42	3480
%	50.1	32.6	10.1	5.9	1.2	

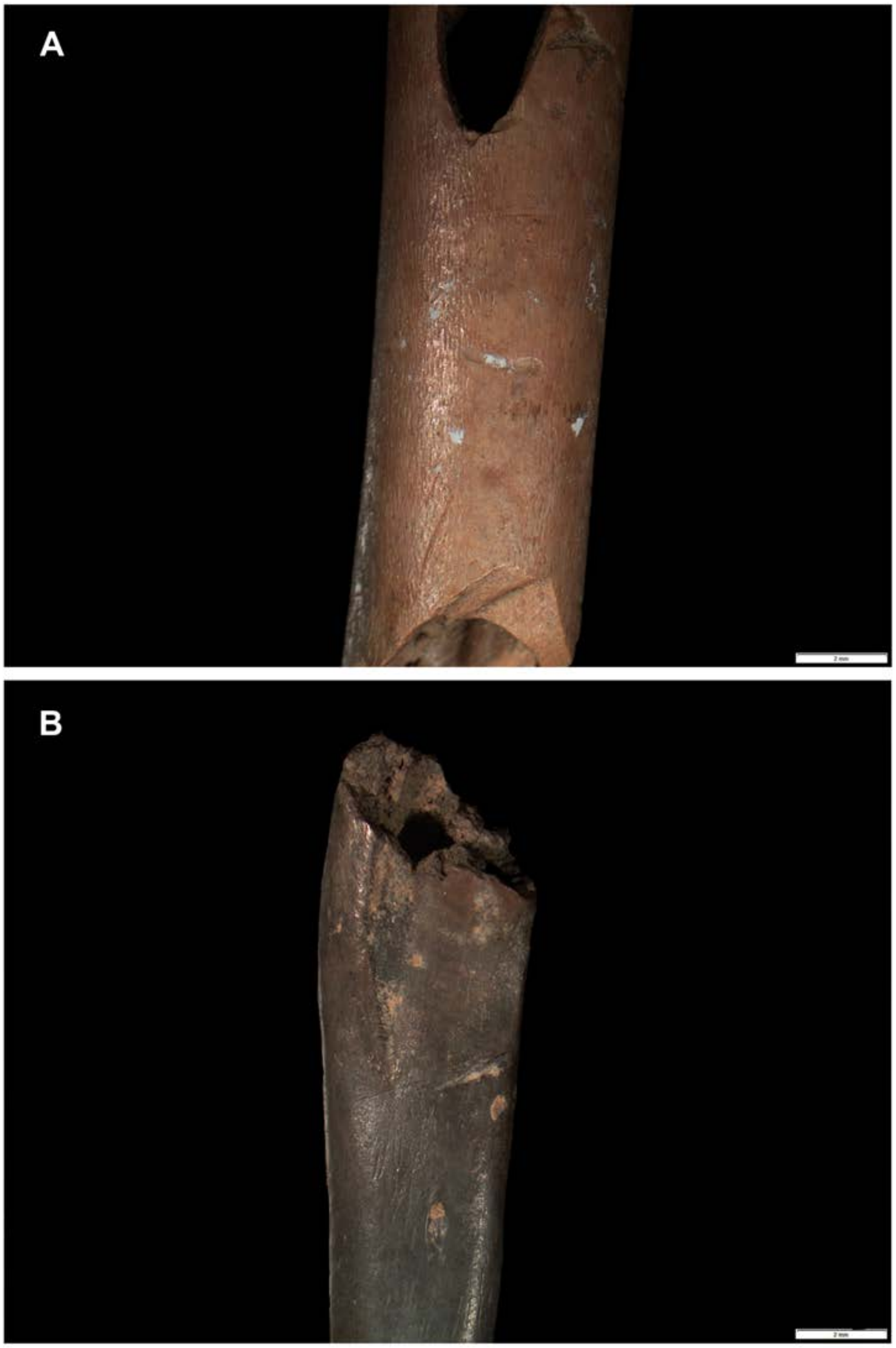

Figure 8.15. Example of burnt damage found on leporid remains from Balma del Gai. Light damage (A) and moderate to strong damage (B) (2 mm scale).

Table 8.11. Total number of skeletal elements displaying other biotic and abiotic bone surface alterations.

Skeletal elements	N	%
Manganese oxide	186	12.2
Diagenetic	4	0.2
Erosion	1	0.06
Abrasion	13	0.9
Dissolution	15	0.7
Concretions	225	14.8
Weathering	72	4.7
Bioerosion	11	0.7
Trampling	3	0.2
Rodent gnawing	91	5.7
Roots	912	59.8
TOTAL	1533	

The analysis of the anatomical representation shows that even though very small elements were scarce, which is consequence of the methodological approach followed as mentioned at the beginning of the *Results* section, the whole skeleton was represented. Anthropic accumulations are also characterized by the presence of all skeletal elements, indicating the transport of the whole carcasses to the site. There is no evidence of differential transport of any specific part of the carcasses, which may occur with some predators. Also, the relative abundance values indicate that cranium elements, mandibles, scapulae, long bones (specially femora, humeri, tibiae, and ulnae) and innominates, and are the most abundant, which is consistent to the anatomical profile expected in an anthropic accumulation where mandibles, long bones, scapulae and innominates are the best represented remains (2016; Brugal, 2006; Cochard, 2004; Guennouni, 2001; Hockett, 1991; Hockett and Haws, 2002; Lloveras et al., 2016; Rillardon and Brugal, 2014).

The corresponding values of the different anatomical indexes, which indicates the representation of different parts of the skeleton show that cranium elements are more abundant than postcranial elements (PCRT/CR= 26.5 %). Even though cranium elements

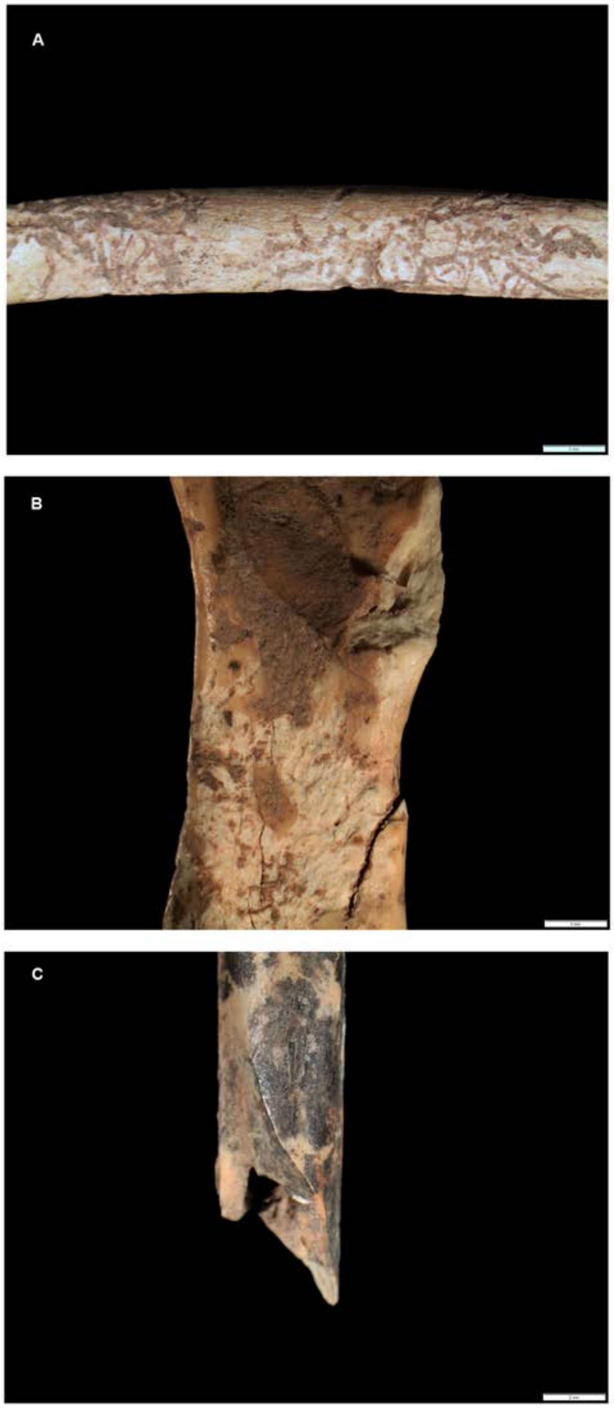

Figure 8.16. Example of different leporid remains displaying damage to the bone surface caused by other biotic and abiotic alterations. Root etching (A), cortical bone loss due to calcite concretions (B), and manganese oxide stains (C) (2 mm scale).

Figure 8.17. Image of a tibia displaying gnawing marks caused by rodents (2 mm scale).

Figure 8.18. Image of *Oryctolagus cuniculus* calcaneus showing evidence of weathering damage (2 mm scale).

are abundant, elements corresponding to long bones are well represented among the sample (PCRLB/CR= 119 %). Distal elements are scarcest than proximal elements (Z/E= 79.1 %), and elements corresponding to the hindlimbs are more represented than forelimbs elements (AN/PO= 89.2 %). When comparing this proportions with the values obtained for different non-human predators, the results are more similar to those obtained for diurnal raptors such as the Bonelli's eagle, and scats remains of Iberian lynx and red fox, but since the study of bone surface alterations such as corrosion damage cause by digestion yield 0.07 % it is quite unlikely the accumulation could be the result of lynx or fox scats since this type of accumulation often show values over 90% of digested remains (Lloveras et al., 2008a, 2012a). The low percentage of digested remains excludes these types of accumulations.

Regarding the analysis of breakage patterns, only 17.8% of the analysed remains presented a maximum length inferior to 10 mm. The majority of the accumulations created by different non-human predators present values over 50% (Lloveras et al., 2008a, 2008b, 2009a, 2012a, 2014, 2016b), others similar values are obtained for non-ingested remains accumulated by terrestrial carnivores: 35% European wildcat (Lloveras et al., 2016b), 28% for red fox (Lloveras et al., 2012a), and 19.7% for the Iberian lynx (Rodríguez-Hidalgo et al., 2013b). The percentages of complete bones (29%) and complete long bones (0.5%) is lower in Balma del Gai's sample compared to other actualistic studies of other predators with two exceptions: red fox (Lloveras et al., 2012a) and European wildcat (Lloveras et al., 2016b) scats. However as already mentioned, these are characterized by high percentages of digested remains. Nevertheless, it is worth bearing in mind that two factors may have contributed to undervalue the percentage of complete remains in the studied sample: a) the underrepresentation of small sized skeletal elements (Patellae, carpal/tarsal, phalanges 3 which are often recovered complete, and b) the presence of skeletal elements displaying modern fractures.

The presence of an elevated count of long bone cylinders fits within the observed range in other assemblages, where more than a 5% according to Cochard (2004a), especially femora, tibiae and humeri; along with multiple fragments of epiphysis of the same skeletal element, are considered evidence of anthropic activity in an archaeological site. This breakage pattern is related to the bone marrow processing by human groups, and although shaft cylinders may appear in assemblages accumulated by non-human predators, they appear in low quantities (Hockett and Haws, 2002). The high proportion of femora, tibiae and humeri cylinders in Balma del Gai (30.6%), as well as the abundance of epiphysis fragments (42%) points to the extraction of marrow from long bones.

The processing of the rabbit carcasses (skinning, disarticulation, defleshing and scraping) and preparation for human consumption is characterized by the presence of cut marks and burnt bones (Lloveras et al., 2009b; Rosado-Méndez et al., 2016), and while cut marks tend to be present in anthropic accumulations, they are however subjected to a significant variability (Brugal, 2006; Cochard, 2004; Hockett and Bicho, 2000). As established in Chapter 5, the number and type of marks produced during the defleshing process of the rabbit carcass clearly varies depending if the meat is fresh, dried or cooked. While defleshing cooked meat has resulted in remains with no marks, defleshing activities in raw, in the other hand, clearly increase he number of marks, which in most cases consisted in several incisions short, oblique and transversal in orientation, and superficial. Also scraping bones can leave long striations, running longitudinal across the entire shaft of long bones, the fossa of the scapulae, and the entire surface of innominates. Cut marks observed in this study matches well with butchery marks described by Pérez Ripoll (2001) from archaeological materials as well as butchery marks obtained from experimental research (Lloveras et al., 2009b; Rosado-Méndez et al., 2016).

In Balma del Gai, 1.2% of the remains displayed cut marks and 23.4% damage due to burning. The presence of cut marks and burnt bones necessarily demonstrate the presence of human activity, but not the quantity in which they are present. The proportions can vary as a result of the human activities conducted and the functionality of the site: seasonality, skinning, disarticulation and defleshing activities, ways of cooking, etc. Both percentages, although low, fit within the range observed for anthropic leporid accumulations in other sites, while the obtained values for burnt remains considerably surpasses most of the registered archaeological cases (Bournery et al., 2004; Cochard and Brugal, 2004; Hockett and Bicho, 2000; Ibáñez and Saladié, 2004; Lloveras et al., 2011, 2016; Pérez Ripoll, 2004; Rillardon and Brugal, 2014).

Table 8.12. Anatomical representation, breakage, digestion and teeth marks for leporid remains accumulated by diurnal and nocturnal raptors compared with the results obtained in the taphonomic analysis of leporid remains recovered from Balma del Gai.

	Eagle Owl (*Bubo bubo*)		Spanish Imperial Eagle (*Aquila adalberti*)	Bonelli's Eagle (*Aquila fasciata*)	Egyptian vulture (*Neophron percnopterus*)		Balma del Gai
Reference	*Lloveras et al., 2009a*		*Lloveras et al, 2008b*	*Lloveras et al., 2014b*	*Sanchis et al., 2013*	*Lloveras et al., 2014*	*Present study*
Origin	Nest	Nest	Pellet	Nest	Nest	Nest	Archaeological
N	1808	1932	824	438	269	133	14875
RA% > values	Pat-cal-in-fem	Cal-in-tib-mts	Phal 3-um-tib	Cr-um-in	Fem-in-rad-uln-mts	Md-cr	Cr elem- md-sca-long bones-in
Ra% < values	Mtc-c/t	Rad-c/t-mtc	Rib-fem-rad-ver	Mtc-rib	Rib-cr	Phal-c/t-ver-long bones	Phal-c/t-ver-rib-pat
PCRT/CR	+ Postcranial	=	+ Cranial	+ Cranial	+ Postcranial	+ Cranial	+ Cranial
P/D	+ Proximal	+ Proximal	+ Distal	+ Proximal	–	–	+ Proximal
AN/PO	+ Hindlimb	+ Hindlimb	+ Hindlimb	+ Hindlimb	–	–	+ Hindlimb
Complete elements %							
Long bones	14.6	10.8	0	51.7	–	–	0.5
Mean value total	53.9	45.9	27	74.7	80	81.2	29
Length (mm.)							
Min.	2.3	2.5	1.8	1.7	–	26.3	2.6
Max.	86.3	90	36.1	89.6	–	70.1	84.7
% < 10 mm	49	40	73	54.9	–	52.4	17.8
% Digested remains	68.8	65.6	98	31.2	1.1	0.8	0.07
% Digested long bones	88.9	83.9	100	31	2.8	–	–
Degree							
Null	31.2	34.4	2	68.8	–	99.2	99.9
Light	40.2	40.2	18.2	2.3	–	0	0.007
Moderate	19.8	19.8	46.8	7.9	–	0.8	0.04
Strong	8	5.3	27.4	14.4	–	0	0.02
Extreme	0.7	0.15	5.6	6.5	–	0	0
Teeth/beak marks	2	1.34	0.5	2.3	10.4	7.5	0.9
% Adult individuals	50	50	–	41.4	41.7	100	92.3

Table 8.13. Anatomical representation, breakage, digestion and teeth marks for leporid remains accumulated by small terrestrial carnivores compared with the results obtained in the taphonomic analysis of leporid remains recovered from Balma del Gai.

	Iberian Lynx (*Lynx pardinus*)		**Red Fox** (*Vulpes vulpes*)		**European wildcat** (*Felis silvestris*)		**Balma del Gai**
Reference	*Lloveras et al., 2008a*	*Rodríguez-Hidalgo et al., 2013*	*Lloveras et al., 2012a*		*Lloveras et al., 2016b*		*Present study*
Origin	Scat	Non-ingested	Scat	Non-ingested	Scat	Non-ingested	Archaeological
N	1522	9594	265	639	87	1457	14875
RA% > values	Md-teeth-cr	Tib-cal-mts-ast	Long bones-sca-cr	Mtc-cal-ast-tib	Sca-hum-rad-uln-cr	Cr-fem-mts-cal	Cr elem- md-sca-long bones-in
Ra% < values	C/t-ver-rib	Sca-ver-hum-rib-fem	Mtc-c/t-in	Cr-sca-rib-in-ver	Teeth-hindlimb	Sca-rib-hum-ver	Phal-c/t-ver-rib-pat
PCRT/CR	+ Cranial	+ Postcranial	=	+ Postcranial	+ Postcranial	+ Cranial	+ Cranial
P/D	+ Proximal	+ Distal	+ Proximal	+ Distal	+ Distal	+ Distal	+ Proximal
AN/PO	+ Forelimb	+ Hindlimb	+ Hindlimb	+ Hindlimb	+ Forelimb	+ Hindlimb	+ Hindlimb
Complete elements %							
Long bones	2.5	37.6	0	5.4	0	23.7	0.5
Mean value total	43	73.2	12	89.4	11.5	92.3	29
Length (mm.)							
Min.	1.1	3	3	4	2	2	2.6
Max.	30.1	69	26.8	86.2	11.4	138.2	84.7
% < 10 mm	80	19.7	91	28	98.8	35	17.8
% Digested remains	97.2	–	99.5	–	98.6	–	0.07
% Digested long bones	100	–	100	–	100	–	–
Degree						–	
Null	2.8	–	0	–	1.4	–	99.9
Light	12	–	6	–	1.4	–	0.007
Moderate	22	–	26	–	9.6	–	0.04
Strong	43.8	–	43	–	39.7	–	0.02
Extreme	19.3	–	25	–	47.9	–	0
Teeth/beak marks	0.26	0.9	3	9.5	0	1.2	0.9
% Adult individuals	21.4	–	87	–	–	–	92.3

The presence of tooth marks on leporid accumulations has been traditionally attributed to non-human predators. This assumption has changed over the past few years, with ethnoarchaeological and experimental research data showing that humans also make modifications during chewing (Landt, 2007; Lloveras et al., 2009b; Saladié et al., 2013; Sanchis Serra et al., 2011). However identifying tooth marks caused by humans from other predators is not a straightforward matter, since tooth marks caused by human teeth are characterized by the removal of minimal to moderate amounts of cancellous bone tissue and are mostly associated with the fractures of long bone in order to remove bone marrow (Landt, 2007; Sanchis Serra et al., 2011). Unlike leporid assemblages accumulated by terrestrial carnivores, punctures marks (TPU) tend to be rare, and are predominantly located in flat bone and long bones diaphysis. Taking into consideration the research cited above, we have determined that at least 60.9% of the registered tooth marks from Balma del Gai, can be attributed to human activity. A minor carnivores' activity has also been detected, however, it is clear that in this site tooth marks also point to the high degree of anthropization of the sample.

Data obtained on bone surface alterations caused by other biotic and abiotic agents indicate that 10.3% of the remains was affected. A 59.5% is ascribed to damage caused by root etching, this is common when remains are accumulated in open shelters like Balma del Gai, where plants can easily grow. The second and third most common alterations present in Balma del Gai were calcium carbonate concretions, possibly due to the precipitation of mineral cement into the fauna remains (14.8%) and stains caused by manganese oxide (12.2%) which is indicative of the remains not being expose to the atmospheric agents for long periods of time, and a waterlogged environment. Also 5.7% of the remains were affected by rodent gnawing. This can be an indication of low sedimentation rate, leading to the exposure or remains while rodent circulated the habitation floor while the site was abandoned. The non-existence of rodent burrows can rule out this activity within the warrens. Moreover, the well-protected areas help with the conservation of the material by blocking the effects of weathering.

8.7. CONCLUSIONS

The Epipalaeolithic leporid assemblage from Balma del Gai appears to be largely of anthropogenic origin. The anatomical representation and breakage patterns (with a high percentage of proximal and distal epiphyses fragments, and a high percentage of long bone cylinders associated with marrow extraction) along with an average presence of cut marks and a significant presence of burnt remains, strongly suggest the assemblage was for the most part accumulated by humans (Brugal, 2006; Cochard, 2004a,b; Hockett and Bicho, 2000, Manne and Bicho, 2009). Although, the low incidence of digestion damage and tooth/beak marks, expressly puncture marks, pits and score marks, suggests a very small quantity of remains accumulated by small terrestrial carnivores. However, taking into account the taphonomical patterns described above, their role was minor. The results suggest evidence of the processing of rabbit carcasses, especially: a) the presence of marks associated to the skinning process and b) a significant quantity of marks associated to the defleshing process. This practice in particular does not seem to make any sense, since it is hard to imagine any human group defleshing such a small size animal when the meat can be consumed directly. Notwithstanding, there is ethnographic research on Native Americans communities from the Southwest of the United States that proves that in places where rabbits are an important, but a seasonal food resource, the meat is separated from the bones and set to dry to prolong its consumption (Bean, 1972; Spier, 1978). Also, experimental research carried out on raw, dried and cooked rabbit limbs (Chapter 5) suggests that limbs can be dried directly, without the need to extract the meat. In this way we can argue that the high percentage of complete elements might be due to the drying and conservation of the whole parts of the carcasses instead of associating it with the taphonomic signature of the Spanish Imperial Eagle. This type of behaviour suggests a mass collection of rabbits, and is evidenced by the high minimum number of individuals recorded in the site, which can be very advantageous in terms of obtaining meat for direct consumption, but also to produce a dried food, which can be preserved for a certain amount of time, and for the supply of rabbit pelt.

This present study shows that in Balma del Gai, rabbits become a primary prey for prehistoric populations during the Epipaleolithic period, which confirms and increases the number of sites that demonstrate a strategic change in the exploitation of small prey throughout the end of Pleistocene and the beginning of the Holocene in Southern Europe and the Mediterranean basin.

CHAPTER 9

COVA DE LA GUINEU

9.1. LOCATION AND ARCHAEOLOGICAL BACKGROUND

Cova de la Guineu is a small cave, located in the municipality of Font Rubí (Alt Penedès), in the province of Barcelona at 734 meters above the sea level, and at 30 kilometers of the actual coastline (Nadal, 1998). The geographic coordinates are YTM 31N (E) 380921 Y (N) 4588723 (Fig. 9.1). The site offers the longest archaeological sequence found in the area of the Foix basin with a marked continuity in the use of the cave by human groups in prehistoric and historic times; including periods alternating intensive and sporadic occupation of Palaeolithic and Epipaleolithic hunter-gatherers groups, Neolithic (Cardial, Post-Cardial and Late Neolithic Period), Chalcolithic, and Medieval occupations (Morales et al., 2013).

Pere Giró, an amateur archaeologist, discovered the archaeological site in 1961 and documented some archaeological remains on the surface level. Between 1979 and 1982 local amateurs plundered the site affecting the ceramic levels from Bronze Age to the Ancient Neolithic periods from inside the cave. Josep Mestres conducted the first archaeological intervention on Cova de la Guineu in 1983 which consisted in the excavation of a $4m^2$ unit in order to contextualize the material recovered by amateurs in the surface level and to establish a stratigraphic sequence for the site. Since 1988 archaeological fieldworks was undertaken and it has continued till this day under the organization of SERP from the University of Barcelona, and the direction of Artur Cebrià and Josep Mestres and other researchers that have change along the time.

From a morphological point of view, this territory presents sheer mountainous areas corresponding to the southern slope of the Catalan Pre-Coastal Range. The area where the archaeological site is located, features a regional geology constituted by Triassic-Jurassic materials from the Muschelkalk (Lower, Mid and Upper) and Keuper facies (Bergadà, 1998,). The Cova de la Guineu is located inside a semi circular depression, with a diameter ranging between 15 and 20 meters, with a large Oak tree in its centre and several galleries clogged with blocks, and it occupies an area of 47 m^2 (Fig. 9.2). The opening of the cave is 5 x 12 m in length and is oriented SE (Bergadà, 1998). The sedimentary infill of the cave has different origins depending on the section (upper and inferior) of the stratigraphic sequence. Sediments deposited in the upper section correspond to slope deposits while sediments corresponding to the inferior section are a mixture of karst, dissolved clay and collusion deposits (Bergadà, 1998; Morales et al., 2013). Also three episodes of falling blocks were identified, the first corresponding to the Epipaleolithic levels (Morales et al., 2013).

9.2. STRATIGRAPHIC UNITS

A stratigraphic and cultural sequence (Fig. 9.3) was establish based on the sediment infill of profile F9-F7 (2.49 m thick) located at the exterior of the cave, and profile E5 (6.05 m thick) (Bergadà; Equip Guineu, 1995):

Profile F9-F7

- Superficial level - it has a thickness that ranges between 80-100 cm. It is comprised of 68% of gravel material of 1-7 cm in size and blocks of dolomitic limestone and sandstone with a sub-rounded morphology. The matrix is formed of sandy silt and clay with a high content of organic material such as leaves and roots. This level corresponds to the sporadic occupations in Medieval and modern times.

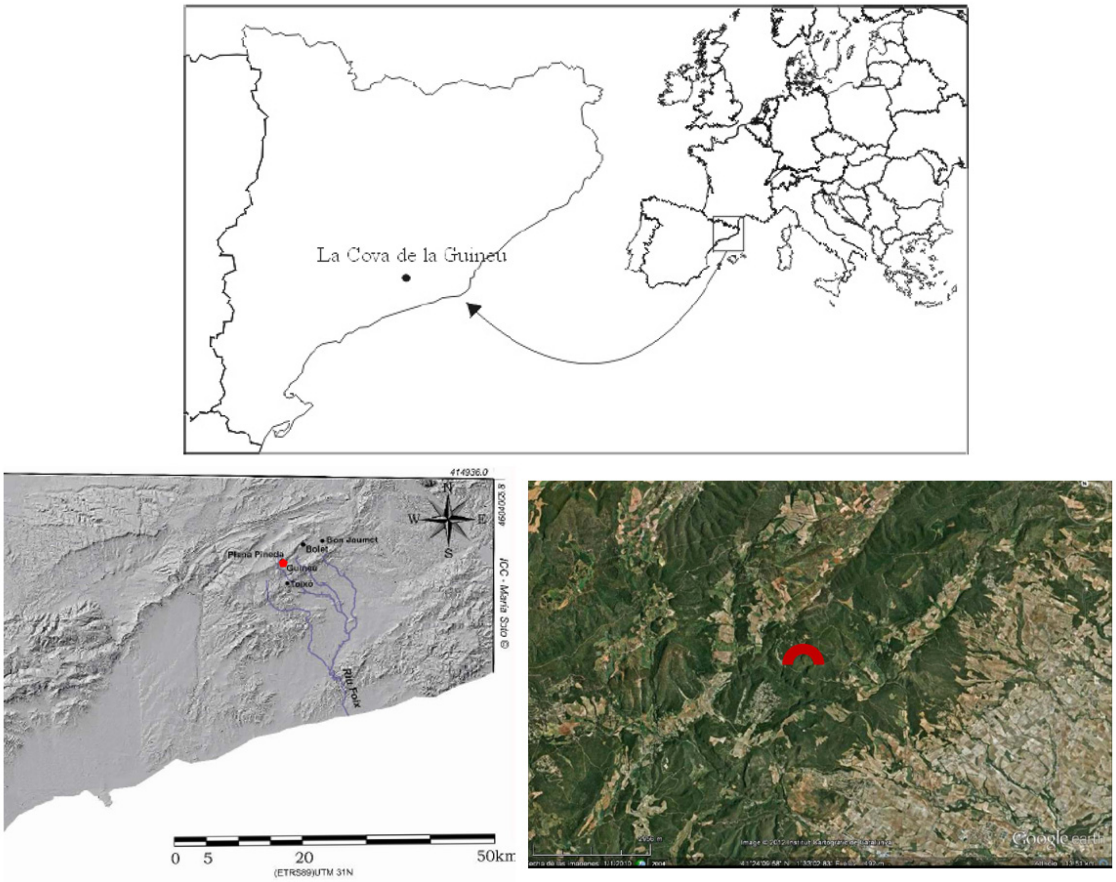

Figure 9.1. Maps showing the location of Cova de la Guineu (red dot) in the Iberian Peninsula.

- Level I.a. - it is 30-40 cm thick and it is constituted by blocks and a 45% of gravel of sub-rounded morphology with carbonates concretions. The blocks surface show traces of dissolution. The matrix is formed by sandy silts and dark brown clay (10 YR 3/2), and a high content of organic material. Its structure is very similar to the superficial level. This level is attributed to the Late Iberian period (end S. II and beginning S. I BC).

Figure 9.2. A photograph of the surrondings of the entrance of Cova de la Guineu archaeological site (Author: A. Cebrià).

- Level I.b. – it is 32 cm thick and its composed by an 80% of gravel of 1-12 cm in size, of subangular morphology, and patches of carbonate concretions. The matrix is composed of sandy silts and dark brown clay (10 YR 3/3). The slope of this level is oriented W. This level is attributed to the Bronze Age (3280 BP).

- Level I.c. – it has a thickness of 23 cm. In this level a decrease of the coarse fraction, in comparison to level I.b, is recorded. Like the other levels, the matrix is also composed of sandy silts and clay, but there is a slight increase in the sand fraction. The whole structure is composed of subangular blocks; two of which fell off the roof changing the morphology and configuration of the cave. This level is attributed to the Late Neolithic.

- Level I.d. - it is 54 cm thick, formed of a 50% of blocks and gravel, of 1-6 cm in size and sub-rounded morphology. The matrix is composed of sandy silts and clay of brown colour (7.5 YR 3/2), with a structure of subangular blocks. This level is attributed to the Neolithic (Early Cardial).

Profile E5

- Level II. – 75 cm in thickness, this level is formed of blocks and a 5% of dolomitic limestone gravel of sub-rounded morphology. The matrix is comprised by sandy silts of brown colour (7.5 YR 3/2). It shows a significant presence of anthropic material such as ash and charcoal. The structure is composed of subangular blocks. An erosional contact between this level and level III was recorded. Level II is attributed to the Neolithic (Early Cardial).

- Level III.a. – it has a sedimentary thickness of 34 cm, and its composed of a 55% of coarse fraction ranging between 1-6 cm (subangular morphology) and 1-2 cm in size. The matrix is made of sandy silts of light brown colour (7.5 YR 6/4) with clay. This level follows a slope in SE direction and is attributed to the Epipaleolithic period.

- Level III.b. – It is 54 cm thick, with larger blocks and coarse fraction than level III.a.

- Level III.c. - It has a sedimentary thickness of 31 cm and comprised of 59% of subangular gravel, 1-6 cm in size. Some coarse fractions appear to have carbonate concretions on the surface. The sedimentary matrix is composed of sandy silts of light brown colour (7.5 YR 6/4) and it follows a slope in SE direction.

- Level III.e. – It is located in the E5/D5 profile. It has a thickness of 20 cm and its composed by a matrix of sandy silts of brown colour (7.5 YR 4/6). The coarse fraction decreases considerably (3%) regarding the previous level.

- Level IV- it is located on the E5/D5 and E5-F5 profiles. It has a thickness of 15 cm, coarse fraction ranging from 1-3 cm in size with traces of dissolution are quite dominant. The sedimentary matrix is comprised of sandy silts of brown colour (7.5 YR 5/4) and it has an angular block structure. Big blocks were recovered from the top of the level. From this level on, due to the appearance of archaeological remains of uncertain cultural ascription, it is difficult to specify the chronological timeline.

- Level V.a. – it is 30 cm thick and it' s composed of sandy silts of brown colour (7.5 YR 5/4). From an archaeological point of view, it yields a low quantity of material.

- Level V.b. – it has a sedimentary thickness of 32 cm with a slight increase of the coarse fraction (14%) and few blocks of dolomitic limestone. The size of the coarse fraction ranges between 1-4 cm and are sub rounded in morphology. The matrix is composed of composed of sandy silts of brown colour (7.5 YR 5/4).

- Level VI – It is 53 cm thick and is formed of sand laminations and clayed silts of brown-orange colour (7.5 YR 5/6). There is a 14% of coarse fraction with an average length of 1-2 cm. Traces of dissolution and roots are present.

- Level VII – It has a thickness of 40 cm and is formed of sandy silts of brown colour (5 YR 5/6). In this level one can see a decrease in the coarse fraction, although it increases considerably into the E5-F5 profile. The lithology of the material is dolomitic sandstone of 1-2 cm in size. In this level the slope softens toward the back of the cave (N direction).

- Level VIII – it has a sedimentary thickness of 115 cm and it is composed by a series of gravel, sand and clayed silt laminations (brown colour; 10 YR 6/6), and few blocks, 35 cm in size of subangular morphology. As in the previous level, the slope softens toward N direction.

- Level IX – it is 41 cm thick and is formed by a series of laminations in a clay matrix of brown colour (10 YR 6/6). Iron oxides–hydroxides are seen among the laminations.

- Level X – it has a thickness of 33 cm, and composed of gravel and blocks of dolomite with dimensions ranging between 15-20 cm, of subangular morphology (25%). The sedimentary matrix is formed of sandy silts and a clay content of brown colour (10 YR 6/4). One can see impregnations of iron oxides-hydroxides and manganese oxide. Angular blocks compose the whole structure of this level.

- Level XI – it is 20 cm thick and composed of sandy silt of brown colour (10 YR 6/4). Within this level de coarse fraction decreases considerably. The dip of the level continues SW toward NE direction. Medium large blocks compose the structure of this level.

- Level XII – it has an undetermined thickness; only 12 cm have been excavated. It is composed of gravel and blocks with dimensions ranging between 15-20 cm, of subangular morphology. The sedimentary matrix is formed of sandy silts and a clay content of light brown colour (7.5 YR 6/4). Medium large blocks compose the structure of this level. A fragment of a mandible corresponding to a fox was found in this level.

9.3. CHRONOLOGY AND MATERIAL CULTURE

As already mentioned, Cova de la Guineu offers the longest archaeological sequence found in the area of the Foix basin with a marked continuity in the use of the cave. A summary of the different levels, radiocarbon dates, and cultural attribution is available in Table 9.1. From this point forward we will emphasize on level III, corresponding to the Epipalaeolithic hunter-gatherers occupation, which is the main focus of this PhD dissertation. Level III is the earliest verifiable episode of human occupation within the cave. Radiocarbon dating (^{14}C) performed to sample Gif-8439 sets level III at approximately 9.850 ± 80 BP (11.220 – 11.399 cal. BP), placing it in the Microlaminar Epipalaeolithic, a period comprising a later stage of the Late Glacial and the beginning of the Holocene (García-Argüelles, 2004; Morales et al., 2013).

9.4 RECOVERED REMAINS

The area of the cave where archaeological remains have been documented is practically located at the back of the cave (Fig. 9.4). In this area it was possible to document all the evidence that points to the activities that were carried out at the site. A series of hearth structures of different sizes were identified, at least one of this structures located in unit D5 is associated with the Epipalaeolithic occupation. Also lithic tools, faunal remains and charcoal were found.

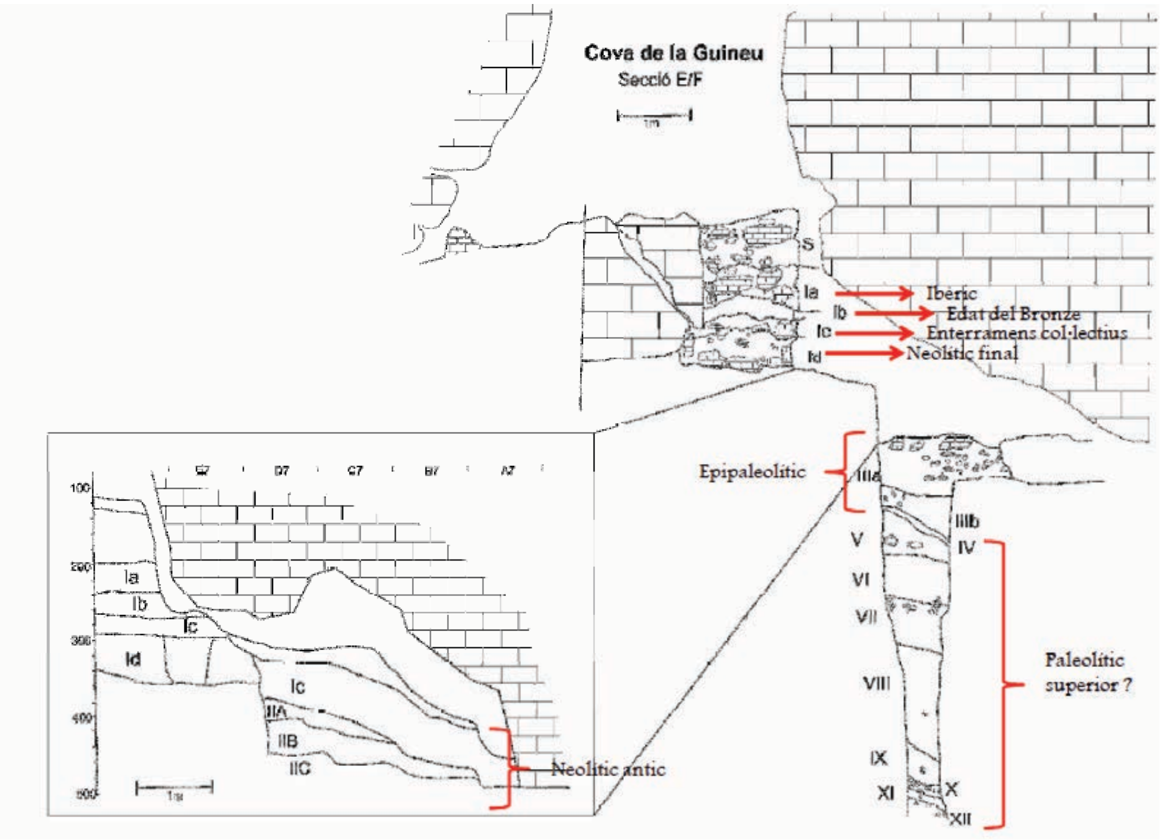

Figure 9.3. Illustration of the archaeological sequence of Cova de la Guineu.

9.4.1. Lithic industry and habitation features

The recovered lithic industry on level III shows flint to be the most dominant lithology in the selection of raw materials with more than a 90%; other materials used are quartzite and quartz. Technologically, the lithic assemblage can be defined as "microlithic", and more specifically characterized by the use of microlaminar technique, which involves extracting narrow and long blades in order to produce projectile elements. Cova de la Guineu's lithic assemblage is composed of a 22.5% of pointed bladelets and a 26% of endscrappers (Fig. 9.5) (Morales et al., 2013).

9.4.2. Floral remains

Anthracological remains recovered from level III. Corresponding to the Epipalaeolithic occupation at Cova de la Guineu, yield some interesting results. Charcoal remains recovered from units D4-E4 and D5-E5, corresponding to the 1983,1988 and 1989 archaeological campaigns, were analysed by M^{a} Teresa Ros from the *Laboratori de Paleoecología del Museu Arqueològic de Barcelona*. According to this study, flora remains from the level III.a., located at the bottom of level III, are characterized by the presence of taxons such as *Pinus sylvestris-salzmanni, Juniperus, Prunus, Buxux sempervirens, Acer opalus, and Quercus sp*. Such finding points to the existence of an open landscape with a low density forest coverage dominated by pine trees, *Juniperus* and *Prunus,* and a more humid environment, deeper soils with dense forest coverage in lower terrain. On the other hand, level III.a., located at the upper side of level III, is characterized by an elevated percentage of oak tree accompanied by other taxa such as maple (*Acer opalus*) and yew (*Taxus baccata*) trees. In comparison to level III.b., frequencies in the number of pine trees and other coniferous taxa (*Juniperus*) decreases, which it may be related to landscape modifications due to climatic change. It corresponded with the arrival of more temperate conditions that promoted the territorial extensions of sub-Mediterranean oak forests (Table 9.2).

9.4.3. Faunal remains

Fauna remains are diverse; the studied material corresponds to bone remains of various size vertebrates (mammals, amphibians, reptiles, and birds) and malacofauna from the excavations of D4-E4 and D5-E5 in 1983 and 1988.

A microvertebrate study was conducted by Manuel Millán from the *Laboratori de Paleoecología del Museu Arqueològic de Barcelona* and by Àngel Galobart from the Institut Paleontològic de Sabadell (Bergadà, 1998; Galobart et al b, 1991). This sample came from the 1988 archaeological campaign. The fauna corresponding to the Epipalaeolithic level can be found in Sub Mediterranean and Mediterranean low forests, with the exception of *Microtus duodecimcostatus*, which is present in the Mediterranean low mountain, and *Microtus arvalis*, present in the high mountain. Among the microvertebrates sample were: *Sciurus vulgaris, Clethrioronomys glareolus, Eliomys quercinus, Apodemus, Microtus arvalis* and *Microtus agrestis* (Table 9.3); all of which inhabit high mountain areas.

The analysis of macrofauna and mesofauna was also conducted by Manuel Millán and Jordi Nadal of SERP from the University of Barcelona. A summary of the taxa identified in Cova de la Guineu is available in Table 9.3. The study of malacofauna remains, corresponding to the 1983 archaeological campaign, was conducted by Manuel Millán in 1988, while materials corresponding to the 1988, 1989 and 1990 archaeological campaigns were later. Among the faunal remains, we must point out the large amount of remains corresponding to *Oryctolagus cuniculus*, which comprise the 98.1% of the total faunal assemblages. European rabbit remains are followed by: *Cervus elaphus* (0.73%), *Capra pyrenaica* (0.21%), *Lepus europaeus* (0.05%), *Capreolus capreolus* (0.05%) and *Sus scrofa* (0.01%).

9.5. ANALYSIS RESULTS

Cova de la Guineus's sample consists of all leporid remains recovered from units D4-E4 and D5-E5. A total number of 11.325 leporid remains were counted, but ultimately only 6.768 (59.8%), which correspond to the number of determined remains (NDR) were considered for the taphonomical analysis. Based on the innominate counts, the estimated number of elements (MNE) is 160 and the minimum number of individuals (MNI) is 84.

9.5.1. Taxonomic determination

All remains were identified as European rabbit (*Oryctolagus cuniculus*). No hare remains were found among the sample.

Table 9.1. Levels, C14 dates, and cultural attribution of the archaeological sequence in Cova de la Guineu (Modified from Morales et al., 2013).

Level	Sample	Reference	C14 Dates	Deviation	Cultural attribution	Observations
I.a.	Charcoal	Oxa-23640	2941	26	Final Bronze-Iron Age	/
	Charcoal	Oxa-23641	3030	26	Final Bronze-Iron Age	/
I.b.	Charcoal	UBAR-258	3280	70	/	Rejected
I.c.	Bone	Oxa-10799	4500	40	Final Neolithic	/
	Charcoal	Gif-10027	2830	80	/	Rejected
	Bone	/	4335	32	Final Neolithic	/
II.a.	/	/	/	/	Antique Neolithic	/
II.b.	/	/	/	/	Antique Neolithic	/
II.c.	Charcoal	Gif/LSM	5480	60	Antique Neolithic	/
	Charcoal	Gif-99112	5330	70	Antique Neolithic	/
	Charcoal	Gif-99113	5480	80	Antique Neolithic	/
	Charcoal	Gif-99114	5580	70	Antique Neolithic	/
II.c. (base)	/	/	/	/	Antique Neolithic (Cardial)	/
III.a.	Charcoal	Gif-8439	9850	80	Epipaleolithic	/
III.b.	/	/	/	/	Epipaleolithic	/
IV	/	/	/	/	Palaeolithic ind	/
V	/	/	/	/	Palaeolithic ind	/
VI	/	/	/	/	Palaeolithic ind	/
VII	/	/	/	/	Palaeolithic ind	/
VIII	/	/	/	/	Palaeolithic ind	/
IX	/	/	/	/	Palaeolithic ind	/
X	/	/	/	/	Palaeolithic ind	/
XI	/	/	/	/	Palaeolithic ind	/
XII	/	/	/	/	Palaeolithic ind	/

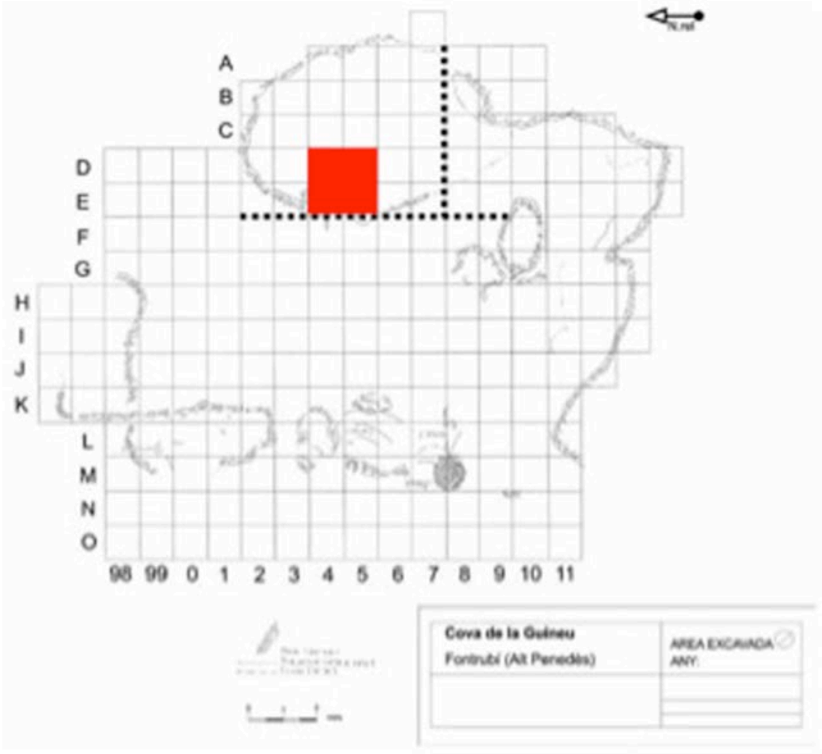

Figure 9.4. Illustration of the structures associated to the Epipaleolithic level.

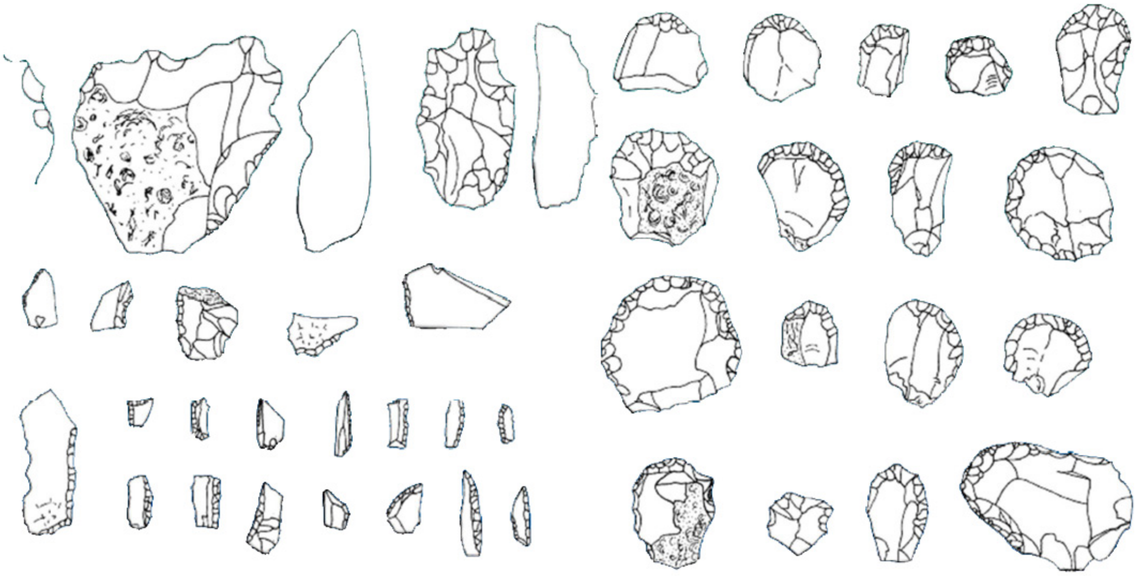

Figure 9.5. Illustration of lithic assemblage recovered from Cova de la Guineu.

9.5.2. Age of death

Based on the state of epiphyseal fusion of long bones, metapodials, scapulae, and innominates, the percentage of adult individuals in our sample is 82.6% while a 17.4% corresponds to immature individuals (Table 9.4).

Table 9.2. Anthracological analysis of Cova de la Guineu (Extracted and modified from Bergadà, 1998).

Taxa	Level III.a	Level III.b
Pinus silvestris-salzm.	X	X
Juniperus sp.	X	X
Acer opalus	X	X
Quercus sp. Cad.	X	X
Taxus baccata	X	
Populus sp.	X	
Quercus ilex-cocc	X	
Arbutus unedo	X	
Erica sp.	X	
Prunus sp.		X
Rosaceae		X
Buxus sempervirens		X
Undetermined	X	

Table 9.3. Analysis of fauna remains recovered from the Epipalaeolithic level of Cova de la Guineu (Modified from Bergadà,).

MICROVERTEBRATES

Millán (1988)	*Galobart (1991)*	*Nadal (1998)*
Sciurus vulgaris	*Apodemus sylvaticus*	*Muridae sp.*
Clethrioronomys glareolus	*Arvicola sapidus*	*Apodemus sylvaticus*
Micomys minutus	*Microtus duodecimcostatus*	*Arvicolinae sp.*
Crocidura russula	*Rana sp.*	*Microtus duodecimcostatus*
Arvicola sapidus	*Colubridae*	*Eliomys quercinus*
Eliomys quercinus	*Crosidura russula*	*Crosidura russula*
Microtus duodecimcostatus	*Eliomys quercinus*	*Ophidia sp.*
Mus musculus	*Podarcis muralis*	*Elaphe escalaris*
Microtus agrestis	*Myotis myotis*	*Anura sp.*
Erinaceus europaeus	*Lacerta lepida*	*Bufo calamita*
Barbastella barbastella	*Microtus arvalis*	
Apodemus sylvaticus		
Lacerta viridis		
Rana ridibunda		
Bufo bufo		

MACROFAUNA and MESOFAUNA

Millán (1988,1991)	*Nadal (1998)*	*García (1991)*
Oryctolagus cuniculus	*Oryctolagus cuniculus*	*Falco naumanni*
Mustela nivalis	*Capreolus capreolus*	*Galliforme*
Mustela putorius	*Cervus elaphus*	*Phaisanidae sp.*
Capreolus capreolus	*Sus scropha*	*Alectoris sp.*
Cervus elaphus	*Capra pyrenaica*	*Alectoris graeca/rufa*
Sus scropha	*Meles meles*	*Alectoris barbara*
Felis sylvestris		*Passeriformes*
Lynx pardellus		
Capra pyrenaica		

MALACOFAUNA

Millán (1988)	*Güell-Serrano (1991)*
Helix asperta	*Cepaea nemoralis*
Helix hortensis	*Pomatia elegans*
Ciclostoma elegans	*Helix sp.*
Glycimeris glycimeris	*Xeroplexa sp.*
Pecten jacobeus	*Jaminia quadridens*
Helix nemoralis	*Glycymeris violasc*
	Pecten jacobaeus
	Pseudotachea splendida *Vitre contracta*

Table 9.4. Skeletal elements valued for the age of death determination. Number of fused (F) and not fused (NF) remains.

Skeletal Element	F	NF	TOTAL
Hum	49	22	71
Rad	34	20	54
Uln	107	32	139
Fem	43	20	63
Tib	40	26	66
Mtc	148	15	163
Mts	176	26	202
IN	286	32	318
Sca	140	23	163
TOTAL	1023	216	1239

9.5.3. Anatomical representation and differential conservation

In order to present the information in an organized way, we have elaborated a table showing the anatomical composition of the leporid assemblage, as well as the relative abundance percentage for each element (Table 9.5). The entire skeleton is well represented. According to the NDR%, the most numerous remains are ribs, upper and lower molars, incisors, cranial elements, 1/2 phalanges, innominates, and mandibles while patellae, carpal/tarsal elements, astragali and 3rd phalanges were the scarcest.

The mean value of relative abundance for this sample is 47.5 %, which indicates an important loss of skeletal elements. This value shows a significant bias of the NDR, as there are skeletal elements that are underrepresented taking into account MNI estimated in our sample, possibly due to the sieving technique used during fieldwork, and which has favoured the loss of small sized remains. In Table 9.5 the relative abundance for each element is presented; according to these percentages the best represented elements are mandibles, cranial elements, innominate, scapulae, and long bones specially tibiae, ulnae, femora and humeri. Meanwhile skeletal elements with the lower RA% were the smallest: patellae, carpal/tarsals, phalanges (1/2 and 3), vertebrae and ribs (Fig. 9.6).

The corresponding values of the different anatomical indexes, that allows us to assess the proportions in which the different parts of the skeleton are represented, are shown in Table 9.6.

Table 9.5. Leporid skeletal element identified in level I from Cova de la Guineu. N number of skeletal elements, N% percentage of skeletal elements, MNE minimum number of elements, and RA% relative abundance.

Skeletal elements	N	N%	MNE	RA%
Mandible	313	4.6	160	95.2
Crania	564	8.3	75	89.3
Incisor	353	5.2	290	57.5
Upper Molar	707	10.4	654	64.9
Lower Molar	721	10.7	680	81
Humerus	150	2.2	76	45.2
Radius	215	3.2	82	48.8
Ulna	241	3.6	121	72
Femer	194	2.9	82	48.8
Tibia	322	4.8	152	90.5
Patella	2	0.02	2	1.2
Scapula	224	3.3	156	92.9
Innominate	391	5.8	160	95.2
Metacarpal	222	3.3	181	21.5
Metatarsal	373	5.5	252	37.5
Phalanges 1/2	421	6.2	382	13.4
Phalanges 3	81	1.2	81	5.4
Calcaneum	111	1.6	88	52.4
Astagal	32	0.5	30	17.9
Carpal/Tarsal	17	0.3	17	0.8
Vertebra	335	4.9	158	4.1
Rib	779	11.5	179	8.9
TOTAL	6768			

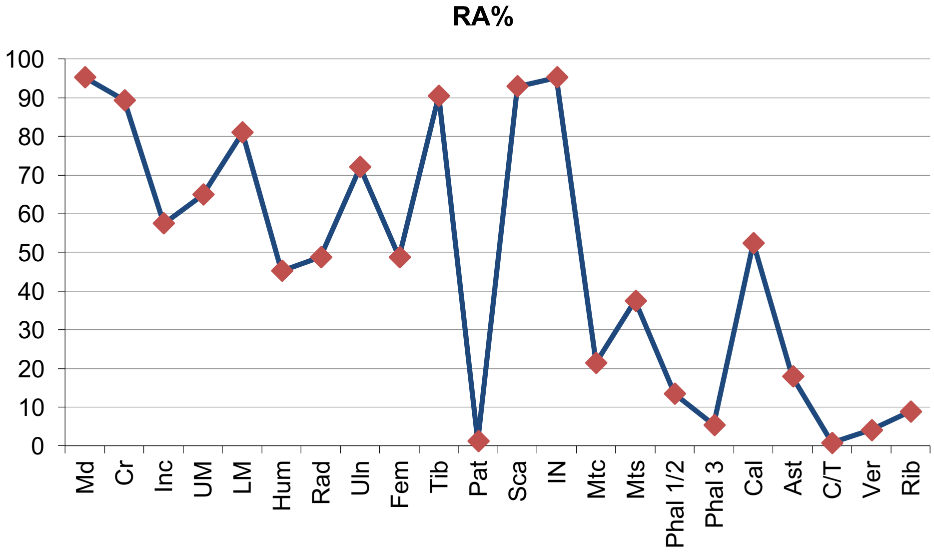

Figure 9.6. Relative abundance of the different parts of the skeleton in Cova de la Guineu's leporid remains sample. *Md* mandible, *Cr* cranium, *Inc* incisors, *UM* upper molar, *LM* lower molar, *Hum* humerus, *Rad* radius, *Uln* ulna, *Fem* femur, *Tib* tibia, *Pat* patella, *Sca* scapula, *IN* innominate, *Mtc* metacarpals, *Mts* metatarsals, *Phal ½* first and second phalanges, *Phal 3* third phalanges, *Cal* calcaneum, *Ast* astragalus, *C/T* carpal and tarsals, *Ver* vertebrae, and *Rib* ribs.

Table 9.6. Proportions of different parts of the skeleton. The calculation formulas and abbreviations have been explained in Chapter 7, dedicated to the methodology of the taphonomic analysis.

Index	Value %	Representation
PCRT/CR	22.2	+ Cranial
PCRAP/CR	27.1	+ Cranial
PCRLB/CR	85.5	+ Long bones
AUT/ZE	20.5	+ Proximal (ZE)
Z/E	149.5	+Distal (*Tibia, radius and ulna*)
AN/PO (1)	71	+ Hindlimbs
AN/PO (2)	100.4	= Equilibrated
AN/PO (3)	82.8	+ Hindlimbs

A calculation approximating to the 100% implies a balance (equilibrium) between the represented elements, while a calculation under or above the 100% entails a lower or higher representation of the skeletal elements. Results show the following:

- The relatively low value obtained for the PCRT/CR index shows that for every 100 cranial elements (CR) there are only a 22.2 % of postcranial elements, which means that postcranial elements are underrepresented. The same occurs with the PCRAP/CR; in this case the appendicular elements are also underrepresented (27.1%). When cranial elements are compared to long bones (PCRLB/CR), the sample shows a deficit of cranial elements (85.5%), indicating a good representation of long bones.

- When comparing the proportions between distal and proximal elements (20.5%), the AUT/ZE index indicates that there is a low representation of skeletal elements that comprises the autopodium in comparison to elements belonging to the zigopodium + stilopodium, which implies an important loss of distal elements.

- The value for the Z/E index (149.5%) shows a mayor representation of skeletal elements that correspond to the zygopodium.

- Values for the AN/PO index were calculated in three different ways:

- When calculating the proportion between AN/PO, three results were obtained. Calculation for 1 and 3 resulted in lower values, 71% and 74.2% respectively, which suggest a greater representation of elements corresponding to the hindlimbs in comparison to elements that comprise the forelimbs, as opposed to calculation 2, 82.8% that indicated an almost equilibrated proportion between forelimbs and hindlimbs. This suggests that the differences in proportions are due to the different values obtained for the metapodial elements.

When compared to Pavao and Stahl's (1999) independent measures of rabbit bone density, it was found that there was no statistically significant correlation between the frequency of rabbit skeletal portions and their density (rho=0.306, p=0.249). This indicates that preservation of rabbit remains at Cova de la Guineu have been generally unaffected by structural density-mediated attrition.

9.5.4. Breakage patterns and types of fractures

The maximum length of the remains is variable with measures ranging between 3.4 to 144 mm. The average maximum length was 18.1 mm and more than 86 % of the remains present length values over 10 mm (Fig. 9.7).

A total of 2,375 remains (35.1%) were complete (Table 9.7), if we consider solely long bones remains the percentage of complete bones it is reduced to 14.2%. As might be expected, the obtained value vary according the size of the skeletal remain, being the smaller remains, such as carpal/tarsals, patellae, 3rd phalanges, ribs, astragali and calcanei, and teeth, that appear less fragmented (Table 9.7 and 9.8 of breakage categories).

Breakage categories established for every skeletal elements show that cranial elements never appeared complete, and they were mainly identified by fragments comprising the neurocranium (NC), maxillae (M), the zygomatic arch (AZ), and the incisive bone (IB). Mandibles were mostly represented by mandibular body + incisive part (MBI), mandibular body (MB), condylar process (CP) and incisive part (IP). In the case of the innominates, it was common to find parts belonging to the ischquium (IS), illium (IL), and fragments containing the acetabulum with both illium and ischquium. Most scapulae fragments contained the glenoid cavity + neck (GCN), glenoid cavity + neck + fossa (GCNF), and neck + fossa (NF) parts. Vertebrae were complete in 16.1 % of the cases, but the most represented fragments were vertebrae body (VB) and the spinous process (SP). Ribs were always fragmented in a 98.2% of cases. Regarding the teeth, 85.2% of isolated and *in situ* pieces were complete.

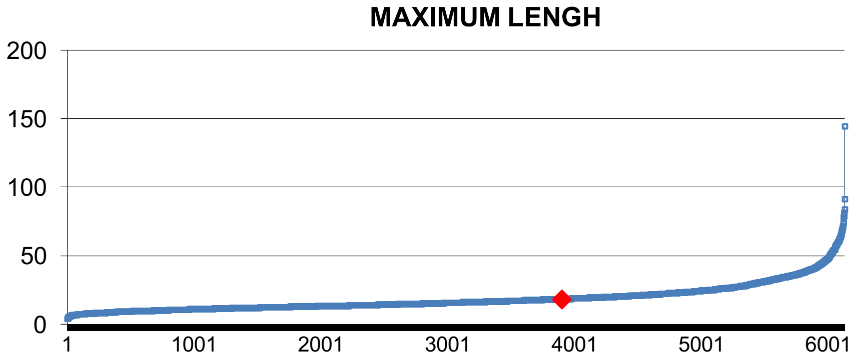

Figure 9.7. Mean length of fragmented *Oryctolagus cuniculus* remains. The red dot denotes the sample's mean value (18.1 mm).

Table 9.7. Number and percentage of complete elements in Cova de la Guineu site. N: number of skeletal remains, C: number of complete elements, and C%: percentages of complete elements. For abbreviations see Chapter 7.

Skeletal elements	N	C	C%
Md	313	2	0.6
Cr	564	0	0
Inc	353	242	68.6
UM	707	598	84.6
LM	721	664	92.1
Hum	150	1	0.7
Rad	215	7	3.3
Uln	241	3	1.2
Fem	194	4	2.1
Tib	322	2	0.6
Pat	2	2	100
Sca	224	0	0
IN	391	4	1
Mtc	222	128	57.7
Mts	373	99	26.5
Phal 1/2	421	341	81
Phal 3	81	81	100
Cal	111	82	73.9
Ast	32	30	93.8
C/T	17	17	100
Ver	335	54	16.1
Rib	779	14	1.8
TOTAL	6768	2375	

All the breakage categories were represented in limb bones and metapodial elements. Humeri, radii, ulnae, femora and tibiae remains are best represented by fragments belonging to the proximal epiphysis + shaft (PES) and shaft (S). Metacarpals and metatarsals are the most complete elements with an average value of 57.7 % and 26.5 % respectively. Patellae, carpal/tarsals and 3rd phalanges were all complete while astragali (93.8 %), 1/2 phalanges (81 %) and calcanei (73.9 %) were almost complete.

A total number of 294 (26.2%) shaft fragments were identified as long bone cylinders. Most of long bones and metapodial elements (55.2%) present fresh fractures, whereas that a 38.1% show dry fractures. Finally, the 6.6% of remains displayed modern fractures, possibly as a consequence of the excavation process, transport and packaging of the remains (Table 9.9).

9.5.5. Bone surface alterations

9.5.5.1. Digestion

A detailed study of the remains under a light microscope was conducted to detect the presence of damage caused by digestion. A 99.6% of the remains were not affected, only 29 cases (0.4%) from our sample presented digestion corrosion damage (Table 9.10). The affected remains were the upper and lower molars, humeri, radii, ulnae, femora, innominate, 1/2 phalanges, calcanei, and astragali. Of all 29 specimens, 21 cases present a light degree of damage (0.3%), 6 cases (0.1%) show moderate degree of digestion, while 2 cases (0.03%) show a strong degree of digestion (Fig. 9.8).

9.5.5.2. Cut marks

A total of 36 bones remains (0.5%) display cut marks. They were mostly observed in humeri (8), tibiae (6), scapulae (4), and innominates (4), mandibles (3) and metatarsals (3) (Table 9.11).

Transversal and oblique orientations were recorded but most of the marks were transversal (24; 66.7 %) to the principal axis of the bone (Table 11). In long bones, especially fragments containing the shaft (PE+S and S+DE), cut marks with oblique orientation co-occur with transversal marks. Transversal marks on mandibles (incisive part + mandibular body), cranium (zygomatic arch), vertebrae (spinous process), scapulae (glenoid cavity + neck + fossa), innominate (illium + ischium + acetabulum), and metatarsus may be related to the skinning and disarticulation of rabbit carcasses, whereas a mix of transversal and oblique marks located on long bone shafts are probably related to defleshing activities (Fig. 9.9 and 9.10).

Table 9.8. Number and percentage of parts of the skeleton included in each breakage category.

Long bones and metapodials	C		PE		PE+S		S		S+DE		DE	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Humeri	1	0.7	4	2.7	15	10	82	54.6	27	18	21	14
Radii	7	3.3	1	0.5	74	34.4	89	41.4	42	19.5	2	0.9
Ulnae	3	1.2	21	8.7	97	40.2	90	37.3	30	12.4	0	0
Femora	4	2.1	35	18	11	5.7	128	66	5	2.6	11	5.7
Tibiae	2	0.6	9	2.8	11	3.4	257	79.8	16	5	27	8.4
Metacarpals	128	57.7	0	0	53	23.9	5	2.2	34	15.3	2	0.9
Metatarsals	99	26.5	2	0.5	151	40.5	20	5.4	99	26.5	2	0.5

Mandibles	*N*	*%*	*Vertebrae*	*N*	*%*	*Innominates*	*N*	*%*
C	2	0.6	C	54	16.1	C	4	1
IP	42	13.4	VB	105	31.3	IL	104	26.6
MBI	79	25.2	VE	3	0.9	AIL	47	12
MB	63	20.1	SP	173	51.6	A	15	3.8
MBB	34	10.9	Rib	*N*	*%*	AISIL	52	13.3
B	39	12.5	C	14	1.8	AIS	42	10.7
CP	54	17.3	F	765	98.2	IS	127	32.5
Crania	*N*	*%*	Patellae	*N*	*%*	*Phalanges 1/2*	*N*	*%*
IB	89	15.8	C	2	100	C	341	81
M	146	25.9	F	0	0	F	80	18.9
AZ	104	18.4						
NC	225	39.9						

Scapulae	*N*	*%*	Calcanei	*N*	*%*
C	0	0	C	82	73.9
GC	12	5.4	F	29	26.1
GCN	61	27.2			
GCNF	56	25	*Astragali*	*N*	*%*
N	39	17.4	C	30	93.8
NF	41	18.3	F	2	6.3
F	15	6.7			
Phalanges 3	*N*	*%*	*Carpal/Tarsals*	*N*	*%*
C	81	100	C	17	100
F	0	0	F	0	0

Teeth	*In situ*					
	Incisors		UM		LM	
	N	*%*	*N*	*%*	*N*	*%*
C	76	75.2	135	97.1	374	96.6
F	25	24.8	4	2.9	13	3.4

	Isolated					
	Incisors		Upper Molars		Lower Molars	
	N	*%*	*N*	*%*	*N*	*%*
	166	65.9	421	83	265	88.3
	86	34.1	86	17	35	11.7

Long bones and metapodials were classified as complete (C), proximal epiphysis (PE), proximal epiphysis + shaft (PES), shaft (S), shaft + distal epiphysis (SDE), and distal epiphysis (DE). Mandibles were classified as complete (C), incisive part (IP), mandible body + incisive part (MBI), mandible body (MB), mandible body + branch (MBB), branch (B), and condylar process (CP). Cranium elements were classified as complete (C), incisive bone (IB), maxillae (M), zygomatic arch (AZ), and neurocranium (NC). Innominates were classified as complete (C), illium (IL), acetabulum + illium (AIL), acetabulum (A), acetabulum + ischium +illium (AISIL), acetabulum + ischium (AIS), and ischium (IS). Scapulae were classified as complete (C), glenoid cavity (GC), glenoid cavity + neck (GCN), glenoid cavity + neck + fossa (GCNF), neck (N), neck + fossa (NF), and fossa (F). Vertebrae were classified as complete (C), vertebral body (VB), vertebral epiphysis (VE), and spinous process (SP). Ribs, patellae, phalanges, calcanei, astragali, carpals and tarsals, and teeth were classified as complete (C) and fragment (F).

Table 9.9. Types of fractures. FF: Fresh fractures, DF: Dry fractures and MF: Modern fractures.

Skeletal elements	FF	DF	MF
Humerus	116	23	8
Radius	63	125	19.0
Ulna	107	120	11.0
Femur	158	20	9
Tibia	240	59	18
Metacarpal	27	63	4
Metatarsal	97	148	28
TOTAL	808	558	97
%	55.2	38.1	6.6

9.5.5.3. Tooth marks

A total number of 43 remains with tooth marks (0.6%) were recorded during the taphonomic analysis. The skeletal elements that show the greater number of marks were innominates (10 cases), tibiae (6), 1/2 phalanges (4), radii (3), femora (3), scapulae (3), and metatarsals. A number of 20 (46.5%) remains displayed punctures (TPU), while a 42% showed pit marks (TPI), 2.3% of the remains presented scoring marks, 3 cases (7%) exhibit crenulated edges (CRE), and a 2.3% (1) displayed notches (Table 9.12).

Punctures marks (TPU) as well as pit marks (TPI) are mostly seen in innominates, long bones (radii, ulnae, femora and tibiae), metapodials, scapulae, mandibles and cranial elements. Scoring marks were recorded in tibiae remains, while crenulated edges were recorded in femora and innominate remains. A notch mark was noticeable in a rib fragment. The majority of the remains displaying tooth marks show more than one type of mark (Fig. 9.11).

Table 9.10. Number and percentages of *Oryctolagus cuniculus* remains included in each digestion category.

Digestion in bone remains	Null		Light		Moderate		Heavy		Extreme		TOTAL
	N	%	N	%	N	%	N	%	N	%	
Mandible	313	100	0	0	0	0	0	0	0	0	313
Cranium	564	100	0	0	0	0	0	0	0	0	564
Upper molar + Inc	879	99.3	5	0.6	1	0.1	0	0	0	0	885
Lower molar + Inc	894	99.8	1	0.1	1	0.1	0	0	0	0	896
Humerus	149	99.3	1	0.7	0	0	0	0	0	0	150
Radius	214	99.5	1	0.5	0	0	0	0	0	0	215
Ulna	239	99.2	2	0.8	0	0	0	0	0	0	241
Femur	193	99.5	0	0	1	0.5	0	0	0	0	194
Tibia	322	100	0	0	0	0	0	0	0	0	322
Patella	2	100	0	0	0	0	0	0	0	0	2
Scapula	224	100	0	0	0	0	0	0	0	0	224
Innominate	390	99.7	0	0	0	0	1	0.2	0	0	391
Metacarpus	222	100	0	0	0	0	0	0	0	0	222
Metatarsus	373	100	0	0	0	0	0	0	0	0	373
Phalanges 1/2	419	99.5	1	0.2	1	0.2	0	0	0	0	421
Phalanges 3	81	100	0	0	0	0	0	0	0	0	81
Calcaneum	102	91.8	7	6.3	1	0.9	1	0.9	0	0	111
Astragalus	28	87.5	3	9.4	1	3.1	0	0	0	0	32
Carpal/Tarsal	17	100	0	0	0	0	0	0	0	0	17
Vertebrae	335	100	0	0	0	0	0	0	0	0	335
Ribs	779	100	0	0	0	0	0	0	0	0	779
TOTAL	6739		21		6		2		0		6768

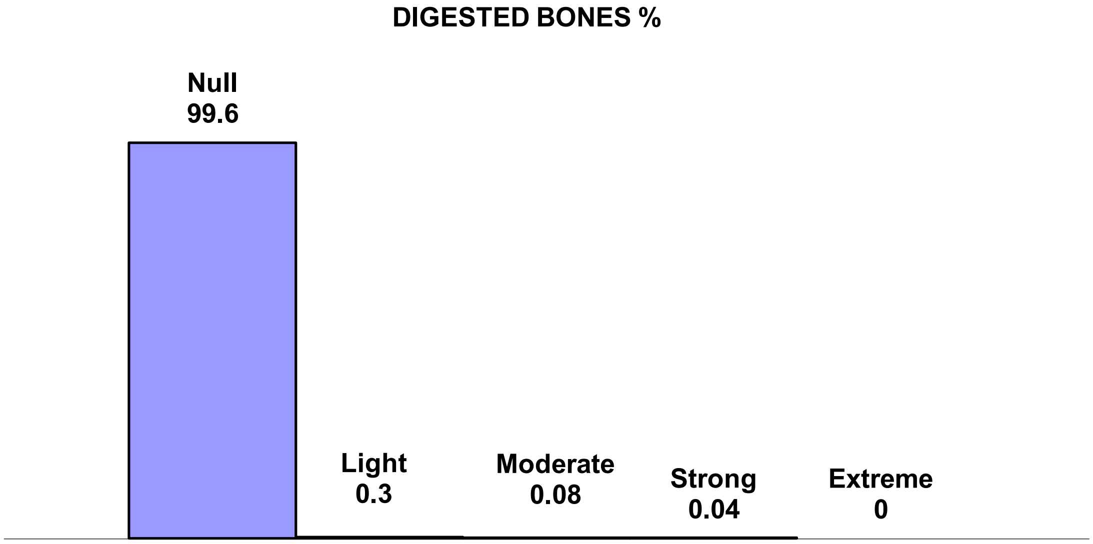

Figure 9.8. Percentage of skeletal remains included in each digestion category.

As already pointed out in Chapter 6, although it is quite complex to distinguish between teeth marks made by non-human and human predators, for it features and comparisons with reference collections of materials consumed by different type of non-human predators (Lloveras, 2011) and with materials resulting from experimental research on human tooth marks (Landt, 2007; Saladie et al. 2013), teeth marks, specifically punctures, pits and score marks can be attributed to the minor action of small carnivores. While fresh fractures causes by biting located in long bone shaft and epiphysis fragments are attributed to marrow consumption by humans.

9.5.5.4. Burnt marks

At first, the sample of elements that presented damages by heat comprised a total of 363 (5.4%). It was after comparing the results obtained from the experimental study on modern and archaeological thermo-altered remains, explained in more detail in Chapter 6, that we made the decision to eliminate from our sample all the remains corresponding to the *light, moderate* and *strong* colour categories, since there was doubt in whether the remains were burnt or not.

For that matter, the calculation of burnt remains was based on 62 remains, representing the 0.9%. Damage due to burning was not located on any particular part of the skeletal elements and it affected different kinds of bone. The most affected skeletal elements were ribs, tibiae, innominates, upper molars, 1/2 phalanges, scapulae, radii, ulnae and calcanei (Table 9.13). The intensity of the burning damage in the remains ranges between extreme and calcined. Specifically, 75.8% of the remains show an extreme degree, and 24.2% of the burnt sample were calcined (white) (Table 9.13 and Fig. 9.12).

9.5.5.5. Other bone surface alterations

A total of 24 skeletal elements display bone surface alterations caused by other biotic and abiotic agents, and comprises 0.35 % of our archaeological sample (Table 9.14 and Fig. 9.13) The most common alteration is bioerosion damage with a total of 7 cases (0.1%), followed by manganese oxide stains (0.1%), dissolution (0.1%), and rodent gnawing marks (0.04%).

9.6. DISCUSSION

The study of age of death of the analysed remains denotes the presence of 82.6 % of adult individuals. Leporid accumulations of anthropic origin are characterized by a procurement strategy focusing in adult individuals, which usually constitute more than 80 % of the hunted individuals, although lower percentages around 50 – 60 % have been recorded (Brugal, 2006; Cochard, 2004a; Guennouni, 2001; Hockett, 1991; Hockett and Bicho, 2000; Martínez-Valle, 1996; Lloveras et al., 2016; Rillardon and Brugal, 2014; Sanchis Serra and Fernández Peris, 2008). On the other hand, taphonomic studies analysing remains recovered from nest and pellets from nocturnal and diurnal raptors, and scats and non-ingested remains from small terrestrial carnivores, show that the percentage of adult individuals consumed may vary depending on the abundance of prey (Table 9.15).

Table 9.11. Total number of cutmarks recorded in leporid remains recovered from Cova de la Guineu.

Skeletal elements			Transversal		Oblique		Longitudinal	
	N	%	*N*	%	*N*	%	*N*	%
Mandible	3	8.3	2	8.3	1	8.3	0	0
Cranium	1	2.8	1	4.2	0	0	0	0
Vertebrae	2	5.5	2	8.3	0	0	0	0
Rib	0	0	0	0	0	0	0	0
Scapula	4	11.1	4	16.7	0	0	0	0
Humerus	8	22.2	4	16.7	4	33.3	0	0
Radius	1	2.8	0	0	1	8.3	0	0
Ulna	2	5.5	0	0	2	16.7	0	0
Innominate	4	11.1	3	12.5	1	8.3	0	0
Femur	2	5.5	2	8.3	0	0	0	0
Tibia	6	16.7	3	12.5	3	25	0	0
Patella	0	0	0	0	0	0	0	0
Calcaneum	0	0	0	0	0	0	0	0
Astragalus	0	0	0	0	0	0	0	0
Carpal/Tarsal	0	0	0	0	0	0	0	0
Metacarpus	0	0	0	0	0	0	0	0
Metatarsus	3	8.3	3	12.5	0	0	0	0
Phalanges 1/2	0	0	0	0	0	0	0	0
Phalanges 3	0	0	0	0	0	0	0	0
TOTAL	36		24		12		0	

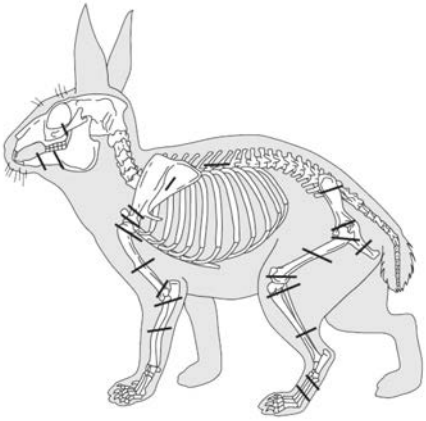

Figure 9.9. Location of skinning, disarticulation and defleshing cut marks on each skeletal element.

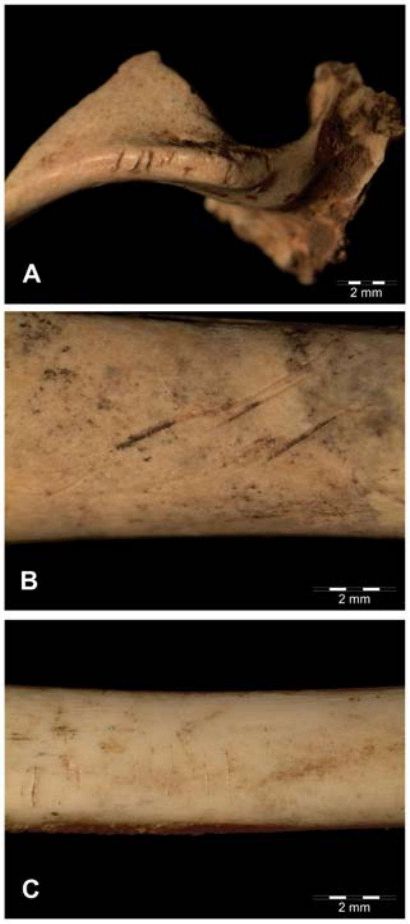

Figure 9.10. Example of cutmarks from leporid remains recovered from Cova de la Guineu. Mandible (A), tibia (B) and radius (c).

Table 9.12. Number of tooth marks counted in leporid remains recovered at Cova de la Guineu site.

Skeletal elements	TPU	TPI	SCO	CRE	NO	TOTAL
Mandible	1	0	0	0	0	1
Cranium	1	1	0	0	0	2
Vertebrae	0	2	0	0	0	2
Rib	1	0	0	0	1	2
Scapulae	1	2	0	0	0	3
Humerus	0	0	0	0	0	0
Radius	2	1	0	0	0	3
Ulna	1	1	0	0	0	2
Innominate	5	3	0	2	0	10
Femur	1	1	0	1	0	3
Tibia	2	3	1	0	0	6
Calcaneum	1	0	0	0	0	1
Astragalus	0	0	0	0	0	0
Carpal/Tarsal	0	0	0	0	0	0
Patella	0	0	0	0	0	0
Metacarpus	1	0	0	0	0	1
Metatarsus	2	1	0	0	0	3
Phalanges 1/2	1	3	0	0	0	4
Phalanges 3	0	0	0	0	0	0
TOTAL	20	18	1	3	1	43
%	46.5	42	2.3	7	2.3	

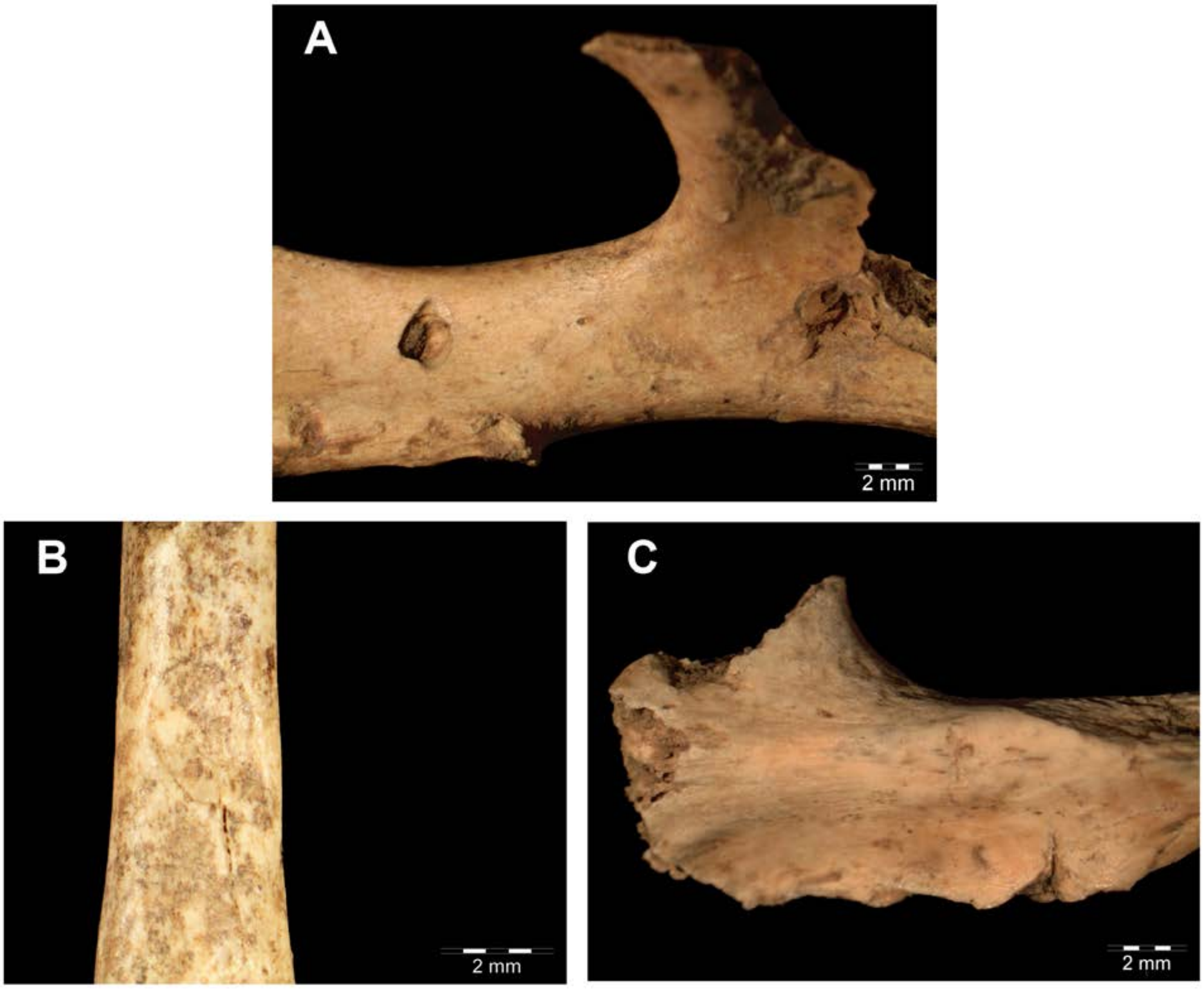

Figure 9.11. Examples of tooth marks on leporid remains recovered from Cova de la Guineu. Tooth punctures (A), tooth pits (B) and crenulated edges (C).

Table 9.13. Total number of burnt marks remains according to colour categories.

Skeletal elements	Light	Moderate	Strong	Extreme	Calcined	TOTAL
Mandibles	0	0	0	1	0	1
Cranium	0	0	0	3	0	3
Upper mol +Inc	0	0	0	4	0	4
Lower mol + inc	0	0	0	2	0	2
Vertebrae	0	0	0	0	0	0
Rib	0	0	0	2	0	2
Scapulae	0	0	0	5	0	5
Humeri	0	0	0	1	0	1
Radii	0	0	0	2	0	2
Ulnae	0	0	0	2	0	2
Innominates	0	0	0	5	0	5
Femora	0	0	0	3	0	3
Tibiae	0	0	0	6	2	8
Patellae	0	0	0	1	0	1
Calcanei	0	0	0	3	5	8
Astragali	0	0	0	0	0	0
Carpal/Tarsals	0	0	0	0	0	0
Metacarpals	0	0	0	1	3	4
Metatarsals	0	0	0	4	0	4
Phalanges 1/2	0	0	0	2	5	7
Phalanges 3	0	0	0	0	0	0
TOTAL	0	0	0	47	15	62
%	0	0	0	75.8	24.2	

Figure 9.12. Examples of burnt remains recovered from Cova de la Guineu.

Table 9.14. Total number of skeletal elements displaying other biotic and abiotic bone surface alterations.

Skeletal elements	N	%
Trampling	2	8.3
Rodent gnawing	3	12.5
Bioerosion	7	29.1
Roots	1	4.2
Weathering	1	4.2
Abrasion	0	0
Dissolution	4	16.7
Concretions	0	0
Manganese oxide Stains	6	2.5
TOTAL	24	
%	0.35	

Figure 9.13. Examples of leporid remains affected by other biotic and abiotic alterations. Bioerosion (A), manganese oxide stains (B), dissolution (C), rodent gnawing (D) and trampling marks (E).

As noted in the previous chapter, in actualistic taphonomic studies on leporid assemblages produced by red fox (*Vulpes vulpes*) (Table 9.16) the percentage of adult individuals may vary from 50% (Cochard, 2004b) to 87 % (Cochard, 2004b; Lloveras et al., 2011), which is well comparable to the results obtained for Cova de la Guineu. Also, the percentage of adult individuals in assemblages accumulated by nocturnal raptors such as the eagle owl (*Bubo bubo*) ranges from 10 – 80 % (Cochard, 2004b; Guillem and Martínez-Valle, 1991; Guennouni, 2001; Lloveras et al., 2009a; Sanchis, 2000).

The analysis of the anatomical representation shows that even thought very small elements were scarce, which it may reflect a differential recovery in the field, the whole skeleton was represented. Anthropic accumulations are also characterized by the presence of all skeletal elements, indicating the transport of the whole carcasses to the site. There is no evidence of differential transport of any specific part of the carcasses, which may occur with some predators. Also, the relative abundance values indicate that mandibles, cranium elements, innominate, scapulae, and long bones, specially tibiae, ulna and femur, are the most abundant, which is close to the anatomical profile expected in an anthropic accumulation where mandibles, long bones, scapulae and innominates are the best represented remains (Brugal, 2006; Cochard, 2004; Guennouni, 2001; Hockett, 1991; Hockett and Haws, 2002).

The corresponding values of the different anatomical indexes, which indicates the representation of different parts of the skeleton show that cranium elements are more abundant than postcranial elements (PCRT/CR= 22.2%). Even though cranium elements are abundant, elements corresponding to long bones are well represented among the sample (PCRLB/CR= 85.5%). Proximal elements are scarcest than distal elements (Z/E= 149.5%), and elements corresponding to the hindlimbs are more represented than forelimbs elements (AN/PO= 82.8%). When comparing this proportions with the values obtained for other non-human predators, the results recedes from assemblages accumulated by nocturnal raptors; and more similar to those obtained for diurnal raptors such as the Spanish Imperial eagle, and non-ingested remains of Iberian lynx and red fox.

Regarding the breakage patterns, only a 13.5% of the analysed remains presented a maximum length inferior to 10 mm. The majority of the accumulations created by different non-human predators present values over 50% (Lloveras et al., 2008a, 2008b, 2009a, 2012a, 2014, 2016b), others similar values are obtained for non-ingested remains accumulated by terrestrial carnivores: 28% for red fox (Lloveras et al., 2012a), and 19.7% for the Iberian lynx (Rodríguez-Hidalgo et al., 2013b). The percentages of complete bones (35.1%) and complete long bones (14.2%) is lower in Cova de la Guineu's sample compared to other actualistic studies of other predators with two exceptions: Iberian lynx (*Lynx pardinus*) scats and Eagle owl (*Bubo bubo*) nest remains. However, these are characterized by high percentages of digested remains (98 - 99.5%). The low percentage (0.4%) of digested remains in the Epipaleolithic level (III) of Cova de la Guineu exclude these types of accumulations. Nevertheless, it is worth bearing in mind that two factors may have contributed to undervalue the percentage of complete remains in the studied sample: a) the underrepresentation of small sized skeletal elements (Patellae, carpal/tarsals, 3rd phalanges) which are often recovered complete, and b) the presence of skeletal elements displaying modern fractures.

The presence of an elevated count of long bone cylinders, more than a 5% according to Cochard (2004a); especially femora, tibiae and humeri; along with multiple fragments of epiphysis of the same skeletal element, usually are considered evidence of anthropic activity in an archaeological site (Brugal, 2006; Cochard, 2004a; Hockett, 1991, 1995, 1996; Hockett and Bicho, 2000; Hockett and Haws, 2002; Pérez Ripoll, 2004, 2005; Sanchis and Fernández Peris, 2008; Lloveras et al. 2011, 2016a). This breakage pattern is related to the bone marrow processing by human groups, and although shaft cylinders may appear in assemblages accumulated by non-human predators, they appear in low quantities (Hockett and Haws, 2002). The high proportion of tibiae, femora and humeri cylinders in Cova de la Guineu (26.2%), as well as the abundance of epiphysis fragments (12%) points to the extraction of marrow from long bones.

The presence of an elevated count of long bone cylinders, more than a 5% according to Cochard (2004a); especially femora, tibiae and humeri; along with multiple fragments of epiphysis of the same skeletal element, usually are considered evidence of anthropic activity in an archaeological site (Brugal, 2006; Cochard, 2004a; Hockett, 1991, 1995, 1996; Hockett and Bicho, 2000; Hockett and Haws, 2002; Pérez Ripoll, 2004, 2005; Sanchis and Fernández Peris, 2008; Lloveras et al. 2011, 2016a). This breakage pattern is related to the bone marrow processing by human groups, and although shaft cylinders may appear in assemblages accumulated by non-human predators, they appear in low

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As noted before, the percentage of skeletal elements affected by digestion corrosion (0.4%) is low. Of the 29 remains affected, 0.3% display light degree of damage, 0.1% show moderate degree of digestion, while 0.03% shows a strong degree of digestion. Such low percentages of altered remains may be related to a minor contribution of a not-specified non-human agent, possibly a small carnivore.

The processing of the rabbit carcasses (skinning, disarticulation, defleshing and scraping) and preparation for human consumption is characterized by the presence of cut marks (Rosado-Méndez et al., 2016) and burnt bones (Lloveras et al., 2009b). Cut marks may be abundant in anthropic accumulations, however they are subjected to a significant variability (Brugal, 2006; Cochard, 2004; Hockett and Bicho, 2000). In Cova de la Guineu, 0.5 % of the remains displayed cut marks and 0.9% exhibit of damage due to burning. The presence of cut marks and burnt bones necessarily demonstrate the presence of human activity, but not the quantity in which they are present. The proportions can vary as a result of the human activities made by humans and the functionality of the site: seasonality, skinning, disarticulation and defleshing activities, ways of cooking etc. Both percentages, although low, fit within the range observed for anthropic leporid accumulations (Bournery et al., 2004; Cochard and Brugal, 2004; Hockett and Bicho, 2006; Ibáñez and Saladié, 2004; Lloveras et al., 2011; Pérez Ripoll, 2004; Rillardon and Brugal, 2014).

Tooth marks presence on leporid accumulations traditionally was attributed to non-human predators. This assumption has change over the past few years; ethnoarchaeological and experimental research has shown that humans also make modifications during chewing (Landt, 2007; Lloveras et al., 2009b; Saladié et al., 2013; Sanchis Serra et al., 2011). However identifying tooth marks caused by humans from other predators is not a straightforward matter. Tooth marks caused by human teeth are characterized by the removal of minimal to moderate amounts of cancellous bone tissue and are mostly associated with the fractures of long bone in order to remove bone marrow (Landt, 2007; Sanchis Serra et al., 2011). Unlike leporid assemblages accumulated by terrestrial carnivores, punctures marks (TPU) are rare, and predominantly located in flat bone and long bones diaphysis. Tooth marks recorded in Cova de la Guineu's archaeological sample (0.6 %), for example punctures marks, pits and score marks may be seen as evidence of a minor contribution of non-human predators, although fresh fractures in shaft and epiphysis fragments, caused by biting, are most certainly caused by humans with the aim of extracting marrow from long bones.

Data obtained on bone surface alterations caused by other biotic and abiotic agents indicate that very few percentages of remains (0.35%) were affected. Modifications in some remains (0.1%) are ascribed to bioerosion damage, possibly caused by bacterial and fungi attack, providing information on different environmental factors that could have affected the integrity of the bone remains. The second and third most common alterations present in Cova de la Guineu were manganese oxide stains (0.1%) and remains affected by dissolution (0.1%), which is indicative of an environment of high humidity and waterlogging. The few cases of rodent gnawing indicate that remains were not expose to the outdoors for long periods of time.

9.7. CONCLUSIONS

Cova de la Guineu's Epipalaeolithic occupations also appear to be of anthropogenic origin. As in Balma del Gai's case, the anatomical representation and breakage patterns (with a high percentage of proximal epiphysis + shaft [PES] and shaft + distal epiphyses [SDE] fragments, shaft fragments [S] and a high percentage of long bone cylinders associated with marrow extraction) along with an average presence of cut marks, strongly suggest the assemblage was for the most part accumulated by humans (Brugal, 2006; Cochard, 2004a,b; Hockett and Bicho, 2000, Manne and Bicho, 2009). Even though the percentage of burnt remains appears to be low, it is comparable with other archaeological site in Southern France (Rillardon and Brugal, 2014). Also, the low incidence of digestion damage and tooth/beak marks, suggests a minor role of small terrestrial carnivores. The results suggest evidence of the processing of rabbit carcasses: a) the presence of marks associated to the skinning process, b) a few cut marks associated to the disarticulation process and c) marks associated to the defleshing process. It could be interpreted that the human groups that inhabited Cova de la Guineu were carrying out the same activities carried out by the groups that inhabited Balma del Gai, suggesting a mass collection of rabbits aimed in the procurement of the pelt and the filleting of the meat for later consumption, but on a smaller scale, at least that is what we can interpret from the anatomical representation and breakage patterns. However, as already said other alteration affecting the bone surface may be masking evidence of activities related to bigger scale rabbit procurement as the one observed in Balma del Gai.

The leporid assemblage from the Epipaleolithic level of Cova de la Guineu can be considered, according to the taphonomic analysis, of anthropic origin. The features that demonstrate this origin are: the relative abundance of some anatomical parts, as well as the loss of vertebrae, the proportions of breakage and the presence of shaft cylinders, the high proportions of adult individuals, the considerably low values of digested remains, and the evidence of cut marks and burnt marks among the sample.

Table 9.15. Anatomical representation, breakage, digestion and teeth/beak marks for leporid remains accumulated by diurnal and nocturnal raptors compared with the results obtained from the taphonomic analysis on Cova de la Guineu's leporid assemblage.

	Eagle Owl (*Bubo bubo*)		Spanish Imperial Eagle (*Aquila adalberti*)	Bonelli's Eagle *(Aquila fasciata)*	Egyptian vulture (*Neophron percnopterus*)		Cova de la Guineu
Reference	*Lloveras et al., 2009a*		*Lloveras et al, 2008b*	*Lloveras et al., 2014b*	*Sanchis et al., 2013*	*Lloveras et al., 2014*	*Present study*
Origin	Nest	Nest	Pellet	Nest	Nest	Nest	Archaeological
N	1808	1932	824	438	269	133	6768
RA% > values	Pat-cal-in-fem	Cal-in-tib-mts	Phal 3-um-tib	Cr-um-in	Fem-in-rad-uln-mts	Md-cr	Md-cr elem-in-sca-long bones
Ra% < values	Mtc-c/t	Rad-c/t-mtc	Rib-fem-rad-ver	Mtc-rib	Rib-cr	Phal-c/t-ver-long bones	Pat-c/t-phal-ver-rib
PCRT/CR	+ Postcranial	=	+ Cranial	+ Cranial	+ Postcranial	+ Cranial	+ Cranial
P/D	+ Proximal	+ Proximal	+ Distal	+ Proximal	–	–	+ Distal
AN/PO	+ Hindlimb	+ Hindlimb	+ Hindlimb	+ Hindlimb	–	–	+ Hindlimb
Complete elements %							
Long bones	14.6	10.8	0	51.7	–	–	14.2
Mean value total	53.9	45.9	27	74.7	80	81.2	18.1
Length (mm.)							
Min.	2.3	2.5	1.8	1.7	–	26.3	3.4
Max.	86.3	90	36.1	89.6	–	70.1	144
% < 10 mm	49	40	73	54.9	–	52.4	13.5
% Digested remains	68.8	65.6	98	31.2	1.1	0.8	0.4
% Digested long bones	88.9	83.9	100	31	2.8	–	–
Degree							
Null	31.2	34.4	2	68.8	–	99.2	99.6
Light	40.2	40.2	18.2	2.3	–	0	0.3
Moderate	19.8	19.8	46.8	7.9	–	0.8	0.1
Strong	8	5.3	27.4	14.4	–	0	0.03
Extreme	0.7	0.15	5.6	6.5	–	0	0
Teeth/beak marks	2	1.34	0.5	2.3	10.4	7.5	0.6
% Adult individuals	50	50	–	41.4	41.7	100	82.6

Table 9.16. Anatomical representation, breakage, digestion and teeth/beak marks for leporid remains accumulated small terrestrial carnivores compared with the results obtained from the taphonomic analysis on Cova de la Guineu's leporid assemblage.

	Iberian Lynx (*Lynx pardinus*)		Red Fox (*Vulpes vulpes*)		European wildcat *(Felis silvestris)*		Cova de la Guineu
Reference	*Lloveras et al., 2008a*	*Rodríguez-Hidalgo et al., 2013*	*Lloveras et al., 2012a*		*Lloveras et al., 2016b*		*Present study*
Origin	Scat	Non-ingested	Scat	Non-ingested	Scat	Non-ingested	Archaeological
N	1522	9594	265	639	87	1457	6768
RA% > values	Md-teeth-cr	Tib-cal-mts-ast	Long bones-sca-cr	Mtc-cal-ast-tib	Sca-hum-rad-uln-cr	Cr-fem-mts-cal	Md-cr elem-in-sca-long bones
Ra% < values	C/t-ver-rib	Sca-ver-hum-rib-fem	Mtc-c/t-in	Cr-sca-rib-in-ver	Teeth-hindlimb	Sca-rib-hum-ver	Pat-c/t-phal-ver-rib
PCRT/CR	+ Cranial	+ Postcranial	=	+ Postcranial	+ Postcranial	+ Cranial	+ Cranial
P/D	+ Proximal	+ Distal	+ Proximal	+ Distal	+ Distal	+ Distal	+ Distal
AN/PO	+ Forelimb	+ Hindlimb	+ Hindlimb	+ Hindlimb	+ Forelimb	+ Hindlimb	+ Hindlimb
Complete elements %							
Long bones	2.5	37.6	0	5.4	0	23.7	14.2
Mean value total	43	73.2	12	89.4	11.5	92.3	18.1
Length (mm.)							
Min.	1.1	3	3	4	2	2	3.4
Max.	30.1	69	26.8	86.2	11.4	138.2	144
% < 10 mm	80	19.7	91	28	98.8	35	13.5
% Digested remains	97.2	–	99.5	–	98.6	–	0.4
% Digested long bones	100	–	100	–	100	–	–
Degree						–	
Null	2.8	–	0	–	1.4	–	99.6
Light	12	–	6	–	1.4	–	0.3
Moderate	22	–	26	–	9.6	–	0.1
Strong	43.8	–	43	–	39.7	–	0.03
Extreme	19.3	–	25	–	47.9	–	0
Teeth/beak marks	0.26	0.9	3	9.5	0	1.2	0.6
% Adult individuals	21.4	–	87	–	–	–	82.6

CHAPTER 10

FONT VOLTADA

10.1. LOCATION AND ARCHAEOLOGICAL BACKGROUND

Font Voltada is an open rock shelter located in the locality of Montbrió de la Marca, part of the Sarral municipality, in the Conca de Barberà region (Tarragona). The archaeological site is situated alongside the road the Barranc de la Torrentera, at an altitude of 626 metres above sea level. It presents no more than 12.5 m long and 1.5 m deep, and it is oriented toward South, located precisely over the Barranc de la Torrentera, that receives a permanent supply of mountain spring water from the Font Voltada spring, which is situated 200 metres upstream of the archaeological site (Mir and Freixas, 1993) (Fig. 10.1).

The rock shelter opens itself in the tertiary conglomerates of the Montsant family (Oligocene), on the eastern bank of the Ebro Depression, adjacent to the Catalan Coastal Range. The alternations of lenticular bodies of conglomerate material with sections of sandy calcareous siltstones has led to the formations of small cavities by differential erosion, as is the case of the Font Voltada (Mir, 1991).

During the expansion of the Barranc de la Torrentera's road, in order to transport burned wood from the 1979 fire, a great grey spot was revealed near the roadside in which lithic tools, bone remains and colorant minerals surfaced. Antoni Freixas, an amateur archaeology, alerted Anna Mir, archaeologist from the Salvador Vilaseca Museum in Reus, about the findings. Anna Mir and Antoni Freixas later excavated the site during the archaeological campaigns of 1980-1983, in which 4 stratigraphic levels were proposed, being level II the only one with evidence of human activity. A radiocarbon date of 10.920 ± 240 BP (12.632 – 13.092) and the material culture recovered set the human occupation level into the Epipaleolithic period (Microlaminar). In 2013, Lluís Lloveras and Josep Veciana carried out a cleaning and sediment sampling campaign, in order to contrast the results from the first archaeological campaigns. In the latest intervention the stratigraphic levels have been re-categorized, in which level III now correspond to the human occupation levels.

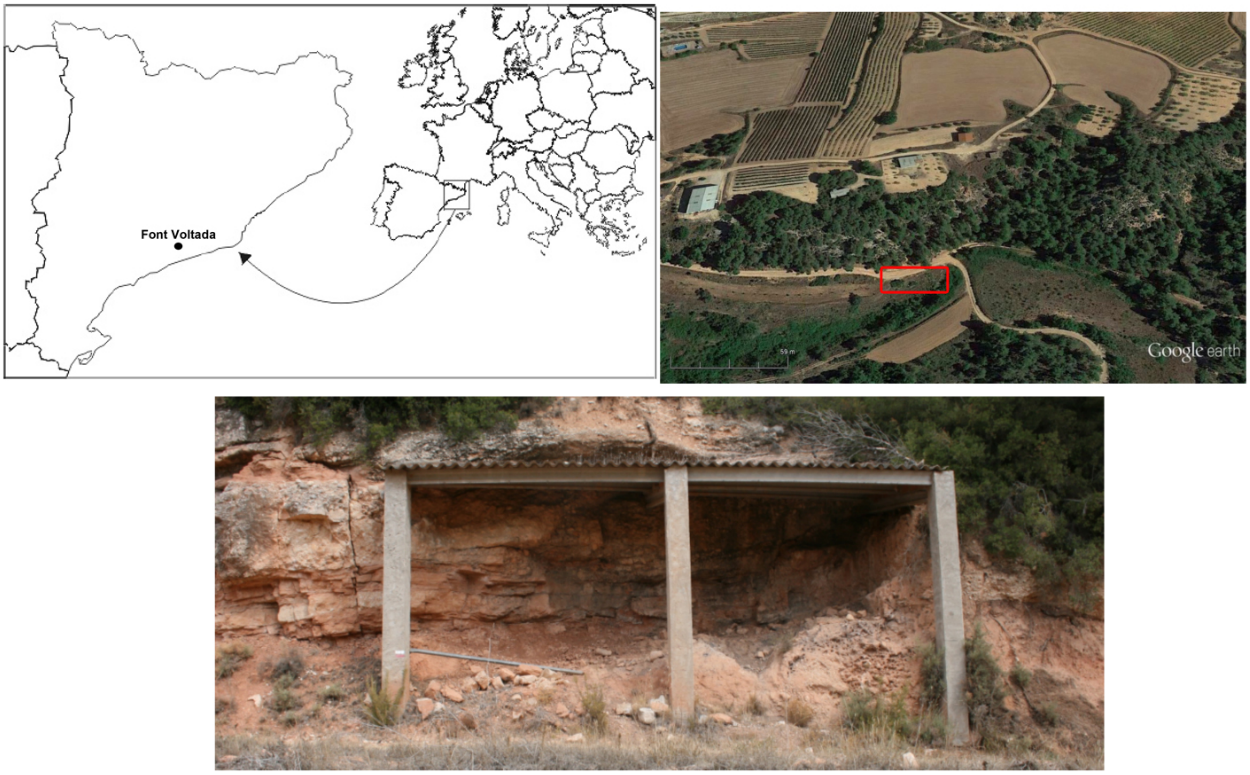

Figure 10.1. Maps of the Northeastern region of the Iberian Peninsula with the location of Font Voltada (red rectangle), and a photograph of the archaeological site.

10.2. STRATIGRAPHIC UNITS

A stratigraphic and cultural sequence was conducted based on the archaeological interventions of 1980-1983. At that time, the site's stratigraphic record was formed by three lithostratigraphic units (Bergadà, 1998; Mir, 1991; Mir and Freixas, 1993) (Fig. 10.2):

- Level I- Silty sand of orange colour.

- Level II- Silty sand of grey colour from the archaeological level. This sediment is composed of silty sand and ashes from combustion and organic materials. The archaeological level is 80 cm thick; it presents a characteristic grey colour that clearly stands out from the other two sterile levels. Three superimposed occupation soils with hearth structures were recorded:

    1. *Superior (z = 40 - 45 cm)*- only preserved in the eastern sector of the cave, in subunits 2 and 4 from unit M2. This occupation soil contained a hearth structure in a bucket shape attached to the wall at the rear end of the cave.

    2. *Middle (z = 60 – 75 cm)*- two other hearth structures were documented in this occupation soil: a.) It is located in sub-units M2 (2) and M2 (4), is bucket shaped and shallow, paved with calcareous blocks, and protected laterally by a semi-crown of calcareous blocks, b.) The second structure is located in unit L2 at the interior of the cave, taking advantage of the natural irregularities of the substrate, on a natural rock step. At the base of this second structure two fire areas delimited by a semi-crown of rocks were found.

    3. *Inferior (z = 70 – 80 cm))*- it contained another hearth structure, flat type in which the associated blocks does not seem to show any previous preparation. The layer of charcoal and ashes at the base of the structure is 1.5 cm thin

- Level III- Sandy lutites (sterile).

As stated at the beginning, a cleaning and sediment sampling campaign was carried out in June 2013 as part of a project directed by Pilar García-Argüelles: *El poblament prehistòric a la vall mitjana del riu Montsant, Margalef de Montsant, Priorat, Tarragona*, from SERP of Universitat de Barcelona. The field campaign was directed by Lluis Lloveras and Josep Veciana with the aims of establishing a stratigraphic sequence of the Font Voltada's archaeological record and to contrast it with the sequence established in the first archaeological campaigns, to perform a stratigraphic and sediment sampling in order to deduct the evolutionary history of the archaeological record with particular interest in the level of human occupation, and to assess the conditions of the archaeological level (Bergadà et al., 2013). The stratigraphic and sedimentary description was based on: a) Longitudinal profiles M2-M1 and L2-L1; and b) Transversal profiles L1-K1 (Fig. 10.3).

Longitudinal profiles

Profiles M2-M1

- Level I – It is 60-80 cm thick, and is formed by a matrix of silty sands of brown colour (10 YR 5/4) with a considerable concentration of roots and limestone coarse fraction (40 %), and round shaped. There is no visible archaeological material. The level is wedge shaped with a steep slope toward the outside of the rock shelter. This level is not documented in the previous archaeological interventions.

- Level II – Its sedimentary thickness ranges between 64 cm (interior) and 14 cm (exterior) and is formed by silty sands of orange colour (5 YR 5/6), with round shaped gravel and a few sub angular shaped fraction scattered across the matrix. This level is correlated with the first lithostratigraphic unit documented by Anna Mir.

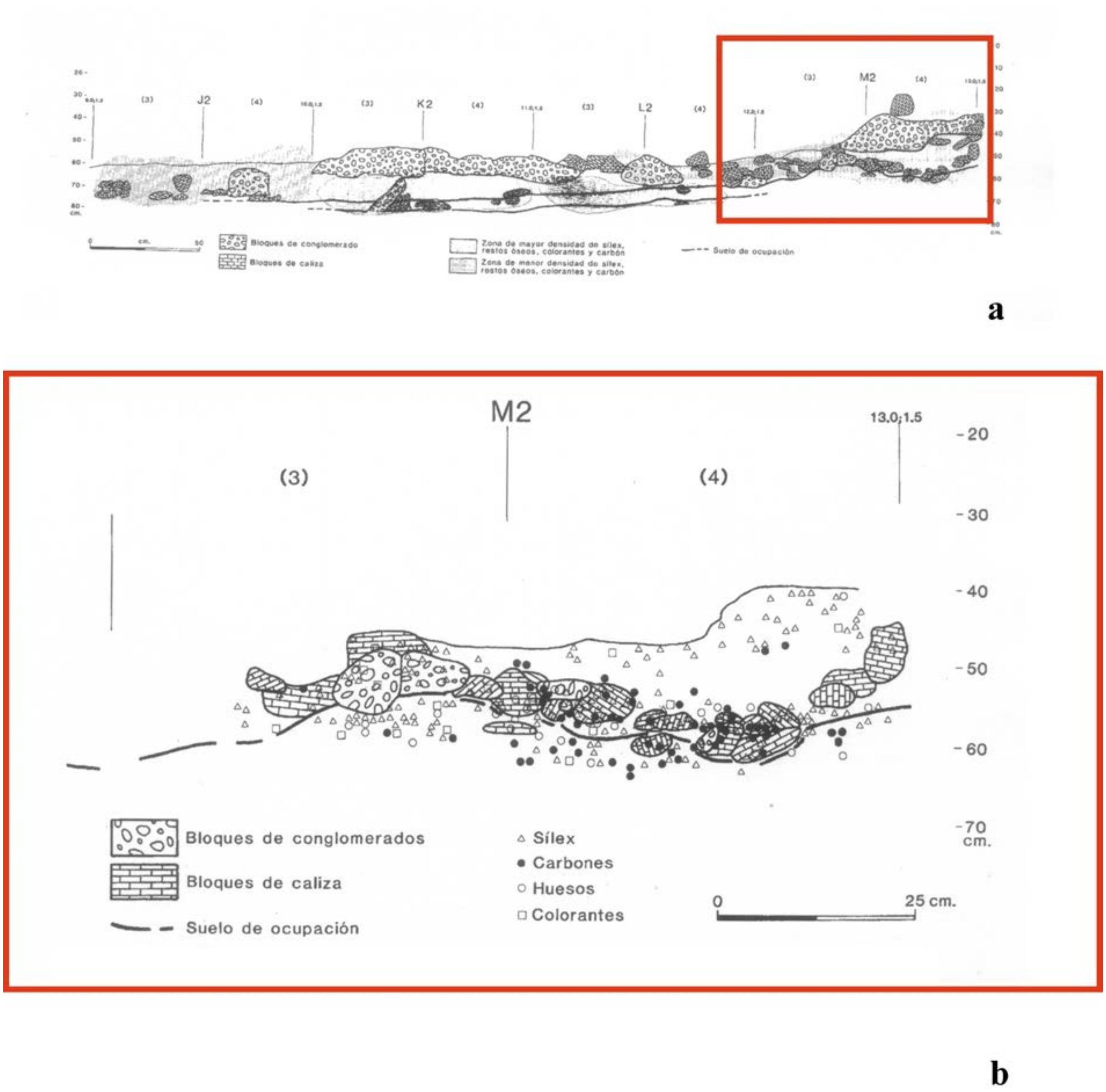

Figure 10.2. Longitudinal section (W-E) of stratigraphic units J2-M2: (a) located of the Epipaleolithic occupation levels and (b) the distribution of the archaeological material (Bergadà, 2013; Mir and Freixas, 1993).

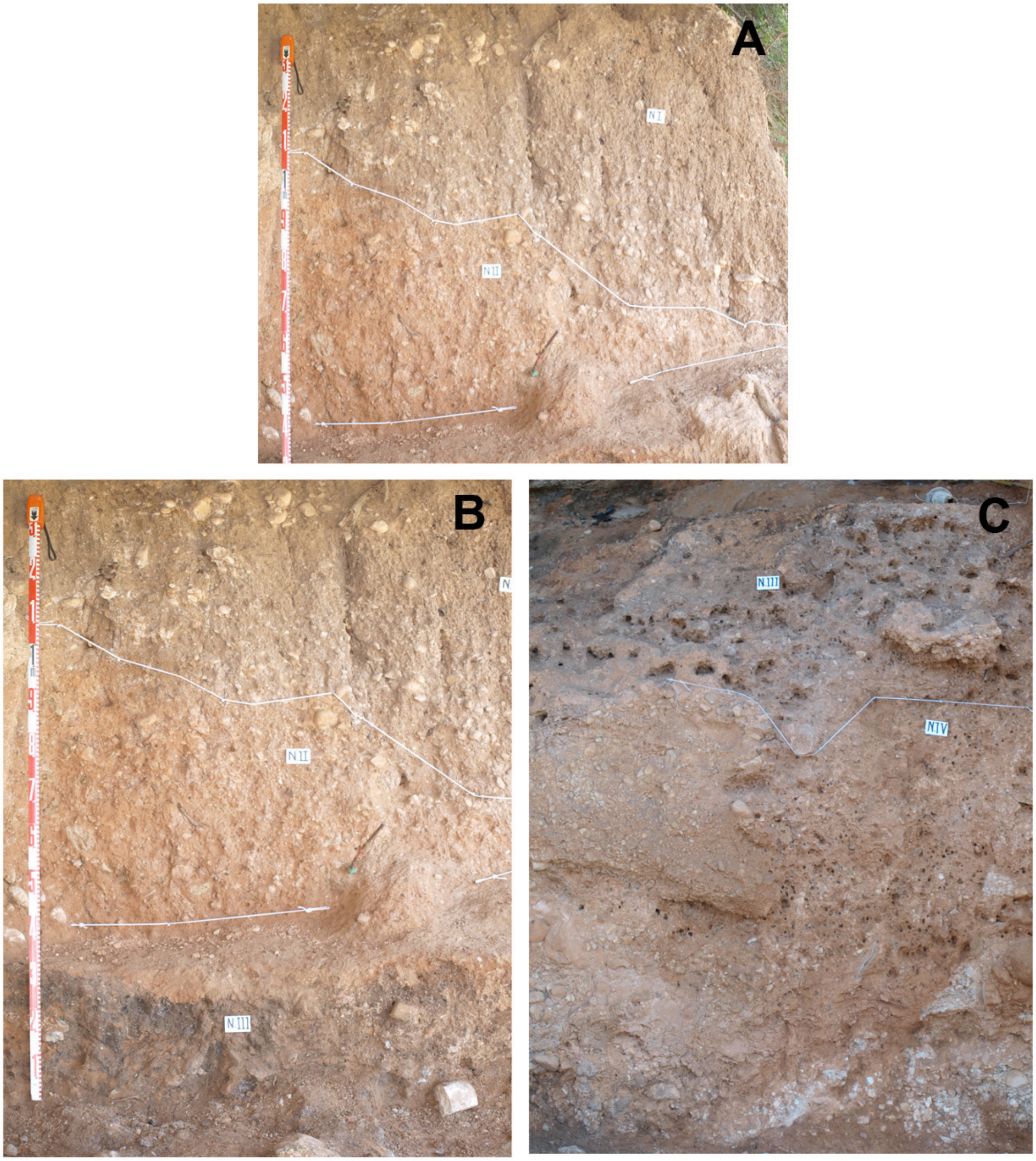

Figure 10.3. Longitudinal profile of units M2-MI, levels I and II (A), general view of level III in unit L2 (B) and view of level III displaying bioturbation from units L1-KI (C). Modified from Bergadà, 2013.

Profiles L2-L1

- Level III – It has a sedimentary thickness of 26 cm and is composed by three sub-levels: a.) Sandy silt with clay of dark brown colour (5 YR 3/2), 10-11 cm thick, b.) Sandy silt with clay of brown colour, 2-3 cm thick, and c.) Sandy silt with dark grey colour clay, 12 cm thick. Toward the interior of the rock shelter sub-levels are well limited while the contact between each sub-levels diffuses itself toward the exterior. This level correlates to the first two occupation soils documented in previous archaeological interventions.

Transversal profile

Profile L1-K1

- Level III – It sedimentary thickness ranges between 51-58 cm and is composed by silty sands of dark brown colour (5 YR 4/2) with reddish stains. The level is marked by traces of bioturbation due to wasp nest. In some sectors it might correlate to the third occupation soil documented by Anna Mir in the first archaeological interventions.

- Level IV – It is approximately 102-110 cm thick and is formed by conglomerate blocks and a matrix of fine sands or orange colour (5 YR 5/8). This level corresponds to the level III documented by Anna Mir.

10.3. CHRONOLOGY AND MATERIAL CULTURE

Radiocarbon dating (^{14}C) performed to a single sample of charcoal fragments recovered from the occupation soils sets the human occupation level in 10.920 ± 240 BP (Mir, 1991; Mir and Freixas, 1993). The absolute date and material culture recovered from the site both takes us back to the Microlaminar Epipaleolithic period (12.632 – 13.092 cal. BP).

10.4. RECOVERED REMAINS

The analysis of the recovered remains from the three occupation soils provides information on the different activities carried out at Font Voltada, for instance: flint recollection and hewing, installation of hearth structures, preparation of minerals used for dyes, hunting and food preparation, and collecting firewood (Mir and Freixas, 1993).

10.4.1. Lithic industry and habitation features

The lithic industry is primarily hewed on flint of different colours. Among a total of 2,975 flakes, 1,257 bladelets (non retouched long flakes), and 632 retouched pieces, only 20 pieces were carved out of quartzite. In a total of 632 retouched pieces, the presence of cortex in 236 tools indicates that scabbling, carving, hewing, and retouching of lithic tools was performed inside the rock shelter. A total of 80 cores (tortoise, prismatic, pyramidal, polyhedral and bipolar) were recovered (Fig. 10.4).

Within the group of simple retouched pieces, the following typological categories are included: sidescrapers (10.09%), points (1.12%), endscrapers (9.64%) and denticulates (17.94%). Among the abrupt retouched pieces, the most important category is the bladelets (22.11%) followed by pointed bladelets (3.37%) and truncated bladelets (1.76%) (Mir, 1991; Mir and Freixas, 1993), all of which allow us to consider Font Voltada as an Epimagdalenian site.

Throughout the archaeological campaigns a considerable amount of mineral materials used as pigments have been recovered. A mineralogical analysis by X-ray diffraction identified four types of colorants: a.) Whitish pigments possibly due to the use of calcium carbonate, b.) Yellow and ochre pigments due to the use of carbonate rocks with hydrated iron oxides (goethite) and a low detrital component (quartz), c.) Reddish pigments derived from the low thermal treatment of yellow and ochre colorants, and d.) Reddish pigments derived from detrital rocks with non- hydrated iron oxides (Mir, 1991; Mir and Freixas, 1993).

10.4.2. Floral remains

Anthracological analysis of charcoal remains shows the abundance of taxa such as *Pinus sylvestris* (57.2%), *Juniperus* sp. (34.6%), *Prunus espinosa* (2.79%), and *Sorbus domestica* (5.31%). The presence of *Pinus sylvestris* and *Juniperus* sp. points to an open vegetation landscape and cold climate, quite similar to the actual conditions of the Oro-Mediterranean landscape; mountain climate with harsh winters and high temperatures in the summer. Also the presence of *Prunus espinosa* and *Sorbus domestica*, characteristic of more temperate climates, may indicate cooler local conditions (Mir, 1991; Mir and Freixas, 1993).

The palinological analysis of a sample of the silty sand that seals the archaeological level (III) shows the dominance of arboreal vegetation (65.4%) and a scarce herbaceous cover (34.6%). The arboreal cover is dominated by *Pinus* (54%) and *Quercus* (10.6%) (Mir, 1991; Mir and Freixas, 1993).

10.4.3. Fauna remains

Jordi Nadal conducted the first comprehensive study of the fauna remains for his PhD dissertation, corresponding to the faunal remains recovered during the excavation campaign carried out by Anna Mir. The assemblage is composed of bones remains and continental malacofauna. At that time, Jordi Nadal analysed 1827 determined remains (Table 10.1). The most abundant taxon is *Oryctolagus cuniculus*, follow by *Capra* and *Cervus elaphus*. Abundant specimens of *Cepacea* and a fragment of a marine bivalve were also recovered in association with a hearth structure (Mir, 1991; Mir and Freixas, 1993).

Table 10.1. Taxa, number of determined remains, maximum number of individuals and percentages of bone remains and malacofauna recovered from Font Voltada.

Taxon	NDR	MNI	%
Oryctolagus cuniculus	1735	80	95.7
Capra pyrenaica	34	3	1.87
Cervus elaphus	29	1	1.59
Sus scrofa	1	1	0.05
Lynx sp.	3	1	0.16
Vulpes vulpes	1	-	0.05
Lepus europaeus	1	1	0.05
Perdicinae	8	1	0.44
Microtus duodecimcostatus	1	4	0.05
Cepaea nemoralis	22	14	-
Xeroplexa cf *monistrolensis*	13	-	-
Testacella haliotidea	3	-	-
Vallonia cf pulchella	25	-	-
cf *Cochlicella*	7	-	-
Chondrinidae	18	-	-
cf *Abida*	1	-	-
Jamina quadridens	1	-	-
Glycymeris	1	-	-

10.5. ANALYSIS RESULTS

A total number of 19.102 leporid remains were counted from level III, only 2.671 (14%) correspond to the number of determined remains (NDR). Based on the calcanei counts, the estimated minimum number of individuals (MNI) is 52 individuals. No hare remains were found among the sample.

10.5.1. Taxonomic determination

All remains were identified as European rabbit (*Oryctolagus cuniculus*). No hare remains were found among the sample.

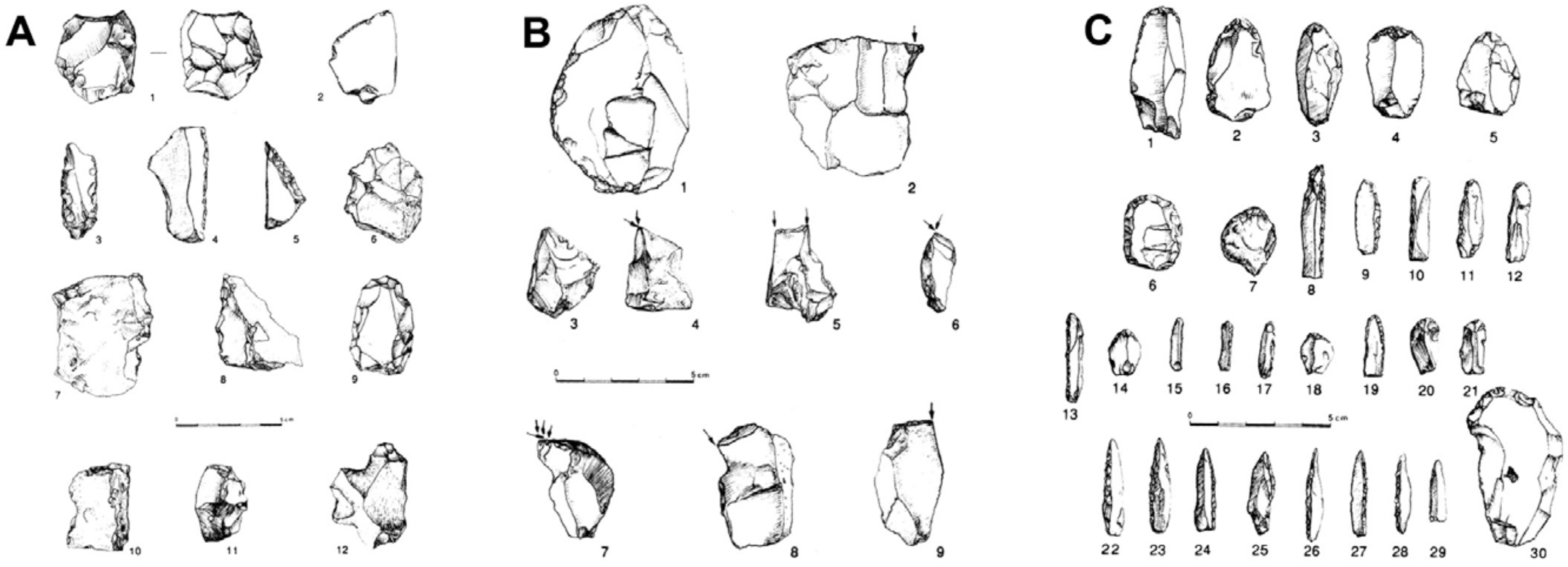

Figure 10.4. (A) 1 core, 2-4 end scrapers, 5 point, 6-12 denticulates; (B) 1 scraper, 2 core, 3 end scraper, 4-9 burin; (C) Scrapers 1-7, 12, 14, 18-21, 30; bladelets 8-11, 13, 15-17; pointed bladelets 22-29. Modified from Mir and Freixas, 1993.

10.5.2. Age of death

Based on the state of epiphyseal fusion of long bones, metapodials, scapulae, and innominates, the percentage of adult individuals in our sample is 96.3% while a 3.6% corresponds to immature individuals (Table 10.2).

Table 10.2. Skeletal elements valued for the age of death determination. Number of fused (F) and not fused (NF) remains.

Skeletal Element	F	NF	TOTAL
Hum	72	2	74
Rad	42	3	45
Uln	85	1	86
Fem	54	3	57
Tib	87	1	88
Mtc	82	0	82
Mts	101	2	103
IN	113	4	117
Sca	102	12	114
TOTAL	738	28	766

10.5.3. Anatomical representation and differential conservation

The anatomical composition of the leporid assemblage, as well as the relative abundance percentage for each skeletal element is presented in Table 10.3. The entire skeleton is well represented. According to the NDR%, the most numerous remains are upper and lower molars, incisors, 1/2 phalanges, calcanei, ribs, scapulae and tibiae; while patellae, carpal/tarsal elements, astragali, 3rd phalanges and vertebrae were the scarcest.

The mean value for this sample is 34.6%, which indicates an important loss of skeletal elements. This value, as in the case of the other archaeological sites that comprise our sample: Balma del Gai and Cova de la Guineu, shows a significant bias of the NDR, as there are skeletal elements that are underrepresented compared to the MNI of our sample. While in Cova de la Guineu this loss is possibly due to the sieving technique used during fieldwork, and which has favoured the loss of small sized remains; in Balma del Gai it is very possible that small fragments have ended up mixed in bags containing materials smaller than 5 mm. It seems that in Font Voltada the underrepresentation of small elements is due to the sieving technique. According to relative abundance (Table 10. 3), the most represented elements are calcanei, scapulae, cranial elements and long bones specially ulnae, tibiae, and humeri. Meanwhile skeletal elements with the lower RA% were the smallest: vertebrae, patellae, carpal/tarsals, ribs, and phalanges (1/2 and 3rd) (Fig. 10.5).

Table 10.3. Leporid skeletal elements identified in level I from Font Voltada. N: number of skeletal elements, N%: percentage of skeletal elements, MNE: minimum number of elements, and RA%: relative abundance. For abbreviations see Chapter 7.

Skeletal elements	N	N%	MNE	RA%
Md	96	3.6	40	38.5
Cr	130	4.9	30	57.7
Inc	232	8.7	172	55.1
UM	278	10.4	172	27.6
LM	225	8.4	145	27.9
Hum	88	3.3	45	43.3
Rad	131	4.9	34	32.7
Uln	118	4.4	80	77
Fem	83	3.1	31	30
Tib	136	5.1	50	48.1
Pat	1	0.03	1	1
Sca	142	5.3	92	88.5
IN	127	4.8	65	62.5
Mtc	92	3.4	58	11.1
Mts	131	4.9	79	19
Phal 1/2	224	8.4	151	8.5
Phal 3	55	2.1	45	4.8
Cal	177	6.6	101	97.1
Ast	39	1.5	27	26
C/T	12	0.4	12	1
Ver	12	0.4	3	0.12
Rib	142	5.3	36	2.8
TOTAL	2671			

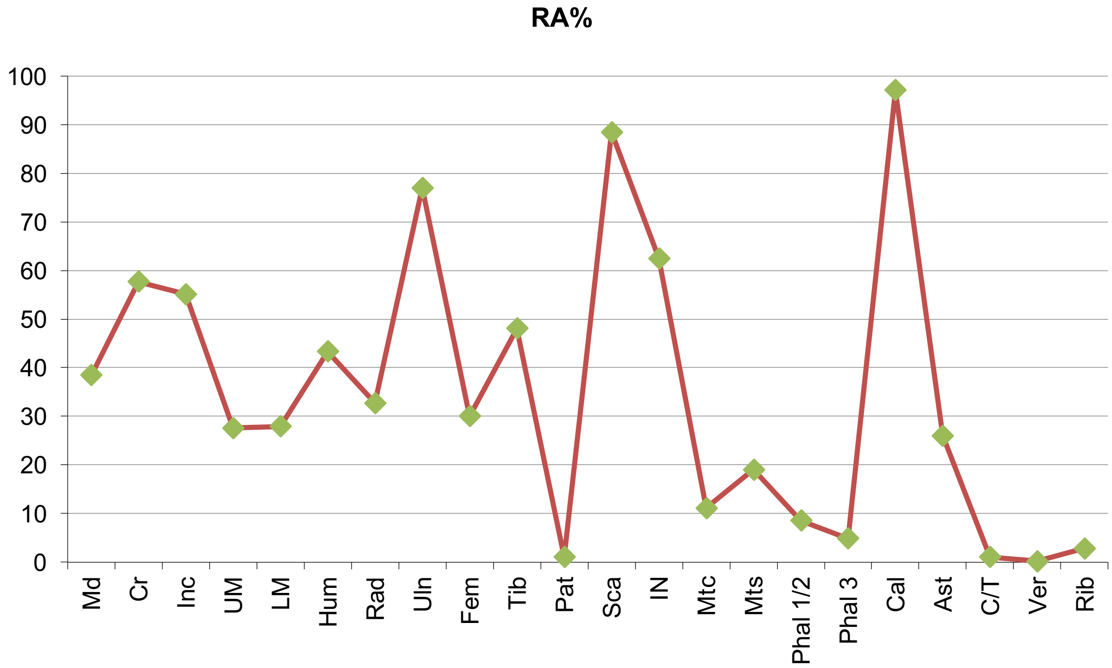

Figure 10.5. Relative abundance of the different parts of the skeleton in Font Voltada's leporid remains sample. *Md* mandible, *Cr* cranium, *Inc* incisors, *UM* upper molar, *LM* lower molar, *Hum* humerus, *Rad* radius, *Uln* ulna, *Fem* femur, *Tib* tibia, *Pat* patella, *Sca* scapula, *IN* innominate, *Mtc* metacarpals, *Mts* metatarsals, *Phal ½* first and second phalanges, *Phal 3* third phalanges, *Cal* calcaneum, *Ast* astragalus, *C/T* carpal and tarsals, *Ver* vertebrae, and *Rib* ribs.

The corresponding values of the different anatomical indexes, that allows us to assess the proportions in which the different parts of the skeleton are represented, are shown in Table 10.4.

Table 10.4. Proportions of different parts of the skeleton. For the calculation formulas of the anatomical representation indexes refer to Chapter 7.

Index	Value %	Representation
PCRT/CR	30.6	+ Cranial
PCRAP/CR	42.4	+ Cranial
PCRLB/CR	133.1	+ Long bones
AUT/ZE	20.1	+ Proximal (ZE)
Z/E	144	+ Distal (*Tibia, radius and ulna*)
AN/PO (1)	102	= Equilibrated
AN/PO (2)	129	+ Forelimb
AN/PO (3)	106.8	= Equilibrated

Results show the following:

- The relatively low value obtained for the PCRT/CR index shows that for every 100 cranial elements (CR) there are only a 30.6 % of postcranial elements, which means that postcranial elements are underrepresented. The same occurs with the PCRAP/CR; in this case the appendicular elements are also underrepresented (42.4%). When cranial elements are compared to long bones (PCRLB/CR), the sample shows a deficit of cranial elements (133.1%), indicating a good representation of long bones.

- When comparing the proportions between distal and proximal elements (20.1%), the AUT/ZE index indicates that there is a low representation of skeletal elements that comprises the autopodium in comparison to elements belonging to the zigopodium + stilopodium, which implies an important loss of distal elements.

- The value for the Z/E index (144%) shows a mayor representation of skeletal elements that correspond to the zygopodium.

- Values for the AN/PO index were calculated in three different ways:

- When calculating the proportion between AN/PO, three results were obtained. Calculation for 1 and 3 resulted almost equilibrated proportion between forelimbs and hindlimbs, 102% and 106.8% respectively, as opposed to calculation 2, 129% that indicated a greater representation of elements corresponding to the forelimbs in comparison to elements that comprise the hindlimbs. This suggests that the differences in proportions are due to the different values obtained for the metapodial elements.

According to Pavao and Stahl's (1999) criteria, there was no statistically significant correlation between the frequency of rabbit skeletal portions and their density (rho= 0.198, P= 0.463). This indicates that the preservation of rabbit remains within the Epipalaeolithic level of Font Voltada was generally unaffected by density-mediated attrition.

10.5.4. Breakage patterns and types of fractures

The maximum length of the analysed remains is variable with measures ranging between 2 to 66.7 mm. The average maximum length was 11.6 mm and more than 56.2% of the remains present length values over 10 mm, while the length of 44% of the remains were under 10 mm (Fig. 10.6).

A total of 477 remains (17.8%) were complete (Table 10.5), if we consider solely long bones remains the percentage of complete bones is reduced to 1.1%. As might be expected, the obtained value vary according to size of the skeletal remain, being the smaller remains, such as lower molars, patellae, astragali, carpal/tarsals and calcanei, that appear less fragmented (Tables 10.5 and 10.6 of breakage categories).

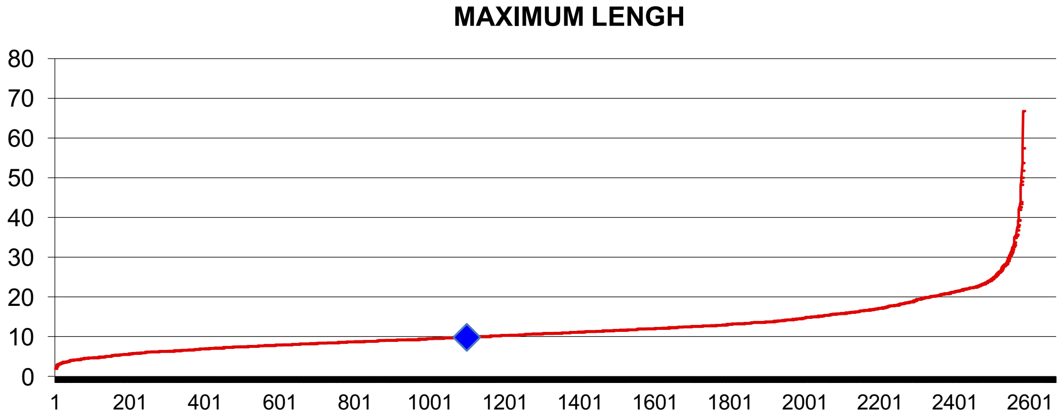

Figure 10.6. Mean length of fragmented *Oryctolagus cuniculus* remains. The blue dot denotes the sample's mean value (11.6 mm).

Table 10.5. Number and percentage of complete elements in Font Voltada. N: number of skeletal remains, C: number of complete elements, and C%: percentages of complete elements. For abbreviations see Chapter 7.

Skeletal elements	N	C	C%
Md	96	0	0
Cr	130	0	0
Inc	232	36	15.5
UM	278	84	30.2
LM	225	107	47.5
Hum	88	0	0
Rad	131	0	0
Uln	118	0	0
Fem	83	0	0
Tib	136	0	0
Pat	1	1	100
Sca	142	0	0
IN	127	0	0
Mtc	92	9	9.7
Mts	131	0	0
Phal 1/2	224	94	41.9
Phal 3	55	49	89
Cal	177	64	36.1
Ast	39	27	69.2
C/T	12	6	50
Ver	12	0	0
Rib	142	0	0
TOTAL	2671	477	

Breakage categories established for every skeletal elements show that cranial elements never appeared complete, and they were mainly identified by fragments comprising the the zygomatic arch (AZ), neurocranium (NC), the incisive bone (IB), and maxillae (M). Mandibles are mostly represented by incisive parts (IP), mandibular body (MB), and condylar process (CP). In the case of the innominate elements, it is common to find parts belonging to the ischium (IS), illium (IL), and fragments containing the acetabulum with both illium and ischium. Most scapulae fragments contain the glenoid cavity (GC), glenoid cavity + neck (GCN), glenoid cavity + neck + fossa (GCNF), and neck + fossa (NF) parts. Vertebrae are never complete, but the most represented fragments are vertebrae body (VB) and the spinous process (SP). Ribs always appear fragmented. Regarding the teeth elements, 47.5% of isolated and *in situ* pieces are complete.

All the breakage categories were represented in limb bones and metapodial elements. Humeri, radii, ulnae, femora and tibiae remains are best represented by fragment belonging to the proximal epiphysis (PE), proximal epiphysis + shaft (PES), shaft (S) and distal epiphysis (DE). Patellae were complete while astragals (69.2%); 1/2 phalanges (42%) and calcanei (36.1%) were almost complete.

A total number of 84 (15.1%) shaft fragments were identified as long bone cylinders. On the whole, 71% of long bones and metapodial elements present fresh fractures, whereas 28.1% show dry fractures. Finally, 1% of the remains displayed modern fractures, possibly due the excavation process, transport and packaging of the remains (Table 10.7).

10.5.5. Bone surface alterations

10.5.5.1. Digestion

A detailed study of the remains under a light microscope was conducted to detect the presence of damage caused by digestion. All remains (100%) were not affected.

10.5.5.2. Cut marks

A total of 8 bones remains (0.3%) display cut marks. They were observed in: calcanei (2), ulnae (1), tibiae (1), femora (1), innominates (1), mandibles (1) and metatarsals (1) (Table 10.8).

Most of the marks were transversal (6; 75%) to the principal axis of the bone. In long bones, especially fragments containing shaft (PE, S and DE), cut marks with oblique orientation co-occur with transversal marks. Transversal marks on tibiae (DE), calcanei, metatarsals (PES) and innominates (IS) may be related to the skinning and disarticulation of rabbit carcasses, whereas a mix of transversal and oblique marks located on the femur shafts was probably related to defleshing activities (Fig. 10.8).

Table 10.6. Number and percentages of parts of the skeleton included in each breakage category.

Long bones and metapodials	C		PE		PE+S		S		S+DE		DE	
	N	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Humeri	0	0	26	29.5	2	2.2	15	17	5	5.7	40	45.5
Radii	0	0	9	6.8	27	20.6	91	69.4	4	3.1	0	0
Ulnae	0	0	63	53.4	17	14.4	31	26.3	4	3.4	3	2.5
Femora	0	0	29	34.9	2	2.4	48	57.8	0	0	4	4.8
Tibiae	0	0	8	5.9	0	0	78	57.3	6	4.4	44	32.3
Metacarpals	9	9.8	2	2.2	47	51.1	7	7.6	24	26.1	3	3.2
Metatarsals	0	0	5	3.8	55	41.9	24	18.3	39	29.8	8	6.1

Mandibles	*N*	*%*	*Vertebrae*	*N*	*%*	*Innominates*	*N*	*%*
C	0	0	C	0	0	C	0	0
IP	41	42.7	VB	3	25	IL	25	19.7
MBI	6	6.25	VE	0	0	AIL	13	10.2
MB	30	31.25	SP	9	75	A	12	9.4
MBB	1	1	Rib	*N*	*%*	AISIL	1	0.8
B	4	4.2	C	0	0	AIS	11	8.7
CP	14	14.6	F	142	100	IS	65	51.2
Crania	*N*	*%*	Patellae	*N*	*%*	*Phalanges 1/2*	*N*	*%*
IB	30	23.1	C	1	100	C	94	42
M	21	16.1	F	0	0	F	130	57.9
AZ	40	30.7						
NC	39	30						

Scapulae	*N*	*%*	Calcanei	*N*	*%*
C	0	0	C	64	36.1
GC	34	23.9	F	113	63.8
GCN	47	33.1			
GCNF	11	7.7	*Astragali*	*N*	*%*
N	19	13.4	C	27	69.2
NF	19	13.4	F	12	30.8
F	12	8.4			
3rd Phalanges	*N*	*%*	*Carpal/Tarsals*	*N*	*%*
C	49	89.1	C	6	50
F	6	10.9	F	6	50

In situ					
Incisors		Upper Molars		Lower Molars	
N	*%*	*N*	*%*	*N*	*%*
6	24	0	0	47	75.8
19	76	0	0	15	24.2

Isolated					
Incisors		Upper Molars		Lower Molars	
N	%	N	%	N	%
30	14.5	84	30.2	60	36.8
177	85.5	194	69.8	103	63.2

Long bones and metapodials were classified as complete (C), proximal epiphysis (PE), proximal epiphysis + shaft (PES), shaft (S), shaft + distal epiphysis (SDE), and distal epiphysis (DE). Mandibles were classified as complete (C), incisive part (IP), mandible body + incisive part (MBI), mandible body (MB), mandible body + branch (MBB), branch (B), and condylar process (CP). Cranium elements were classified as complete (C), incisive bone (IB), maxillae (M), zygomatic arch (AZ), and neurocranium (NC). Innominates were classified as complete (C), illium (IL), acetabulum + illium (AIL), acetabulum (A), acetabulum + ischium +illium (AISIL), acetabulum + ischium (AIS), and ischium (IS). Scapulae were classified as complete (C), glenoid cavity (GC), glenoid cavity + neck (GCN), glenoid cavity + neck + fossa (GCNF), neck (N), neck + fossa (NF), and fossa (F). Vertebrae were classified as complete (C), vertebral body (VB), vertebral epiphysis (VE), and spinous process (SP). Ribs, patellae, phalanges, calcanei, astragali, carpals and tarsals, and teeth were classified as complete (C) and fragment (F).

Table 10.7. Types of fractures. *FF* fresh fractures, *DF* dry fractures, and *MF* modern fractures.

Skeletal elements	FF	DF	MF
Humerus	67	17	1
Radius	90	40	1
Ulna	87	30	0
Femur	72	11	0
Tibia	117	14	4
Metacarpal	37	46	0
Metatarsal	72	57	2
TOTAL	542	215	8
%	71	28.1	1

10.5.5.3. Tooth marks

A total number of 7 remains with tooth marks (0.3%) were recorded during the taphonomic analysis. It should be noted that all of the remains only displayed punctures marks. The skeletal elements that show marks were ulnae (2 cases), ribs (1), scapulae (1), femora (1), tibiae (1), and metatarsals (1) (Table 10.9 and Fig. 10.8).

As already pointed out in chapters 8 and 9, although it is quite complex to distinguish between teeth marks made by non-human (Lloveras, 2011) and humans (Saladie et al., 2013,), for it features and comparisons with reference collections teeth marks recorded in the Font Voltada's archaeological sample, in general, could be to a minor contribution of small terrestrial carnivores.

10.5.5.4. Burnt marks

As occurred during the taphonomic analysis of leporid remains in Cova de la Guineu and as already explained in Chapter 9, at first 1.692 (63.3%) remains were considered to me affected by fire. After comparing our results to the data obtained in the experimental study on burnt modern and archaeological bone discussed in much detail in Chapter 6, we decided to remove 1.090 remains corresponding to the moderate colour categories, leaving 602 remains (22.5%). Damage due to burning was not located on any particular part of the skeletal elements and it affected different kinds of bone. The most affected skeletal elements were teeth, 1/2 phalanges, ribs, calcanei, scapulae, radii, innominates, ulnae, tibiae, and metatarsals. The intensity of the burning damage in the remains ranges between strong and calcined. Approximately, 26.2% of the remains display strong (black) damage, 55% presents extreme (grey) degree of burning damage, while 18.7% of the remains show a calcined (white) degree of damage (Table 10.10 and Fig. 10.9).

10.5.5.5. Other bone surface alterations

A total of 164 skeletal elements display bone surface alterations caused by other biotic and abiotic agents, and comprises 6.1% of our archaeological sample (Table 10.11 and Fig. 10.10) The most common alteration is calcium carbonate concretions with a total of 142 cases (5.3%), followed by root etching marks (0.7%), rodent gnawing marks (0.07%), and dissolution (0.03%).

10.6. DISCUSSION

The study of age of death of the analysed remains denotes the presence of 96.3 % of adult individuals. The frequency of adult individuals in the Epipalaeolithic level from Font Voltada is placed within that range. Additionally, comparisons with data from taphonomic studies analysing remains recovered from nest and pellets from nocturnal and diurnal raptors (Table 10.12), and scats and non-ingested remains from small terrestrial carnivores (Table 10.13), show that the percentage of adult individuals consumed may vary depending on the abundance of prey. As all ready mentioned in chapters 8 and 9, actualistic taphonomic studies on leporid assemblages produced by red fox (*Vulpes vulpes*) show that the percentage of adult individuals may vary from 50% (Cochard, 2004b) to 87 % (Cochard, 2004b; Lloveras et al., 2011), which it comes near to the results obtained for Font Voltada. Also, the percentage of adult individuals in assemblages accumulated by the Egyptian vulture (*Neophron percnopterus*) ranges from 41.7 – 100 % (Lloveras et al., 2014; Sanchis et al., 2013).

Table 10.8. Total number of cutmarks recorded in *Oryctolagus cuniculus* remains recovered from the Font Voltada.

Skeletal elements			Transversal		Oblique		Longitudinal	
	N	%	*N*	%	*N*	%	*N*	%
Mandibles	1	12.5	0	0	1	50	0	0
Cranium	0	0	0	0	0	0	0	0
Vertebrae	0	0	0	0	0	0	0	0
Rib	0	0	0	0	0	0	0	0
Scapulae	0	0	0	0	0	0	0	0
Humeri	0	0	0	0	0	0	0	0
Radii	0	0	0	0	0	0	0	0
Ulnae	1	12.5	1	16.7	0	0	0	0
Innominates	1	12.5	1	16.7	0	0	0	0
Femora	1	12.5	0	0	1	50	0	0
Tibiae	1	12.5	1	16.7	0	0	0	0
Patellae	0	0	0	0	0	0	0	0
Calcanei	2	25	2	33.3	0	0	0	0
Astragali	0	0	0	0	0	0	0	0
Carpal/Tarsals	0	0	0	0	0	0	0	0
Metacarpals	0	0	0	0	0	0	0	0
Metatarsals	1	12.5	1	16.7	0	0	0	0
1/2 Phalanges	0	0	0	0	0	0	0	0
3rd Phalanges	0	0	0	0	0	0	0	0
TOTAL	8		6		2		0	

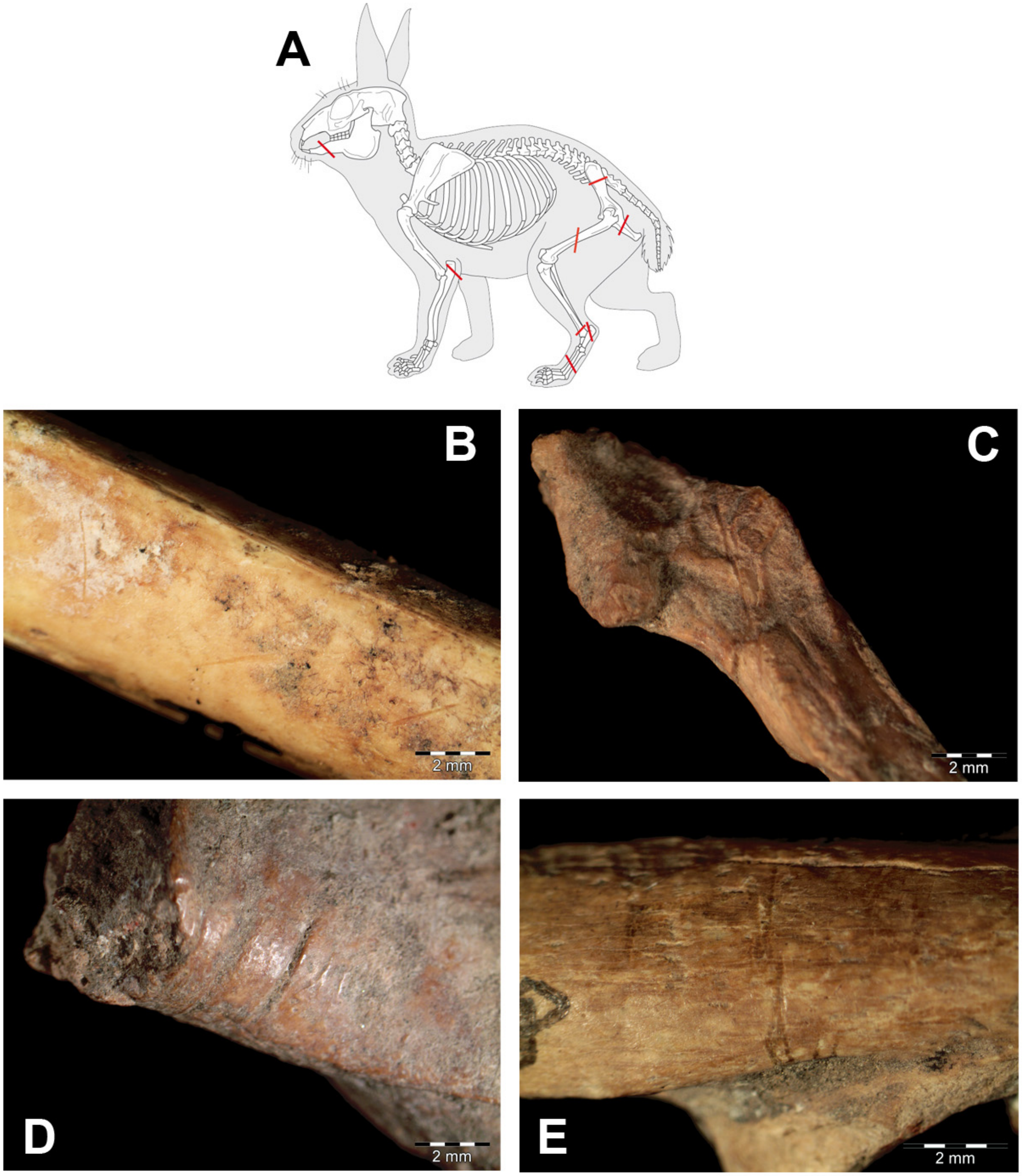

Figure 10.7. (A) Example of cutmarks from leporid remains recovered from Font Voltada: tibia (B), ulna (C), pelvis (D) and calcaneum (E).

Table 10.9. Number of tooth marks counted in leporid remains recovered at the Font Voltada.

Skeletal elements	TPU	TPI	SCO	CRE	NO	TOTAL
Mandibles	0	0	0	0	0	0
Cranium	0	0	0	0	0	0
Vertebrae	0	0	0	0	0	0
Rib	1	0	0	0	0	1
Scapulae	1	0	0	0	0	1
Humeri	0	0	0	0	0	0
Radii	0	0	0	0	0	0
Ulnae	2	0	0	0	0	2
Innominates	0	0	0	0	0	0
Femora	1	0	0	0	0	1
Tibiae	1	0	0	0	0	1
Calcanei	0	0	0	0	0	0
Astragali	0	0	0	0	0	0
Carpal/Tarsals	0	0	0	0	0	0
Patellae	0	0	0	0	0	0
Metacarpals	0	0	0	0	0	0
Metatarsals	1	0	0	0	0	1
1/2 Phalanges	0	0	0	0	0	0
3rd Phalanges	0	0	0	0	0	0
TOTAL	7	0	0	0	0	7
%	0.3	0	0	0	0	

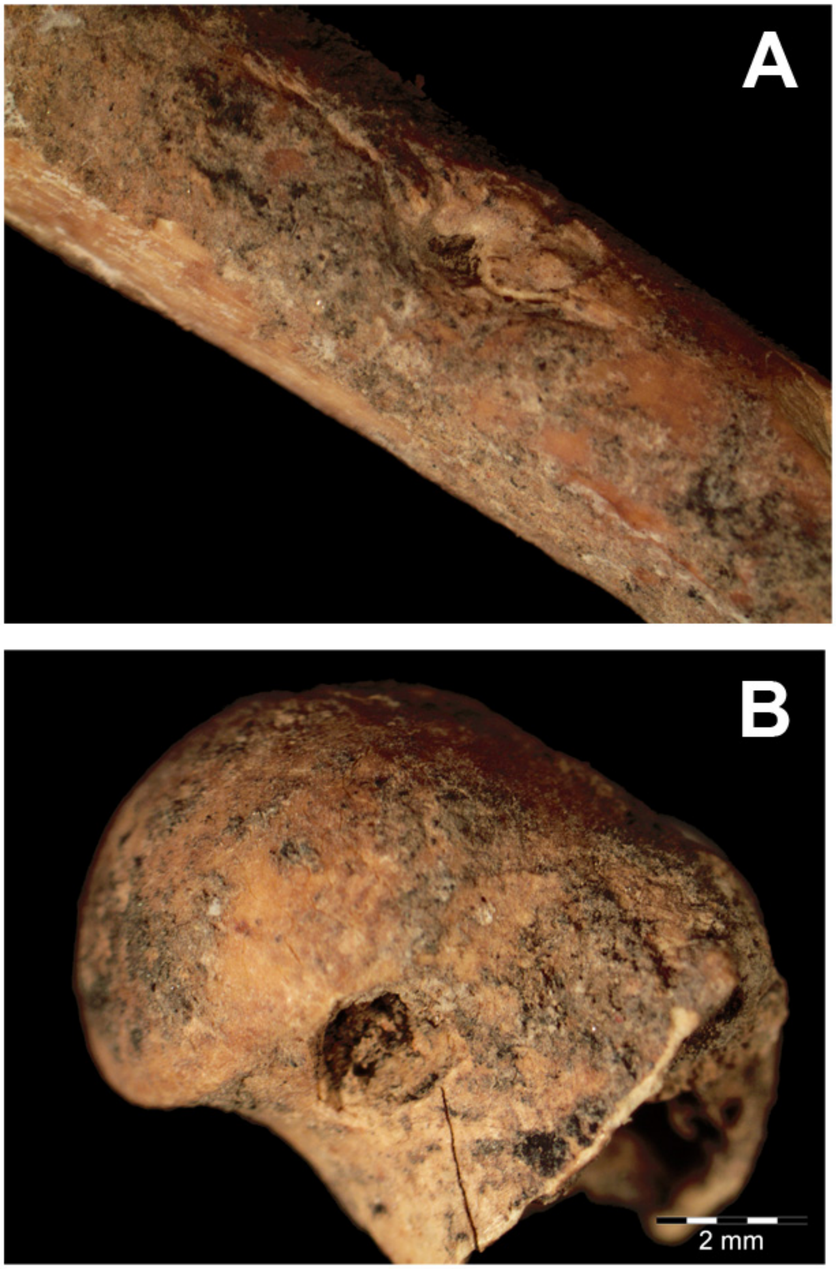

Figure 10.8. Examples of tooth marks on leporid remains recovered from Font Voltada. Tooth pit (A) and tooth puncture (B).

Table 10.10. Total number of burnt marks remains according to colour categories.

Skeletal elements	Light	Moderate	Strong	Extreme	Calcined	TOTAL
Mandibles	0	0	4	10	0	14
Cranium	0	0	15	8	7	30
Upper mol +Inc	0	0	26	49	7	82
Lower mol + inc	0	0	9	13	3	25
Vertebrae	0	0	0	3	0	3
Ribs	0	0	16	31	11	58
Scapulae	0	0	3	31	7	41
Humeri	0	0	2	15	3	20
Radii	0	0	11	21	5	37
Ulnae	0	0	12	11	9	32
Innominates	0	0	5	11	2	18
Femora	0	0	4	8	4	16
Tibiae	0	0	12	14	6	32
Patellae	0	0	0	0	0	0
Calcanei	0	0	4	19	9	32
Astragali	0	0	3	6	2	11
Carpal/Tarsals	0	0	1	0	0	1
Metacarpals	0	0	8	9	7	24
Metatarsals	0	0	9	21	10	40
1/2 Phalanges	0	0	10	31	14	55
3rd Phalanges	0	0	4	20	7	31
TOTAL	0	0	158	331	113	602
%	0	0	26.2	55	18.7	

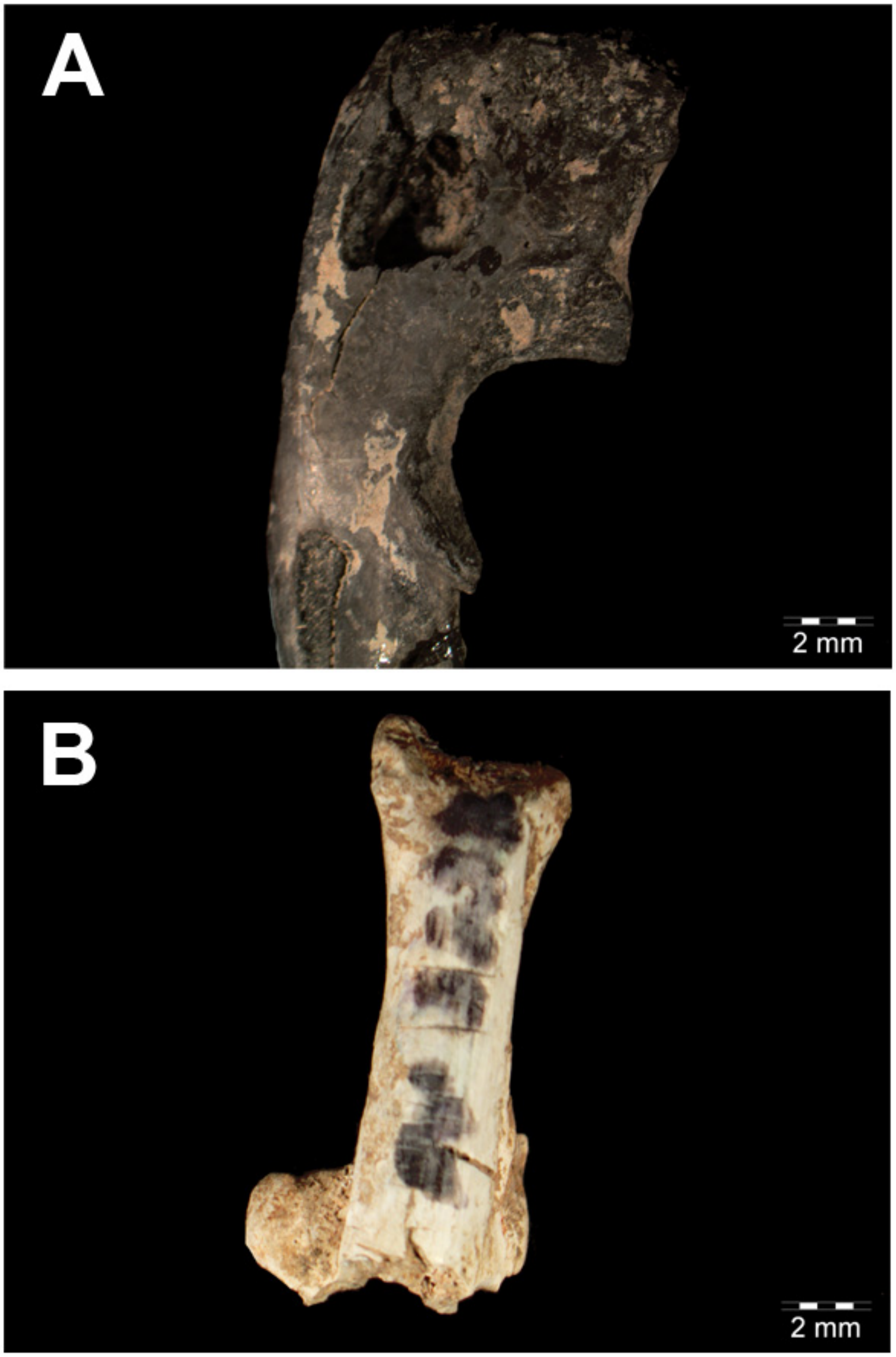

Figure 10.9. Examples of burnt remains recovered from Font Voltada. Ulna displaying a strong to extreme degree (A) and calcaneum displaying the highest degree (calcined) (B).

Table 10.11. Total number of skeletal elements displaying other biotic and abiotic bone surface alterations.

Skeletal elements	N	%
Trampling	0	0
Rodent gnawing	2	0.07
Bioerosion	0	0
Roots	19	0.7
Weathering	0	0
Abrasion	0	0
Dissolution	1	0.03
Concretions	142	5.3
Manganese oxide stains	0	0
TOTAL	164	
%	6.1	

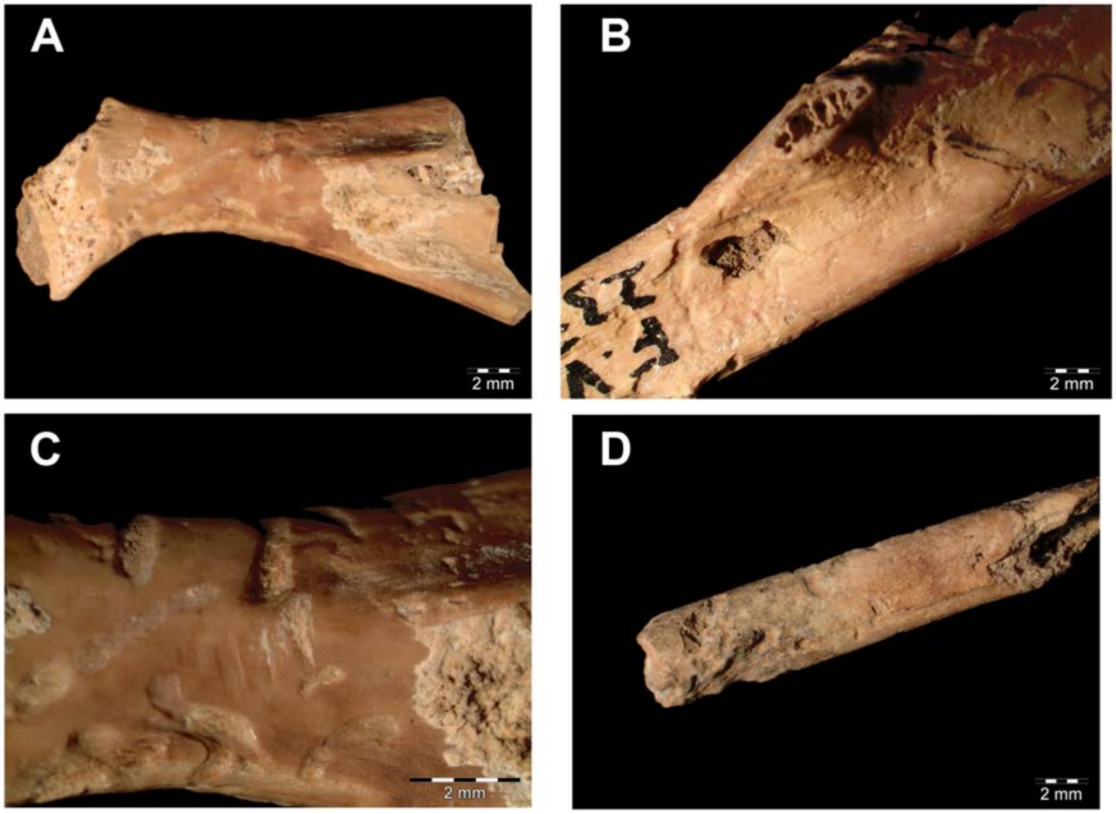

Figure 10.10. Examples of leporid remains affected by other biotic and abiotic alterations. Concretions (A), root etching (B), rodent gnawing (C) and dissolution (D).

The analysis of the anatomical representation shows that the whole skeleton was represented, even thought very small elements were scarce, which it may reflect a differential recovery in the field. Accumulations of anthropogenic origin are also characterized by the presence of all skeletal elements, indicating the transport of the whole carcasses to the site. There is no evidence of differential transport of any specific part of the carcasses, which may occur with some predators. Also, the relative abundance values indicate that calcanei, scapulae, cranial elements, innominate, and long bones specially ulna, tibiae, and humerus, are the most abundant, which is close to the anatomical expected in an anthropic accumulation where mandibles, long bones, scapulae and innominates are the best represented remains, while the axial skeleton is less represented (Brugal, 2006; Cochard, 2004; Guennouni, 2001; Hockett, 1991; Hockett and Haws, 2002).

When we compare the resulting relative abundance values from Font Voltada with the ones obtained for different types of non-human predators, we see a considerable difference. Comparisons between taphonomic data obtained from diurnal raptors show that the quantity of cranium elements does not match the profile obtained for Font Voltada, where cranium elements percentages tend to be slightly high, meanwhile when comparing data with results obtained from nocturnal raptors cranium element are less abundant.

The corresponding values of the different anatomical indexes, which indicates the representation of different parts of the skeleton show that cranium elements are more abundant than postcranial elements (PCRT/CR= 30.6 %). Even though cranium elements are abundant, elements corresponding to long bones are well represented among the sample (PCRLB/CR= 133.1 %). Proximal elements are scarcest than distal elements (Z/E= 144 %), and elements corresponding to the hindlimbs and forelimbs are balanced (AN/PO= 102 %). When comparing this proportions with the values obtained for other non-human predators, the results are more similar to those obtained for diurnal raptors such as the Bonelli's eagle, and scats remains of Iberian lynx and red fox, but since the study of bone surface alterations such as corrosion damage cause by digestion yield 0 % it is quite unlikely the accumulation could be the result of lynx or fox scats since this type of accumulation often show values over 90 % of digested remains (Lloveras et al., 2008a, 2012a). A non-existent % of digested remains excludes these types of accumulations.

As for the analysis of breakage patterns, only a 44 % of the analysed remains presented a characterized by high percentages of digested remains. Nevertheless, it is worth bearing in mind that two factors may have contributed to undervalue the percentage of complete remains in the studied sample: a.) the underrepresentation of small sized skeletal elements (Patellae, carpal/tarsal, phalanges 3) which are often recovered complete, and b.) the presence of skeletal elements displaying modern fractures.

The presence of an elevated count of long bone cylinders fits within the observed range in the other two assemblages, where more than a 5 % according to Cochard (2004a). The breakage pattern observe in Font Voltada is related to the bone marrow processing by human groups, and although shaft cylinders may appear in assemblages accumulated by non-human predators, they appear in low quantities (Hockett and Haws, 2002). The high proportion of tibiae, humeri and femora cylinders in Font Voltada (15.1%), as well as the abundance of epiphysis fragments (31.3%) points to the extraction of marrow from long bones.

The processing of the rabbit carcasses (skinning, disarticulation, defleshing and scraping) and preparation for human consumption is characterized by the presence of cut marks (Rosado-Méndez et al., 2016) and burnt bones (Lloveras et al., 2009b), and while cut marks tend to be abundant in anthropic accumulations, they are however subjected to a significant variability (Brugal, 2006; Cochard, 2004; Hockett and Bicho, 2000). In Font Voltada, 0.3% of the remains displayed cut marks and exhibit 22.5% of damage due to burning. The presence of cut marks and burnt bones necessarily demonstrate the presence of human activity, but not the quantity in which they are present. The proportions can vary as a result of the human activities made by humans and the functionality of the site: seasonality, skinning, disarticulation and defleshing activities, ways of cooking etc. Both percentages, although low, fit within the range observed for anthropic leporid accumulations, while the obtained values for burnt remains considerably surpasses all of the registered archaeological cases (Bournery et al., 2004; Cochard and Brugal, 2004; Hockett and Bicho, 2000; Ibáñez and Saladié, 2004; Lloveras et al., 2011; Pérez Ripoll, 2004; Rillardon and Brugal, 2014).

The presence of tooth marks on leporid accumulations it has been traditionally attributed to non-human predators. This assumption has change over the past few years, with ethnoarchaeological and experimental research data showing that humans also make modifications during chewing (Landt, 2007; Lloveras et al., 2009b; Saladié et al., 2013; Sanchis Serra et al., 2011). However, as all ready explains in the previous two chapters, identifying tooth marks caused by humans from other predators is not a straightforward matter, since tooth marks caused by human teeth are characterized by the removal of minimal to moderate amounts of cancellous bone tissue and are mostly associated with the fractures of long bone in order to remove bone marrow (Landt, 2007; Sanchis Serra et al., 2011). Unlike leporid assemblages accumulated by terrestrial carnivores, punctures marks (TPU) tend to be rare, and are predominantly located in flat bone and long bones diaphysis. Tooth marks percentages recorded in Font Voltada's archaeological sample are low (0.3 %), similar to the values obtained in Imperial eagle pellets and lynx scats, which might point to a minor contribution of non-human agents.

Data obtained on bone surface alterations caused by other biotic and abiotic agents indicate that 6.1 % of the remains was affected. A 5.3 % is ascribed to damage caused by calcium carbonate concretions, possibly due to the precipitation of mineral cement into the fauna remains. The second and third most common alterations present in Font Voltada were root etching (0.7 %), and remains affected by rodent gnawing (0.07 %) and dissolution (0.03 %), which is indicative of that the remains were not expose to the atmospheric agents for long periods of time, and a waterlogged environment.

10.7. CONCLUSIONS

Font Voltada's leporid assemblage also seems to be of anthropogenic origin. As with the previous cases (Balma del Gai and Cova de la Guineu), the anatomical representation and breakage patterns (with a high percentage of proximal and distal epiphyses fragments) along with a low, but average presence of cut marks and a significant presence of burnt remains, strongly suggest the assemblage was for the most part accumulated by humans (Brugal, 2006; Cochard, 2004a,b; Hockett and Bicho, 2000, Manne and Bicho, 2009). Unlike Balma del Gai and Cova de la Guineu, the percentage of complete element, complete long bones (0%) and remains < 10 mm (43%), reveals a highly fragmented assemblage. Also, the percentage of burnt bone, in comparison to the total number of remains in the sample is high. The high percentage of burnt bones suggest a direct consumption of the carcasses by human groups and then discarding any bone remains to the open fire to keep the area clean. Notwithstanding, like the other two cases, bone surface alteration may be clouding any evidence of butchering activities. Colour patinas due to mineral dyes can make it difficult to identify cut marks, especially light intensity marks. Also, water loss caused by fire can cause the bone to shrink, while affecting it structural stability, and cause cracks along the surface of the bone. These results points to a punctual procurement of rabbits for direct and immediate consumption.

The taphonomic analysis of rabbit remains from Font Voltada admits the possibility of it being of an anthropogenic origin. This present study shows that in Font Voltada, rabbits become a primary prey for prehistoric populations during the Epipaleolithic period. These results confirms and increases the number of sites that demonstrate a strategic change in the exploitation of small prey throughout the end of Pleistocene and the beginning of the Holocene in Southern Europe and the Mediterranean basin.

Table 10.12. Anatomical representation, breakage, digestion and teeth/beak marks for leporid remains accumulated by diurnal and nocturnal raptors compared with the results obtained from the taphonomic analysis on Font Voltada's leporid assemblage.

	Eagle Owl (*Bubo bubo*)		Spanish Imperial Eagle (*Aquila adalberti*)	Bonelli's Eagle (*Aquila fasciata*)	Egyptian vulture (*Neophron percnopterus*)		Font Voltada
Reference	*Lloveras et al., 2009a*		*Lloveras et al, 2008b*	*Lloveras et al., 2014b*	*Sanchis et al., 2013*	*Lloveras et al., 2014*	*Present study*
Origin	Nest	Nest	Pellet	Nest	Nest	Nest	Archaeological
N	1808	1932	824	438	269	133	2671
RA% > values	Pat-cal-in-fem	Cal-in-tib-mts	Phal 3-um-tib	Cr-um-in	Fem-in-rad-uln-mts	Md-cr	Cal-cr-teeth-sca-in-long bones
Ra% < values	Mtc-c/t	Rad-c/t-mtc	Rib-fem-rad-ver	Mtc-rib	Rib-cr	Phal-c/t-ver-long bones	Pat-mtc-phal-c/t-ver-rib
PCRT/CR	+ Postcranial	=	+ Cranial	+ Cranial	+ Postcranial	+ Cranial	+ Cranial
P/D	+ Proximal	+ Proximal	+ Distal	+ Proximal	–	–	+ Proximal
AN/PO	+ Hindlimb	+ Hindlimb	+ Hindlimb	+ Hindlimb	–	–	=
Complete elements %							
Long bones	14.6	10.8	0	51.7	–	–	1.1
Mean value total	53.9	45.9	27	74.7	80	81.2	17.8
Length (mm.)							
Min.	2.3	2.5	1.8	1.7	–	26.3	2
Max.	86.3	90	36.1	89.6	–	70.1	66.7
% < 10 mm	49	40	73	54.9	–	52.4	44
% Digested remains	68.8	65.6	98	31.2	1.1	0.8	0
% Digested long bones	88.9	83.9	100	31	2.8	–	0
Degree							
Null	31.2	34.4	2	68.8	–	99.2	100
Light	40.2	40.2	18.2	2.3	–	0	0
Moderate	19.8	19.8	46.8	7.9	–	0.8	0
Strong	8	5.3	27.4	14.4	–	0	0
Extreme	0.7	0.15	5.6	6.5	–	0	0
Teeth/beak marks	2	1.34	0.5	2.3	10.4	7.5	0.3
% Adult individuals	50	50	–	41.4	41.7	100	96.3

Table 10.13. Anatomical representation, breakage, digestion and teeth/beak marks for leporid remains accumulated small terrestrial carnivores compared with the results obtained from the taphonomic analysis on Font Voltada's leporid assemblage.

	Iberian Lynx *(Lynx pardinus)*		Red Fox *(Vulpes vulpes)*		European wildcat *(Felis silvestris)*		Font Voltada
Reference	*Lloveras et al., 2008a*	*Rodríguez-Hidalgo et al., 2013*	*Lloveras et al., 2012a*		*Lloveras et al., 2016b*		*Present study*
Origin	Scat	Non-ingested	Scat	Non-ingested	Scat	Non-ingested	Archaeological
N	1522	9594	265	639	87	1457	2671
RA% > values	Md-teeth-cr	Tib-cal-mts-ast	Long bones-sca-cr	Mtc-cal-ast-tib	Sca-hum-rad-uln-cr	Cr-fem-mts-cal	Cal-cr-teeth-sca-in-long bones
Ra% < values	C/t-ver-rib	Sca-ver-hum-rib-fem	Mtc-c/t-in	Cr-sca-rib-in-ver	Teeth-hindlimb	Sca-rib-hum-ver	Pat-mtc-phal-c/t-ver-rib
PCRT/CR	+ Cranial	+ Postcranial	=	+ Postcranial	+ Postcranial	+ Cranial	+ Cranial
P/D	+ Proximal	+ Distal	+ Proximal	+ Distal	+ Distal	+ Distal	+ Proximal
AN/PO	+ Forelimb	+ Hindlimb	+ Hindlimb	+ Hindlimb	+ Forelimb	+ Hindlimb	=
Complete elements %							
Long bones	2.5	37.6	0	5.4	0	23.7	1.1
Mean value total	43	73.2	12	89.4	11.5	92.3	17.8
Length (mm.)							
Min.	1.1	3	3	4	2	2	2
Max.	30.1	69	26.8	86.2	11.4	138.2	66.7
% < 10 mm	80	19.7	91	28	98.8	35	44
% Digested remains	97.2	–	99.5	–	98.6	–	0
% Digested long bones	100	–	100	–	100	–	0
Degree						–	
Null	2.8	–	0	–	1.4	–	100
Light	12	–	6	–	1.4	–	0
Moderate	22	–	26	–	9.6	–	0
Strong	43.8	–	43	–	39.7	–	0
Extreme	19.3	–	25	–	47.9	–	0
Teeth/beak marks	0.26	0.9	3	9.5	0	1.2	0.3
% Adult individuals	21.4	–	87	–	–	–	96.3

PART III:

GENERAL DISCUSSION AND CONCLUSIONS

CHAPTER 11

GENERAL DISCUSSION

In this section we intend to address different issues with the aim of characterizing the leporid assemblages from Balma del Gai, Cova de la Guineu and Font Voltada, in order to define the main features of small game exploitation during this period. The data have been placed within their own chronological and geographical context. First, a comparison is made between the results obtained in all three assemblages in order to establish and define similarities and differences. Second, in order to characterize the evolution and trend in the strategies and decisions on fauna procurement by hunter-gatherers groups, we compare our results with other published sequences of the Mediterranean Basin, paying special attention in the exploitation of leporids. Lastly, we compare our results with data provided by other sites from the Upper Palaeolithic in Southwestern Europe.

During the Pleistocene and Holocene transition in Southwestern Europe, changes in subsistence strategies, characterized by a broadening of the diet and an intensified exploitation of small prey occurs (Aura et al., 2002; Hockett and Haws, 2002; Jones, 2006; Pérez-Ripoll, 2001; Sanchis, 2010; Stiner and Munro, 2002; Villaverde et al., 1996). These changes can be explained by a combination of several parameters, for instance: environmental conditions (climate, abundance and dispersion of resources) and human factors (technological, social, demographic and cultural). This intensified exploitation of small prey is evidenced through the large quantities of leporid remains, especially

European rabbit (*Oryctolagus cuniculus*), in archaeological sites from this period (Fa et al., 2013). In the Mediterranean area of the Iberian Peninsula the presence of large leporid accumulations of anthropic origin are confirmed from the beginning of the Upper Palaeolithic, although several studies demonstrate rabbit exploitation in older sites (Blasco, 2008; Cochard et al., 2012; Sanchis Serra and Fernández Peris, 2008).

The exploitation of small prey, specially the European rabbit in the Iberian Peninsula, is a key data in order to understand some human behaviours, for instance group mobility, seasonality of camps and broad spectrum strategies among others in prehistoric hunter-gatherers groups, since it is of the most dominant taxa among faunal remains in archaeological sites of prehistoric hunter-gatherers groups in the Iberian Peninsula. However, rabbits are considered the favourite prey among a great number of medium and large size predators in Iberia, furthermore it is the most important species recovered from Palaeolithic and Epipalaeolithic sites in the north-eastern region of the Iberian Peninsula. The taphonomic signatures on rabbit remains left during the consumption by different predators are useful markers in determining whether or not a leporid assemblage is the result of human activity.

11.1. LEPORID ACCUMULATIONS DURING THE EPIPALEOLITHIC IN NORTHEAST IBERIA: OUR ARCHAEOLOGICAL SAMPLES.

During the Epipalaeolithic different models of mobility and subsistence are recorded. As already discussed in Chapter 1, two types of mobility are perceived: *residential* and *logistical*. While *residential mobility* refers to the action of shifting base camp characterized by assemblages that generally contain narrow fauna with just a few taxa, groups showing *logistical mobility* make residential moves less often with individuals or small task specific groups venturing out from and back to a residential camp, characterized by broader faunal assemblages (Aura et al., 2002, Jones, 2012, Rillardon and Brugal, 2014).

To the mobility patterns we must add subsistence strategies; according to Saña (2013), three models or strategies have been suggested to explain, at some point, the economic and social changes that took place during the Pleistocene-Holocene transition. The first strategy is based on the procurement of the European rabbit, with most archaeological sites exhibiting more than the 90% of the total number of remains. A second strategy is based on the procurement of wild goat (*Capra pyrenaica*), while a third strategy is based mainly on other ungulates hunting. Also, regional differences in hunting strategies are evident; meanwhile in the Ebro Valley and Northern Iberia sites appear to be focused on a generalized cervids and wild boar hunting, sites in the Eastern region are linked to rabbit hunting, while sites in the central part of the Peninsular Levant are associated with wild goat hunting.

We see that a strategy focused in rabbit hunting is reflected in the archaeological samples discussed within this PhD dissertation (Figure 11.1). Our data also show that, based on the faunal assemblages, the three archaeological sites discussed here show a logistical mobility patterns, since they all exhibit broad faunal accumulations, mostly composed of small prey such as small size mammals, birds, land snails and aquatic resources. While in Balma del Gai the elevated number of leporid remains comprises the 95% of the minimum number of individuals in the fauna assemblage, followed by red deer (*Cervus elaphus*), wild board (*Sus scrofa*) and small bovids, like the chamois (*Rupicapra rupicapra)* and the wild goat (*Capra pyrenaica*), the fauna from Cova de la Guineu, also characterized by a great number of rabbit remains, represents more than 90% of the number of identified specimens. If one excludes rabbit remains, terrestrial snails are also abundant; and ungulates such as red deer, wild goat, roe deer and wild board were also registered. In Font Voltada's case, the importance of leporid remains is overwhelming and accounts for more than 95% of the recovered remains, followed by lower percentages of wild goat, red deer and wild board. In principle, we can see a pattern of mass exploitation of leporids, followed by a mixed exploitation of two other species, either wild goat or deer, and other minor taxa. Faunal remains of anthropogenic origins are the result of a series of economic and strategic decisions, and although a large number of remains recovered in Balma del Gai, Cova de la Guineu and Font Voltada were found among other faunal remains, *Oryctolagus cuniculus* remain the predominant taxon in all three sites, surpassing the 90% (Nadal, 1998).

In accord to the results obtained from the taphonomical analysis of leporid accumulations from the Epipalaeolithic levels of Balma del Gai, Cova de la Guineu and Font Voltada, prehistoric humans seem to be the primary accumulators in all three sites. The frequency of adult individuals, the anatomical representation profile, the breakage patterns (high fragmentation of the remains normally performed in fresh bone), the presence of cut marks and thermo-altered remains, show that the leporid accumulations in all three sites seem to corroborate this fact. However, despite the anthropogenic origin of all three accumulations, non-human contributions are also documented. A few numbers of remains exhibiting digestion damage, and the presence of some small punctures, pits and score marks suggest some action of small terrestrial carnivores in all cases, that despite being a punctual contribution, must be taken into account.

The frequency of adult individuals from our three samples is placed within 82.6 - 96.3% (Table 11.1). These results are similar to the ones obtained from the analysis of archaeological leporid assemblages from different geographic areas, where the high percentage of adult remains is associated with human procurement (Brugal, 2006; Cochard, 2004a; Guennouni, 2001; Hockett, 1991; Hockett and Bicho, 2000; Martínez-Valle, 1996; Lloveras et al., 2016; Rillardon and Brugal, 2014; Sanchis Serra and Fernández Peris, 2008). Anthropogenic accumulations are normally characterized by more than 80% of adult individuals, although lower percentages, around 50 – 60% have also been recorded (Martínez-Valle, 1996; Sanchis Serra and Fernández Peris, 2008). The high percentage of adult individuals in all three samples provides us with information on procurement strategies, for instance the possibility of a mass collection of leporids. Even though Jones (2006) argues that mass collection strategies from a near burrow is evidenced by predominant numbers of females and young individuals within a faunal assemblage, data which is not available for any of our samples, other authors like Cochard et al. (2012) brings to our attention that the absence of juvenile individuals is possibly due to a lack of interest in such small individuals or because they are unavailable in a specific season. To this we must also add the differential conservation of small bone elements due to diagenetic processes and the conservation of skeletal elements that are prone to fragmentation, which may hide mass collecting patterns. Also, a marked presence of leporids at the site, at least a *minimum number of individuals,* between 84 and 195 in Cova de la Guineu and Balma del Gai (in only 1 square unit) respectively, suggests the possible use of some kind of technology or technique that allows the procurement of a large amount of this kind of prey such as nets, snares, traps, etc (Bean, 1972, Lupo and Schmitt, 2005, Nelson, 1973). Taking into consideration that those faunal assemblages that are rich in leporid remains usually are related to long-term occupations, and ultimately implying changes in the socio-economic organization of hunter-gatherers groups during the Upper Palaeolithic, some have argue that most of this changes may be related to technological innovation, but one must not forget that availability of prey as well as the functionality of the site and the environmental conditions of the territory will influence the taxonomic spectrum of the faunal assemblage. In this case the abundance of rabbits befall on its high reproduction rates and ecological flexibility which enables them to adapt to the new climate conditions during the Pleistocene-Holocene transition, promoting its expansion to other areas of Iberia with stable geographical and climatic conditions that would allowed its successful development.

Regarding the anatomical representation profile and breakage patterns, our analysis points to the occurrence of whole skeletons in the three samples, which means there is no evidence of differential transport of any part of the rabbit carcasses (Table 11.2), all of which show higher values of cranial elements, especially mandibles and teeth, scapulae and long bones; relative abundance profile for the three assemblages do not differ significantly. The values obtained in the analysis of the three samples are quite close to the anatomical profile expected for anthropogenic accumulation (Brugal, 2006; Cochard, 2004; Guennouni, 2001; Hockett, 1991; Hockett and Haws, 2002). Also, it must be borne in mind that a loss in small distal limb elements is evident in all three samples: in Cova de la Guineu and Font Voltada this loss ultimately reflects a differential recovery in the field as a consequence of the sieving strategy used, whereas in Balma del Gai small elements (most certainly carpal/tarsals, phalanges and above all fragmented ribs and vertebrae) recovered during the wet sieving of the material through 0.5 mm meshes has ended up mixed with the < 5 mm material.

The intentional breakage of long bones with the aim of extracting extra nutrients and fat leaves certain patterns in the archaeological record. Since this activity requires the removal or even the total crushing of the epiphysis from the shaft of long bones in other to extract the marrow, we often see a patterns characterized by high percentages of diaphyseal cylinders and epiphysis displaying the morphological characteristics of fresh fractures. Data from Balma del Gai's leporid assemblage indicate that 379 long bone cylinders, and a total of 1127 proximal and distal end of femorae, tibiae and humeri were recovered. In Cova de la Guineu, 294 cylinders and a total of 131 epiphyses were recorded, while 84 long bone cylinders and 226 epiphyses were recovered in Font

Voltada. The percentage of fresh fractures in all three sites is quite high, most of them concentrated in the proximal and distal ends of long bones. Judging from the percentage

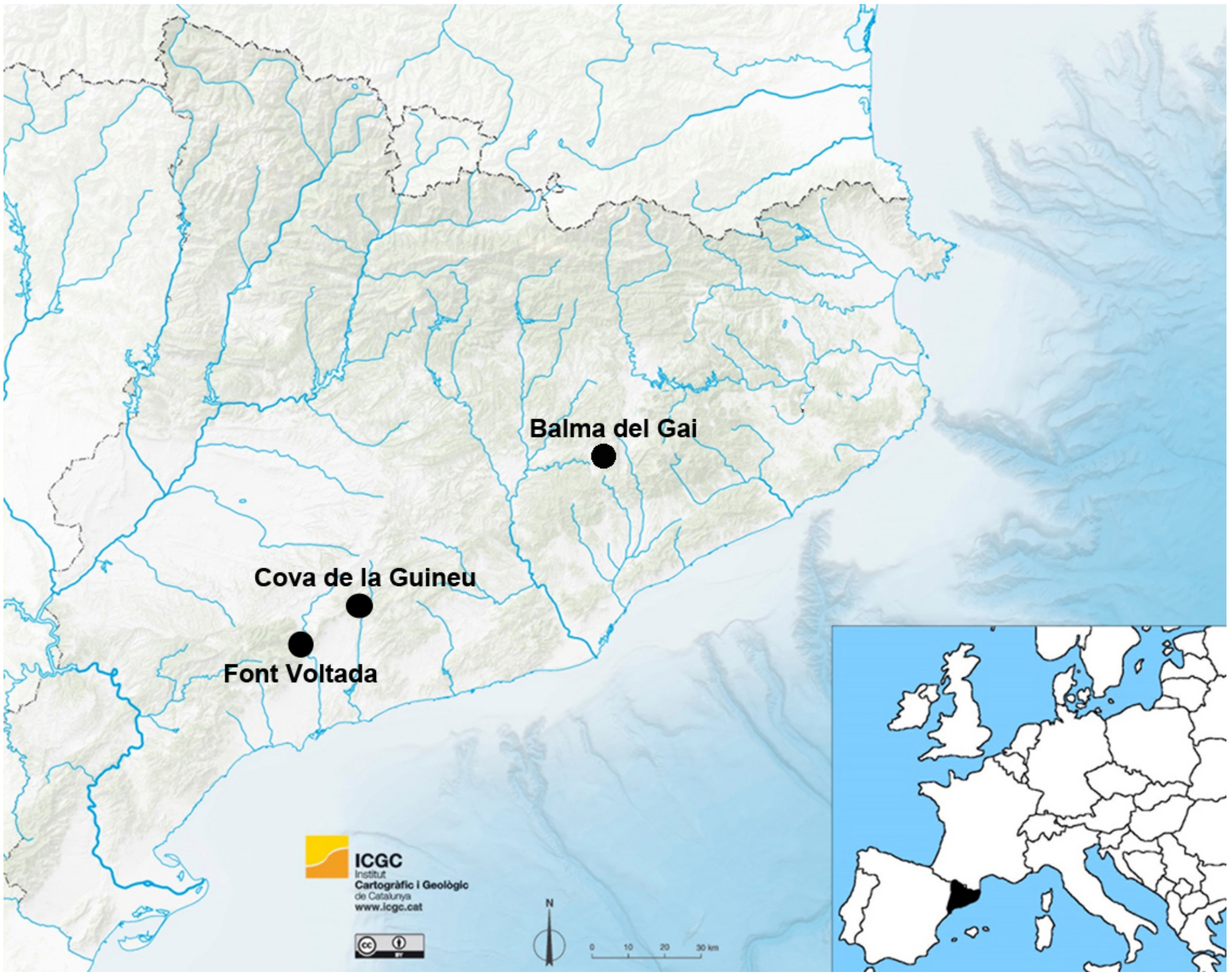

Figure 11.1. Location of the archaeological sites that comprise our sample: Balma del Gai, Cova de la Guineu and Font Voltada.

Table 11.1. Number of remains recovered, percentages of adult individuals, shaft cylinders, cut marks and burnt marks from archaeological leporid assemblages in Balma del Gai, Cova de la Guineu and Font Voltada.

Site	Balma del Gai	Cova de la Guineu	Font Voltada
NDR	14875	6768	2671
% Cylinders	30.6	26.2	15.1
% Teeth/beak marks	0.9	0.6	0.3
% Adult individuals	92.3	82.6	96.3
% Cutmarks	1.2	0.5	0.33
% Burnt marks	23.4	0.9	22.5

of leporid remains under 10 mm, Font Voltada's assemblage appears to be more fragmented than the other two samples (Table 11.2), which lead us to think in an immediate consumption of meat and the intentional fracturing of long bones aimed at obtaining the marrow, while the large number of long bone shaft cylinders and percentage of complete bones in Balma del Gai and Cova de la Guineu suggests the possibility of other procurement activities focused on meat extraction for its eventual conservation and/or direct meat preservation in bone. However, direct consumption of the carcasses is also documented. Overall, these results are consistent with the characteristics defined for assemblages produced by humans (Cochard, 2004a; Hockett, 1991; Hockett and Bicho, 2000; Lloveras et al. 2009a; Pérez Ripoll, 2004, 2005).

Regarding other bone surface alterations, cut marks due to the different butchery activities and thermo-altered bones could suggest activity induced by humans. Cut marks, according to their anatomic location and orientation, can be classified into various activities that are practiced during the processing of the rabbit carcasses: skinning, disarticulation, defleshing and scraping. We see evidence of all three of the activities involved in the processing of the rabbit carcasses (skinning, disarticulation and defleshing) within our samples. Also, a previous study carried in Balma del Gai (Nadal, 1998) raised the possibility of the use of meat conservation techniques, as these would easily generate a higher percentage of marks on bone. The proportion of cut marks, although it may seem low in all three samples can fit with this type of activity.

Our experimental study on identifying the different butchering activities (see Chapter 5) show that defleshing, scraping and removing tendons may indeed leave characteristic types of marks that varied in frequency, location, orientation and intensity, and that the number and type of marks produced during such activities clearly varies depending on the meat condition (fresh, dried, cooked). In Balma del Gai 1.2 % of remains display cut marks (Table 11.1.); the presence of cut marks located in mandibles (incisive part, mandibular body + incisive part and diastema), cranium (zygomatic arch and neurocranium), calcanei, metacarpals, metatarsals and 1/2 phalanges points to skinning activity, suggesting that the animal's skin (pelt) was being extracted in a single piece, which indicates its subsequent use for other possible functions, for example clothing and as containers. Signs of disarticulation of the carcasses are implied by few cut marks located in the innominates, scapulae, and proximal and distal ends of long bones. Defleshing marks are the most abundant and mostly located in innominates and long bones shafts. In the case of Cova de la Guineu, as in Balma del Gai, the proper identification of cut marks might have been clouded by other surface alterations, for example bioerosion by microorganisms, manganese oxide stains, dissolution and rodent gnawing, not to mention hard layers of sediment on the bone surface.

Overall, butchery marks suggest activities similar to the ones detected in Balma del Gai: a harnessing of rabbit pelts and the filleting of muscle packages, aimed for drying to prolong its consumption, but in a smaller proportion. Although, once again we must stress the matter that proper identification of cut marks might have been masked by other bone surface alteration, and in that way altering the real results and cultural interpretations. Regarding Font Voltada, the few cut marks located in one mandible (incisive), metatarsals and calcaneus points to the skinning activity. Signs of disarticulation of the carcasses are implied by few cut marks located in the innominate (ischium), and distal ends of long bones (tibia and ulna). Only one of the remains show incisions associated to the defleshing process. In Font Voltada's case, the low percentage of cut marks and the highly fragmented assemblage do not support the hypothesis of meat conservation techniques within the site, instead it supports the idea that a direct consumption of the rabbits carcasses was taking place on the site.

Continuing with the subject of bone surface alterations, bones can undergo important alterations when exposed to a heat source, affecting its colour, surface texture and structural stability, which are frequently used to estimate the heating temperature at which the archaeological samples were exposed. However, it must be bare in mind that other taphonomic processes can affect these variables during burial. Burnt marks in faunal remains can be indicative of use of fire in different activities, as they can be burnt as a result of cooking practices, as fuel or inadvertently burnt by a fire generated in close proximity. It must be considered that, beyond aiding in the process of food digestion and

Table 11.2. Anatomical representation, breakage, digestion and teeth marks for leporid remains obtained in the taphonomic analysis of leporid remains recovered from Balma del Gai, Cova de la Guineu and Font Voltada.

	Balma del Gai	Cova de la Guineu	Font Voltada
NDR	14875	6768	2671
RA% > values	Cr elem- md-sca-long bones-in	Md- Cr elem-in-sca-long bones	Cal-cr-teeth-sca-in-long bones
Ra% < values	Phal-c/t-ver-rib-pat	Pat-c/t-phal-ver-rib	Pat-mtc-phal-c/t-ver-rib
PCRT/CR	+ Cranial	+ Cranial	+ Cranial
P/D	+ Proximal	+ Distal	+ Proximal
AN/PO	+ Hindlimb	+ Hindlimb	=
Complete elements %			
Long bones	9	14.2	1.1
Mean value total	29	18.1	17.8
Length (mm.)			
Min.	2.6	3.4	2
Max.	84.7	144	66.7
% < 10 mm	17.8	13.5	44
% Digested remains	0.07	0.4	0
Degree			
Null	99.9	99.6	100
Light	0.007	0.3	0
Moderate	0.04	0.1	0
Strong	0.02	0.03	0
Extreme	0	0	0
Teeth/beak marks	0.9	0.6	0.33
% Adult individuals	92.3	82.6	96.3

reducing the intake of harmful microorganisms, cooking practices allows the manipulation of the entire carcasses, which in some way may end influencing its processing chain and its later consumption. For instance, as evidence in our experimental study (Chapter 5), cooked or roasted carcasses make the disarticulation process effortlessly, for the same reason meat can be extracted from the bone easily without the aid of any tools contrary to extracting raw meat or dried meat adhered to bone. This explanation would account for the low number of cut marks observed in Font Voltada. Also, as already mentioned, fire not only affects the colour and texture of bone but also its structure, causing a loss of organic component which will eventually allow shrinkage and cracks in the bone surface, not to mention an increase in size of the hydroxyapatite crystals at an atomic level (Shipman et al., 1984b; Surovell and Stiner, 2001; Stiner et al., 1995; Weiner, 2010). As for the proper identification of burnt bones in our samples, at first a sample of 363 bone remains (5.4%) was considered burnt in Cova de la Guineu. After comparing the crystallinity index of Cova de la Guineu's archaeological sample, since it was not clear that these remains were actually burnt, only the *minimum number* of 63 remains, belonging to the extreme (grey tonalities) and calcined (white) colour categories were taken into consideration; this leaves us with 0.9% of burnt remains. The same occurred in Font Voltada where only the remaining 602 remains considered the *minimum number* of burnt remains, belonging to the strong (brown tonalities), extreme (grey tonalities) and calcined (white) colour categories were taken into consideration; this leaves us with 22.5% of burnt remains. Font Voltada's leporid assemblage, for all means is the most fragmented of all three samples, and the one with the most elevated percentage of burnt remains. At some point it is unclear whether the high level of fragmentation within this assemblage is either due to intentional breakage aimed at the extraction of marrow from long bones or if its due to damage cause by the intentional tossing of the remains to a hearth, for reasons of cleanliness, or for been in close proximity to the hearths. Either way the sample of burnt remains is considered of anthropogenic origin.

In brief, as described above the suggested model for the intensive exploitation of small preys, leporids in particular, by hunter-gatherers groups in the final stages of the Upper Palaeolithic and early stages of the Holocene in the Iberian Mediterranean region is based on a pattern of logistic mobility and seasonal occupations. As suggested by Saña (2013), the subsistence strategy is based on the procurement of rabbit hunting complemented by hunting focused on medium sized species with limited migratory mobility (deer and wild goat), and the inclusion of other small mammals, birds, snails and aquatic resources (in some cases). Also, it is very common to find accumulations of a natural character contributed by other non-human predators in faunal assemblages dating from this period.

In our archaeological sample, the density of rabbit remains and breakage patterns suggest two types of occupation with different functionalities. First, an intensive occupation (Balma del Gai and Cova de la Guineu), possibly focused on a mass capture of rabbits evidenced by: a) the presence of cut marks corresponding to different butchering activities (skinning, disarticulation and defleshing), which (according to location) also suggests a conservation of meat and processing of rabbits' pelt, and b) breakage patterns, with high percentages of long bones cylinders and epiphysis fragments, points to the extraction of marrow, an activity that would have added a substantial increase of nutrient and calories to their diet. Second, a less intense or punctual occupation, in the case of Font Voltada, aimed to the direct (on site) consumption of the rabbits evidenced by: a) very few cut marks corresponding to different butchering activities (skinning and disarticulation), b) remains < 10 mm (43%), which reveals a highly fragmented assemblage, also pointing to the extraction of marrow, and c) a high percentage of burnt bones suggest a direct consumption of the carcasses by human groups and possibly discarding any bone remains to the open fire to keep the area clean.

11.2. LEPORID EXPLOITATION DURING THE PLEISTOCENE-HOLOCENE TRANSITION IN THE IBERIAN MEDITERRANEAN BASIN.

We can find other sites from the same period and with the same characteristics (regarding the relationship between the rabbit representation in respect to other taxa available in each assemblage) in the Catalonian region, for instance Cova del Bolet (Nadal and Estrada 2007), Balma de la Griera (Nadal, 1998), Cova del Parco (Fullola et al., 2006), Abric del Filador (García-Argüelles et al., 2005), Picamoixos (García et al., 1996); however, data comparison between these and our archaeological samples can be somewhat complicated. This is due to the lack of taphonomic data on leporid accumulations, the low number of determinable remains (in comparison to the number of remains analysed in our samples) and a certain lack of clear radiocarbon dates. We consider that the majority of the sites cannot be contrastable at a methodological level; therefore there is no reliable information on the leporid accumulations.

To date, the only comparable leporid assemblage comes from the Late Upper Palaeolithic (Magdalenian) and Epimagdalenian levels from Molí del Salt (Vimbodì, Catalonia) (Vaquero, 2004; Martínez-Polanco et al., 2016; Rufà, 2017). This site is located in NE Iberia at approximately 40 km from Tarragona, at 490 m above sea level, between the Catalan Pre-Coastal Range and the Catalan Central Depression. The stratigraphic sequence is composed of a 2.5 m thick package containing a Mesolithic unit (Level Sup) and the Late Upper Palaeolithic layers (Units A and B) from the Epimagdalenian and Late Magdalenian. Level Sup is dated between 9,110 – 8,717 cal BP, Sub unit A Sup is between 13,130 – 12,690 cal BP, and Sub unit A between 14,120 – 12,695 cal BP (García-Diez and Vaquero, 2015; Vaquero, 2004). Unlike our archaeological samples, Molí del Salt presents a stratigraphic sequence that goes from the Late Upper Palaeolithic to the Mesolithic, a factor that facilitates the evaluation of the exploitation of small prey during the Pleistocene - Holocene transition. In our assessment of the results presented by Rufà et al (2017), we will only focus our interest in the Epimagdalenian and Late Magdalenian leporid assemblages.

Leporid remains sub-unit A (Late Magdalenian) show a predominance of *Oryctolagus cuniculus* remains (NDR= 15,915) comprising the 97.1% of the fauna and a frequency of adult individuals of 96.7% (Rufà et al., 2017). These results are similar to the ones obtained for our samples (Balma del Gai, Cova de la Guineu and Font Voltada) and from the analysis of archaeological leporid assemblages from different geographic areas, where the high percentage of adult remains is associated with human procurement (Brugal, 2006; Cochard, 2004a; Guennouni, 2001; Hockett, 1991; Hockett and Bicho, 2000; Martínez-Valle, 1996; Lloveras et al., 2016; Rillardon and Brugal, 2014; Sanchis Serra and Fernández Peris, 2008). The high percentage of rabbit remains is followed by lower percentages of red deer (*Cervus elaphus*), wild goat (*Capra pyrenaica*), wild board (Sus scrofa), small terrestrial carnivores, and roe deer (*Capreolus capreolus*) and small terrestrial carnivores. A 1.5% of cut marks and 30.5% of burnt remains were identified. Relative abundance values show that mandibles and long bones such as tibiae and femora were the most abundant. Long bones (tibiae, femora and humeri) show significant breakage, which includes high proportions of shaft cylinders. Damage by digestion corrosion was recorded in 0.03% of the remains. Where the presence of puncture marks caused by beak/teeth of a predator is concerned, 1.4 % shows this type of modifications (Table 11.3a), presenting a minor accumulating agent.

Level A^{sup} (Epimagdalenian) show a predominance of *Oryctolagus cuniculus* remains (NDR= 3752) comprising the 98.3% of the fauna and a frequency of adult individuals of 96.7% (Rufà et al., 2017). It is also ascribe to a strategy based on the procurement of the European rabbit. The high percentage of rabbit remains is followed by lower percentages of Red deer (*Cervus elaphus*), wild goat (*Capra pyrenaica*), small terrestrial carnivores, wild board (*Sus scrofa*) and roe deer (*Capreolus capreolus*). A 1.2% of cut marks and 23.5% of burnt remains were identified. Relative abundance values show that mandibles and long bones such as tibiae and femora were the most abundant. As in level A, long bones (especially tibiae, femora and humeri) show significant breakage, which includes high proportions of shaft cylinders. Where the presence of puncture marks caused by beak/teeth of a predator is concerned, 0.9% shows this type of modifications, presenting a minor accumulating agent (Table 11.3a).

One of the things that we first notice in an exponential increase in leporid remains in the Upper Palaeolitic levels, especially in the Late Magdalenian. In reference to Table 1 from Rufà et al (2017), one can see an increase in leporid remains from units B1 and B2 (NIPS=2,523) to unit A (NISP=15,915) corresponding to the Late Magdalenian, followed by a decrease in remains from level A^{sup} (NISP= 3,732), which correspond to the Epimagdalenian, all the way to level Sup (NISP= 457) corresponding to the Mesolithic. Also, considering the whole faunal assemblage, we see that although there is an increasing percentage of *Oryctolagus cuniculus* remains, exceeding the 90% of the recovered remains, we can also find other taxa, although in a smaller amount, of medium-sized prey. These results are in accordance with the obtained results for other archaeological sites from the same chronology in Iberia, all of which will be discussed throughout the development of this section, in which we see a subsistence strategy based in leporid exploitation followed by the hunting of medium-sized ungulates.

Overall, as with our sample, the percentage of adult individuals, breakage patterns (% of diaphyseal cylinders, of fragmentation and % of complete elements), percentage of cut marks and percentage of burnt marks points to an anthropogenic acquisition of rabbits, even though articulated skeletons have been recorded, possibly as consequence of natural death, low values of digestion damage and tooth marks most certainly correspond to a minor contribution of non-ingested remains accumulated by small terrestrial carnivores (since they are documented among the whole faunal assemblage). The low, but not atypical, percentage of cut marks is indicative of butchery activities, such as skinning, disarticulation and defleshing. Also, defleshing cut marks with a longitudinal orientation points to the defleshing of raw meat. Another important modification is the high percentage of burnt remains and also a high percentage of epiphyseal fragments and shaft cylinders are oriented to a direct consumption of meat, and the extraction of marrow and fat. The exceedingly high number of burnt remains would account for such a low percentage of cut marks, since cooked or roasted carcasses would allow a more efficient disarticulation and defleshing process. Also, this cooking technique could account for the high values of fragmentation, since it will aid in the bone marrow extraction. The results obtained for Molí del Salt are quite consistent with the ones obtained in Font Voltada, aimed to a possible on site consumption of the rabbits, since the high values of fragmentation may be clouding other activities as meat conservation. The percentage of fresh fractures and breakage patterns points to the extraction of bone marrow, while a high percentage of burnt bones suggest a direct consumption of the carcasses by human groups.

The existence of well-studied sites along the Valencian territory and the presence of leporid exploitation, from the Late Upper Palaeolithic (Late Magdalenian) to the Epipalaeolithic, are detailed in various works (Aura et al., 2002; Morales, 2015; Pérez Ripoll and Martínez Valle, 2001). Despite not reaching a number of determinable remains resembling that of our sample, these sites are considered important, allowing us to trace and establish the evolution of the presence of these taxa within these archaeological sequences, and to define the most frequent subsistence strategy.

Regarding the relation between the rabbit representation in respect to other taxa available in each assemblage, there is a pattern of increase in numbers of leporid remains during the Magdalenian to Epipalaeolithic transition in most of the sites (Cacho et al., 1995; Morales, 2015). For example, as in the case of Molí del Salt (Vimbodì, Tarragona), in the interior profile of Tossal de la Roca (Vall d'Alcalà, Alicante) we observed a clear increase in rabbit procurement since the Magdalenian period. Data extracted from Cacho et al. (1995) show that the total number of *Oryctolagus cuniculus* remains in level IV (Upper

Magdalenian; 15,360 ± 1,100 BP), equals 679. In other levels, III and II (final Upper Palaeolithic; 12,480 ± 210 and 12,390 ± 250 BP), there is a decrease in numbers (603 and 279 respectively), and increasing again in level I (Epipalaeolithic) with a total of 1,210 remains. In the exterior profile, rabbit remains in level IIb, corresponding to the Epipalaeolithic, which in terms of chronology can be considered Mesolithic (9,150 ± 100 and 8,530 ± 90 BP), and level IIa (8,350 and 8,050 ± 120 BP) reduces to a total of 8 and 244 respectively. In all levels of the interior profile, the high percentage of rabbit remains is followed by lower percentages of wild goat and red deer (level IV), and the appearance of wild board in levels III and chamois in level II (Table 11.3a).

The same situation occurs in Coves de Santa Maira (la Marina Alta, Alicante) W entrance, were the percentage of leporid remains increases or decreases according to the different cultural phases. In the Magdalenian level (SM-5) leporid remains represent 83.4 % of the determinable remains, meanwhile the proportions of wild goat is estimated in 15.6%, and other minority taxa in 0.8%. In the Microlaminar Epipalaeolithic or Epimagdalenian (SM-4.2), 13 840 – 13 080 cal BP, the percentage of leporid remains ranges between 95.9 % - 79.3 % within layers 14 and 19 respectively, with a total of 84.6% of determinable remains, while goat remains are estimated in 14.8%. The total percentage of leporid remains in the Geometric Epipalaeolithic or Sauveterroide (SM-4.1), 10 200 - 11 270 cal BP, is 78.3%, but ranging from 94.7 – 61.5% between layers. Taking into consideration the other taxa available, the percentage of wild goat remains is 18.1% while minority taxa represents the 3.6%. These levels show a high number of remains belonging to adult individuals (Brugal, 2006; Cochard, 2004a; Guennouni, 2001; Hockett, 1991; Hockett and Bicho, 2000; Martínez-Valle, 1996; Lloveras et al., 2016; Rillardon and Brugal, 2014; Sanchis Serra and Fernández Peris, 2008). Coves de Santa Maira is one of the few sites that have a taphonomic study on leporid remains, although the analysis is more focused on the global study of the faunal assemblage. According to Morales (2015), a 27.6% of the leporid remains (SM-5) are burnt and the high incidence of cut marks in elements of the zygopodium is related to the extraction of muscle packs. Also their considerable presence in scapulae, humeri and femora in the Magdalenian level suggests a greater importance of the defleshing activity during this period than during the Epipalaeolithic (Table 11.3b), perhaps for meat conservation purposes but one cannot rule out the direct consumption of the carcasses since high values of burnt remains were recorded.

Another site with the same characteristic increase in the percentages of rabbit remains compared to other taxa, and has an updated taphonomic study of leporid remains, is Cova Fosca (Ares de Maestrat, Castellón). This site has a sequence covering the Epipalaeolithic (11 154 – 10 740 cal BP) to the Middle Neolithic period, were the leporids number of identified specimens amounted to fully half of the mammal sample (Llorente, 2015). According to Estevez (1981), the faunal assemblage is dominated, in all levels, by rabbit remains, followed by wild goat and red deer. Data extracted from Llorente (2015) shows that indeed lagomorphs' taxa dominated the Epipalaeolithic faunal assemblage in 61.7 %, followed by micro-mammals (29%), wild ungulates (5.3%) and undetermined bovids (3.2%) and 70% of the rabbit remains were classified as adults. Regarding the taphonomical analysis, over 3% of the remains were complete, however there is evidences of significant breakage, which includes high proportions of shaft cylinders (50%) during the Epipalaeolithic period and decreases toward the end of the sequence. A high percentage of fresh fractures were only registered in the Epipalaeolithic levels and were associated with the procurement and consumption of bone marrow. The analysis of the faunal assemblage showed little evidence of the effects of non-human predators on the remains with a 0.07% of tooth/beak marks and 0.8% of damage caused by digestion. Only 0.1% of the remains show cut marks while 15.6% of the leporid remains were burnt. Also, the considerable presence of scapulae, humeri and femora in the Magdalenian level suggests a greater importance of the defleshing activity during this period than during the Epipalaeolithic, which suggests, according to Llorente (2015), that this lack of anthropic marks might be due to a different type of processing of the rabbit carcasses (Table 11.3b).

The same trend (increase-decrease and viceversa in number of remains) is also observed in Cova Matutano (Villafamés, Castellón) and Cova dels Blaus (Vall d'Uixó, Castellón) (Table 11.3c). We see in Tables 11.3b and 11.3c, that the stratigraphic sequence from Cova Matutano ranges between the Upper Palaeolithic (Magdalenian) to the Microlaminar Epipalaeolithic (Olària et al., 1981), the leporid accumulation from levels IV to IIC represents the 95% of identified remains, with strong variations between levels, especially the Magdalenian and Epipalaeolithic (80.4%), where the percentages of rabbit begin to descend, and an increase in red deer percentages is evident. Data extracted from Casabó i Bernard (2004) show that as from level IIB the rabbit regains importance in levels corresponding to the Microlaminar Epipalaeolithic (Table 11.3c). The same occurs in Cova dels Blaus (Table 11.3c), where leporid remains represent 92.5 – 89.3% of the determined remains during the Magdalenian (Levels V - IV) and 85.6 – 87.5% during the Epipalaeolithic (Levels III – I) (Martínez Valle, 1996).

In the southern part of the Iberian Peninsula, in Andalucía (Spain), the archaeological sequence in Nerja Cave (Nerja, Málaga) show that the percentage of rabbit remains also increases since the early stages of the Upper Palaeolithic and increasing again in the Magdalenian (12 500 – 9 000) by 65% (Aura Tortosa et al., 2002a b). In the Magdalenian level, wild goat remains increases to 20% while red deer decreases to 0.7%. Recent studies on the faunal assemblage from *"Sala del Vestíbulo"* (Morales, 2015), corresponding to the Epipalaeolithic – Mesolithic sequence (levels NV-4 and NV-3, respectively), shows that the most abundant taxon is leporids, ranging between 85.3% (NV-4) and 42% (NV-3). In all sub-levels of NV-4 the percentage of leporids ranges between 77.1 and 85.3%. The high percentages of European rabbit, as in the Upper Palaeolithic, are followed by concentration of wild goat. In regard to bone surface alterations, cut marks in long bones respond to the extraction of muscle packs for posterior conservation. Shaft cylinders are high during the Epipalaeolithic (50%), which could mean hunter-gatherers groups were possibly maximizing the exploitation of leporid carcasses by extracting nutrients and fat in terms of bone marrow (Table 11.3c).

11.3. LEPORID EXPLOITATION DURING THE UPPER PALAEOLITHIC IN SOUTHWESTERN EUROPE.

It is of great importance to know the origin of leporid accumulations during the initial phases of the Upper Palaeolithic in Southwestern Europe (Spain, Portugal and Southern France) to asses the evolution of small prey exploitation and to see if there has been a significant change in the dominant leporid procurement pattern during the transition from the end of the Upper Palaeolithic to the Epipalaeolithic.

With this in mind, in the Mediterranean region, the Aurignacian leporid accumulation in Terrasses de la Riera dels Canyars (Gavà, Catalonia, Spain) show a percentage proportion between leporid remains and other taxa, in which, when excluding the rabbit remains, the faunal composition is dominated by herbivores' (60%) and carnivores' (40%). The leporid sample comes unit M24 (MLU; Cala A), dated 39.6 cal. Ka BP, and shows a predominance of *Oryctolagus cuniculus* with 3,458 number of determined remains, comprising approximately 69.1% of the fauna. The frequency of adult individuals is 79% (Rosado-Méndez et al., 2015), and even though anthropogenic accumulations are characterized by values over 85% of adult rabbits this type of accumulation could also show variability between sites (Martínez Valle, 1996; Sanchis and Fernández Peris, 2008). As for the breakage patterns, 16.7% of the remains are < 10 mm with low proportions of shaft cylinders (3.6%). Where the presence of digestion damage and puncture marks caused by beak/teeth of a predator is concerned, 1.3% of the remains show digestion damage while 2.5 % exhibit punctures marks, which points to the presence of a non-human accumulating agent (Table 11.4). The percentage of cut marks is quite low (0.2%) to infer a specific butchery activity. In this specific case (outdoor site), variables such as anatomical representation, breakage pattern, presence of digestion damage and tooth marks, points to the action of small terrestrial carnivores as the main agents, however, variables such as anatomical profile (high relative abundance of long bones, mandibles, scapulae and innominates) and the presence of cut marks points to a minor anthropogenic contribution (Rosado-Méndez et al., 2015). These results suggest that although changes are beginning to be seen in subsistence strategies, focused on the exploitation of leporids, still in these chronologies can be found assemblages where accumulations are generated as a result of the primary activity of terrestrial carnivores.

On the other hand, another example of Aurignacian leporid accumulations is Arbreda Cave (Serinyà, Catalonia, Spain) shows the evolved Aurignacian level (level G) exhibits 82.1% of adult rabbit individuals; within the range established in archaeological sites (Table 11.4). Also, the anatomical representation in Arbreda Cave show the presence of all skeletal elements and a good representation of teeth, mandibles, long bones, scapulae and innominates. Regarding breakage patterns, 13.3% of shaft cylinders and 33.7% of epiphysis fragments points to bone marrow procurement. The presence of cut marks (1%) and burnt marks (6.5%) fit within the range observed for anthropogenic leporid accumulations during the Upper Palaeolithic in the Mediterranean region. Also, even though the identification of human teeth marks is not a straightforward matter because of all the variability (human and other predators), at least 23% of teeth marks could be associated to human consumption (Lloveras et al., 2016).

One example of change in subsistence in the Mediterranean region is provided by the Gravettian levels (XV-XVI) of Cova de les Cendres (Teulada-Moraira, Alicante) with signs of human consumption evidenced by the elevated presence of cut marks (13.4%) related to disarticulation and defleshing activities, and high percentage of fragmented remains. In the leporid sample, 90% are adult individuals and the anatomical representation in Cendres show elevated numbers of mandibles and long bones. Regarding breakage patterns, a high percentage of shaft cylinders points to bone marrow procurement. Also, a considerable numbers of striations on long bone surface have been interpreted by some researchers (Villaverde et al., 2010) as score marks produced by human teeth when scraping the bone from soft tissue, which would imply a direct consumption of the carcasses. There are a 5% of the remains that exhibit digestion damage, which points to the intervention of nocturnal raptors (Martínez-Valle, 1996; Villaverde et al., 1999) (Table 11.4), which is one of the most common characteristics of leporid accumulation during the early stages of the Upper Palaeolithic. Recent studies on the leporid assemblages of the Magdalenian level corroborate the results highlighting the abundance of this prey during the late phases of the Pleistocene (Real Margalef, 2010).

In the case of Portugal, rabbits have been exploited intensely by humans since the Gravettian to the Epipaleolithic. Leporid assemblages from archaeological sites in the area exhibit breakage patterns and bone surface alterations consistent with human activity (Bicho et al., 2000, 2003, 2006; Brugal, 2006; Cochard and Brugal, 2004; Davis et al., 2007; Hockett and Haws, 2002; Hockett and Ferreira Bicho, 2000; Lloveras et al., 2011; Manne and Bicho, 2009) that would imply a maximization of the carcasses processing. For example, if we consider the case of Gruta do Caldeirão (Tomar, Portugal), the leporid accumulation in the Solutrean level appears to be largely anthropogenic. The anatomical representation, highly fragmented remains with epiphysis and shaft cylinders (27%) associated with marrow extraction, burnt marks (3.1%) and cut marks (0.8%) suggest most part of the remains were accumulated by humans with a marginal contribution of small terrestrial carnivores (Lloveras et al., 2011). The premise that small prey like rabbits

Table 11.3a. % of leporids determined remains, anatomical representation, anthropogenic alterations, breakage, digestion and teeth marks obtained in the taphonomic analysis of Magdalenian and Epipaleolithic sites in the Mediterranean region of Iberia.

Site	Molí del Salt	Molí del Salt	Tossal de la Roca	Tossal de la Roca
Reference	Rufà et al., 2017	Rufà et al., 2017	Cacho et al. 1995	Cacho et al., 1995
Chronology	Late Magdalenian (Level A)	Epimagdalenian (A^{sup})	Late Magdalenian (Levels IV, III and II)	Epipaleolithic (Levels I, IIb and IIa)
% Leporids	97.1	98.3	-	-
NDR	15 915	3 752	679; 603; 279	1210; 8; 244
Other fauna	*Cervus elaphus, Capra pyrenaica, Sus scofra*	*Cervus elaphus, Capra pyrenaica*	*Capra pyrenaica, Cervus elaphus, Sus scofra*	*Capra pyrenaica, Cervus elaphus, Sus scofra*
PCRT/CR	-	-	+ cranium	+ cranium
P/D	-	-	-	-
AN/PO	+ Posterior (Hind limb)	+ Posterior (Hind limb)	+ Posterior (Hind limb)	+ Posterior (Hind limb)
% Cylinders	Present	Present	Present	Present
% Cut marks	1.5	1.2	Present	Present
% Burnt marks	30.5	23.5	3.6	2.1
% Adult individuals	96.7	-	-	-
Complete elements %	-	-	-	-
% < 10 mm	High % fragmentation	High % fragmentation	High % fragmentation	High % fragmentation
% Digested remains	0.03	0.03	-	-
Teeth/beak marks	1.4	0.9	-	-

gained more significance during the Upper Palaeolithic is supported by the results obtained during the analysis of other Solutrean leporid accumulations in the Portuguese region. Another example is Lapa do Anecrial (Table 11.4) with faunal assemblage massivelly dominated by *Oryctolagus cuniculus*, with 1600 number of determined bone and teeth remains. In comparison to other Upper Palaeolithic sites exhibiting accumulations of thousands of rabbit remains, Anecrial is considered a poor- dense site. The leporid assemblage is characterized by adult individuals (98.8%), with a good balance between right and left elements, which is evidence of the inflow of complete carcasses (there is no differential transportation) to the archaeological site. The percentage of cut marks is low (0.02%) and 5.7% of burnt remains would imply a direct consumption of the rabbits, probably involving cooking/roasting, which would account for the low value of cut marks. Regarding anatomical representation, underrepresentation of small distal elements, consistent with the differential recovery on the field or the differential conservation of certain elements due to diagenetic processes, and high percentage of long bones shaft (70%), typical of human action for marrow extraction, is recorded. As already said, high quantities of long bone cylinders were recorded, however epiphysis fragments and scores marks were recorded, indicating possible differential human use, for example cured meat (drying or smoking limbs) and/or smashing bones for grease procurement (Brugal, 2006).

Another example is Vale Boi (Southern Portugal), were the rabbit assemblage constitute 72% of the number of determined remains (Table 11.4). Marine shellfish and other ungulates were also recovered. Along the Gravettian, Solutrean and Magdalenian sequences, *Oryctolagus cuniculus* is the dominant taxon followed by red deer (*Cervus elaphus)* and horse (*Equus caballus)*. Over 95% of the individuals were adults, few cut marks (< 1%) and tooth/beak marks and digestion damage (less that 1%), all according to Manne and Bicho (1999), were recorded. According to Manne et al. (2012), the percentage of determined rabbit remains decreases along the archaeological sequences,

Table 11.3b. % of leporids determined remains, anatomical representation, anthropogenic alterations, breakage, digestion and teeth marks obtained in the taphonomic analysis of Magdalenian and Epipaleolithic sites in the Mediterranean region of Iberia.

Site	Santa Maira	Santa Maira	Cova Fosca	Cova Matutano
Reference	Morales, 2015	Morales, 2015	Llorente, 2015	Olària et al., 1981
Chronology	Late Magdalenian (SM-5)	Epipaleolithic (SM-4.2 to SM-4.1)	Epipaleolithic	Late Magdalenian (Levels IV-IIC)
% Leporids	83.4	84.6 – 78.3	61.7	95
NDR	-	-	-	3689; 7024; 3144
Other fauna	*Capra pyrenaica*	*Capra pyrenaica*	*Micro-mammals, wild ungulates, Bovids*	*Cervus, Equus, Capra*
PCRT/CR	-	-	-	-
P/D	-	-	-	-
AN/PO	-	-	-	-
% Cylinders	-	-	50	-
% Cut marks	> High	-	0.1	-
% Burnt marks	27.6	-	15.6	-
% Adult individuals	> Adults	>Adults	70	> Adults
Complete elements %	-	-	-	
% < 10 mm	-	-	High % fragmentation	High % fragmentation
% Digested remains	-	-	0.8	-
Teeth/beak marks	-	-	0.07	-

Table 11.3c. % of leporids determined remains, anatomical representation, anthropogenic alterations, breakage, digestion and teeth marks obtained in the taphonomic analysis of Gravettian, Solutrean, Magdalenian and Epipaleolithic levels of sites located in Valencia (Spain) and Andalucía (Spain).

Site	Cova Matutano	Cova dels Blaus	Cova dels Blaus	Cueva de Nerja	Cueva de Nerja
Reference	Casabó i Bernard, 2004	Martínez-Valle, 1996	Martínez-Valle, 1996	Aura et al., 2002	Morales, 2015
Chronology	Epipaleolithic (Levels IIB-IA)	Magdalenian (Levels V-IV)	Epipaleolithic (Levels III-II)	Magdalenian	Epipaleolithic (Levels NV-4 and NV-3)
% Leporids	80.4	92.5 – 89.3	85.6 – 87.5	65	85.3 - 42
NDR	2223; 1638; 1580	-	-	-	-
Other fauna	*Cervus, Capra*	-	-	*Capra pyrenaica, Cervus elaphus*	*Capra pyrenaica*
PCRT/CR	-	-	-	-	-
P/D	-	-	-	-	-
AN/PO	-	-	-	-	-
% Cylinders	-	-	-	-	50 - 20
% Cut marks	-	-	-	-	Present
% Burnt marks	-	-	-	-	-
% Adult individuals	> Adults	-	-	> Adults	-
Complete elements %				-	-
% < 10 mm	High % fragmentation	-	-	-	-
% Digested remains	-	-	-	-	-
Teeth/beak marks	-	-	-	-	-

for example while rabbits comprise the 81% of the identified specimens during the Gravettian, the proportion decreases to a 65% during the Solutrean and then again during Magdalenian (45%), however this discrepancy it is said to be due to differential representation of single skeletal elements (Manne et al., 2012).

Picareiro Cave (Hockett and Bicho, 2000), another site dated during the Late Upper Palaeolithic from the Portuguese Estremadura (Table 11.4), shows that red deer and wild boar are among the taxa recovered, nonetheless, rabbits constitute 82.3% of the remains, where 99.4% of the individuals were classified as adults. Regarding anatomical representation, all skeletal elements are well represented, indicating the carcasses were brought complete to the site. Cranium elements were abundant, and fore limbs and hind limbs proportion were balanced, with only 3.7% of complete long bones. The taphonomical analysis of the remains shows no evidence of natural rabbit accumulation, nor evidence of minor non-human accumulations. Approximately 69% of the remains exhibit burnt marks, more specifically burnt patterns consistent with rabbits' carcasses been roasted over or within hot coal. Differential colours in limb elements, specifically proximal and distal ends, evidence this (Hockett, 1992), also the none-existence of cut marks within the sample shows that after which, the cooked carcasses were dismember and consumed directly. Breakage patterns indicate 23.6% of shaft cylinders and 584 fragments of proximal and distal epiphysis, which is consistent with bone marrow extraction activity.

Contrary to Portuguese archaeological sites, in France, as expressed by some authors (Cochard and Brugal, 2004), the importance of rabbit procurement in hunter-gatherers subsistence economy in Southern France it clearly manifests itself during the final stages of the Upper Palaeolithic (final Magdalenian and Azilian) (Table 11.4). The dominance of leporid is not constant since there are archaeological sites with an abundant presence of leporids, while in others are clearly scarce. Also zooarchaeological analysis of the faunal assemblages from Southern France suggest a procurement model that differs from those recorded in the Mediterranean region of the Iberian Peninsula (Aura et al., 2002). For example, in the Magdalenian level of Faurélie II (Table 11.4), European rabbit remains comprise 97% of the determined remains recovered (NDR=7695), while the other 3% corresponds to other herbivores (Cochard and Brugal, 2004). Also, the distribution of rabbit remains is diffuse throughout the excavated area, without any relation to the only hearth present in the northwest area of the shelter. Data on anatomical representation show all skeletal elements are well represented, indicating the carcasses were brought complete to the site. Relative abundance of skeletal elements shows 81% of elements corresponding to the forelimbs (scapulae, humeri, radii and ulnae), 69% of elements corresponding to the hindlimbs (innominate, femora and tibiae) and 65% of cranium elements such as mandibles and maxillae. Over 95% of the individuals were adults, 7.5% of shaft cylinders (N=146) points to the bone marrow extraction activity, the 1.6% of cut marks is evidence of butchering activities (defleshing).

Other sites (Table 11.4), like Bois Ragot (Cochard and Brugal, 2004) contain leporid (*Lepus timidus*) remains that exceed the 85% of the recovered remains. The rabbit assemblage is characterized by 94% of adult individuals and high percentage of long bones shaft (6.2%), typical of human action for marrow extraction is recorded. 6.2% of the remains exhibits cut marks consistent with disarticulation and defleshing activities (aimed to the acquisition of pelt and meat), while 4.1% of the remains are considered accidentally burnt. Also, in Moulin du Roc (Dordogne, France) the analysis of relative abundance of skeletal elements, bone surface alterations and breakage patterns suggest the leporid accumulation on the Magdalenian level is of anthropogenic origin (Jones, 2012). The non-existence of teeth/beak marks, remains affected by digestion damage indicate that there was no contribution from non-human predators, while a 10% of cut marks and 19% of burnt remains points to a human-accumulated assemblage. Also, the high percentage of long bones cylinders is consistent with the bone marrow extraction activity. Although *Oryctolagus cuniculus* is the dominant taxon recorded, it is followed by considerable numbers of *Rangifer tarandus* (reindeer), *Cervus elaphus* and *Capreolus capreolus* (roe deer). Another example is Oullins (Eastern Languedoc, France), where level 7b, corresponding to the Early Magdalenian, verifies the inclusion of the European rabbit in the diet of hunter-gatherer communities in that region (Rillardon and Brugal, 2014). 83.3% of adult individuals characterize the rabbits’ assemblage; the percentage of cut marks (2%) and burnt remains (8.5%), and high percentage of long bones shaft (13%) is recorded. As already said when discussing similar archaeological sites, high quantities of long bone cylinders are indicative of breakage aimed to the extraction of marrow.

Table 11.4. Comparison of anthropogenic evidence for leporid accumulations recorded in different Upper Palaeolithic sites from the Iberian Peninsula, Southern France and the studied samples.

Site	Reference	Cultural level	NDR	% Adults	% Cylinders	% CM	% BM
Riera dels Canyars	Rosado-Méndez et al. 2015	Aurignacian	3458	79	3.6	0.2	0
Arbreda Cave	Lloveras et al., 2016	Evolved Aurignacian	2953	82.1	13.3	1	6.5
Cendres	Pérez Ripoll, 2004	Gravettian	3729	-	-	13.4	8
Caldeirão	Lloveras et al., 2011	Solutrean	3705	83	27	0.8	3.1
Anecrial	Cochard and Brugal, 2004	Gravettian, Solutrean	1600	98.8	70	0.02	5.7
Vale Boi	Manne and Bicho, 2009, Manne et al., 2012	Gravettian, Solutrean, Magdalenian	5828	95	-	0	7
Picareiro	Hockett and Ferreira Bicho, 2000	Magdalenian	8981	99.4	23.6	0	2.8
Faurélie II	Cochard and Brugal, 2004	Magdalenian	7695	95	7.5	1.6	27.4
Bois Ragot	Cochard and Brugal, 2004	Magdalenian	12777	94	6.2	6.2	4.1
Moulin du Roc	Jones, 2012	Magdalenian	6596	-	42.7	10	19
Oullins	Rillardon and Brugal, 2014	Magdalenian	470	83.3	13	2	8.5
Balma del Gai	Present study	Epipaleolithic	14875	92.3	30.6	1.2	23.4
Cova de la Guineu	Present study	Epipaleolithic	6768	82.6	26.2	0.5	0.9
Font Voltada	Present study	Epipaleolithic	2671	96.3	15.1	0.4	22.5

11.4. A DIACHRONIC VISION: LEPORID CONSUMPTION ALONG THE UPPER PALAEOLITHIC AND EPIPALEOLITHIC.

The data presented throughout this chapter allows us to compare the exploitation of small prey during the Pleistocene-Holocene transition at a regional scale (Catalonia) and then extend to other regions of Iberian (Valencia, Andalucía and Portugal) and south of France (Figure 11.2). Our results on the nature of subsistence strategies among the last hunter-gatherers societies in Northeast Iberia, based on the taphonomical analysis of leporid accumulations, constitute a dataset that will allow the proposal of a general scheme in regard to the broadening of the diet during the Pleistocene-Holocene transition, manifesting itself within the Mediterranean region as an increase of rabbit remains percentages in sites with chronological sequences corresponding to the Upper Palaeolithic, but more importantly during the Epipalaeolithic.

The reasons why Upper Palaeolithic sites in Southwestern Europe exhibit exorbitant amounts of European rabbit it has been the subject of discussion for quite sometime. Several authors (Cochard and Brugal, 2004; Davis, 2002; Jones, 2004, 2006, 2012; Pérez Ripoll, 2006) have argued over: A) a selective hunting since 18 ka BP, confirmed by data from various sites located in the western Mediterranean region (Table 11.3 a, b, c) that show an increases in leporid consumption during the Late Magdalenian and even earlier, that comprises almost 90% of the determined remains recovered in each site, these high percentages are followed by lower values of *Capra pyrenaica* (wild goat)*, Cervus elaphus (*red deer*)* and *Sus scrofa* (wild boar); B) the premise that the increase of the European rabbit during the Upper Palaeolithic favored its hunting had lead various authors to propose a mass hunt model, in which rabbit procurement may have provided an energetic amount similar to that offered by other animals of greater size (Jones, 2006; Cochard and Brugal, 2004). Others point the elevated quantities of leporid remains as an adaptive response by hunter-gatherers groups in the Mediterranean region to population growth or as a consequence of a foraging model specialized in easy-to-hunt animal. By having high reproductive rates (with two litters per year), exhibiting a gregarious and territorial behavior, and easy-to- capture, rabbit procurement would have become a more convenient strategy; C) from an ecological point of view, other suggested that leporid hunt, may have resulted as consequence of emerging resources in times of scarcity. At the same time that cold climate species disappeared as a result of the climate amelioration, the abundance of rabbits will allow the prehistoric human populations to maintain certain sedentary strategies in coordination with the hunting of medium-sized mammals. This tendency towards specialization, making way for the diversification of small prey, undergoes a setback during the Sauveterroide Epipalaeolithic, with various sequences showing a decrease in rabbit remains (as seen through levels IV-IIC to IIB-IA from Cova Matutano, and levels NV-4 and NV-3 from Nerja), possibly related to a change in site functionality and refocused in the exploitation of other food resources, for instance marine resources as evidence in Nerja Cave.

Small preys' role must be valued in connection with the rest of the taxa among the faunal assemblage in each site. Differences in small prey exploitation between Middle Palaeolithic (Mousterian) and Early Upper Palaeolithic has been inferred through a model based on different types of occupation and exploitation of the territory characterized by a reduction in human groups mobility combined with a seasonal specialization of more gregarious species with limited migratory patterns as for example, deer and wild goat, and the procurement of more static food resources such as rabbits.

Data from archaeological sites in Valencia (Tossal de la Roca, Coves de Santa Maira, Cova Fosca, Cova Matutano, Cova dels Blaus and Cendres) and Andalucía (Nerja Cave), confirm the anthropogenic origin of leporid accumulations since the beginning of the Upper Palaeolithic, during the Aurignacian, Gravettian and Solutrean, perhaps as an alternate food resource to medium size herbivores according to some authors (Aura et al., 2002; Martínez Valle, 2001; Villaverde et al., 1999).

Another factor to consider is whether the nature and location of these settlements can condition the abundance of small prey in a certain way, since Palaeolithic sites in Iberia exhibit a great diversity in terms of geographical contexts, ranging from places near the coast, to steeper locations, or even located more than 1,000 meters in altitude. It is possible that changes in diet respond to variations in resources availability. Hockett and

Figure 11.2. Location of the sites discussed in the text: 1-Molí del Salt, 2-Tossal de la Roca, 3-Coves de Santa Maira, 4-Cova Fosca, 5-Cova Matutano, 6-Cova dels Blaus, 7-Cueva de Nerja, 8-Cendres, 9-Arbreda, 10-Riera dels Canyars, 11-Caldeirão, 12-Anecrial, 13-Vale Boi, 14-Picareiro, 15-Faurélie II, 16-Bois Ragot, 17-Moulin du Roc and 18-Oullins.

Haws (2002) argue that rabbit exploitation is based on local factors of resource density as well as climate conditions. A difference in the use of landscape implies different sites with different functions; Jones (2013) explains that groups with *residential mobility* are constantly changing places, generating faunal assemblages with fewer taxa, meanwhile groups with *logistic mobility* move less often, with individuals or small task-specific groups venturing out from and back to a residential camp, and exhibiting broader faunas. In the case of archaeological sites in the Mediterranean region (Valencia, Portugal and our archaeological sample), faunal assemblages point to a logistic mobility. This type of sites are also characterized by it location, usually in mid-range elevation, within a range a wide number of patches or increasing resource predictability (Jones, 2013). In accordance with the above, it is believed that small prey exploitation during the Upper Palaeolithic in Portugal is linked to local density factors and climate conditions. In Southern France, even though rabbit exploitation is evidenced by Early Upper Palaeolithic accumulations but it is not until the Magdalenian when this resource is exploited in an intensive manner (Cochard and Brugal, 2004; Jones, 2004; 2012). There is an evident relation between the intensity of resources exploitation and site function, all of this according to the number of leporid remains in each site ranging from rich to poor assemblages, all of which depends on the time of occupation and season.

The record studied in this Ph. D. dissertation confirms the trends that have been observed since the beginning of the Upper Palaeolithic period, and especially in the Late Upper Palaeolithic period, in relation to the hunting of small prey (leporids) in the South-western European area, more specifically in the southern Mediterranean basin of France and the Iberian Peninsula (to the Portuguese coast). This tendency will reach its splendour during the Epipalaeolithic period, as evidenced by the data of the studied sites, as well as its comparison with the faunal record of contemporary sites. The variability of each case can respond to variables of different natures, such as: type of settlement, seasonality, and precise location of the enclaves, among others. The question of why a diminishing importance of leporid hunting occurs during the Mesolithic of notches and denticulate is open, a decrease that begins in some cases during the Sauveterroide phase, although not in the case of the only record (Balma del Gai) in our samples that covers this chronology.

CHAPTER 12

CONCLUSIONS

Throughout this work, through the analysed sites and the literature consulted, we have seen how small prey has played a role in the feeding of human communities since the early stages of their evolution. In spite of this, its importance in the diet has been changing to that of this time, generally increasing, due to the necessary balance that must exist between the investment that entails the capture and the energy return that is obtained from them. In the case of south-western Europe and in particular in the Iberian Peninsula, the hunting of small prey, obviously, has as its main protagonist a taxonomic group of mammals, leporidae, and in particular a species, the rabbit (*Oryctolagus cuniculus*), which can b considered endemic to the area.

My work has focused precisely on the evaluation of this resource in a very specific area of the peninsula, Northeast (Catalonia), in a particularly significant period of prehistory for its climatic, ecological and cultural transformations, the Epipalaeolithic.

From what has been said so far, it is understood that the rabbit, as a particularly abundant species and widely distributed throughout the study area, has not been the exclusive potential prey of human groups. Many predators in the region have specialized in hunting and consumption, from carnivorous mammals, usually small to medium sized, to large diurnal and nocturnal raptors. Because of this, and because many of these taxa can also occupy the same spaces used as habitats (caves and rock shelters) of humans, the first requirement in a study of these characteristics should be taphonomic contrasts of the agents of accumulation in the archaeological sites.

Thus, we have seen in several chapters of this thesis (state of the question and discussion) as in the stages prior to the Upper Palaeolithic, the exploitation of rabbits is already present among the human communities that occupied the Iberian Peninsula from its beginnings, in turn are also significant the deposits of those moments in which the accumulations of leporid bones must be attributed mainly to lynx, foxes or owls real. This trend will not be reversed in our region of analysis until the Upper Palaeolithic. Although some increasingly scarce cases of rabbit accumulations by non-anthropic causes will continue to be detected (this would be the case studied by myself of the chronologically Aurignacian site of the Terrasses de la Riera dels Canyars, in Gavà, Barcelona, which in fact must be considered a strictly paleontological station) the concentrations of leporid remains will have a clearly anthropic origin. The causes of this change have been diverse: ecological, demographic, cognitive, and technological. Although I think that the final cause must surely be considered as a feedback from all of them, the debate among the experts remains open and controversial.

However, although the increase of the game hunting-food importance of the rabbit is detected from the beginning of the Upper Palaeolithic, it will be from the Tardiglaciar, and coincident with the chronotypic complex of the Magdalenian, that its increase will be exponential. Thus, in the Catalonian region, of the hunting models proposed in the literature, for this period and the next, two seem to dominate the registry: that of the specialized hunting of mountain goat in the abrupt zones and the one of the hunting of the rabbit in the Flatter ecosystems.

During the subtle passage from the Late Upper Paleolithic to the Epipalaeolithic, characterized by the complexes Epimagdalenian and microlaminar Sauveterroide, object of our thesis, continues the increase in the importance of the rabbit. It is possible to say that, from a human ecology perspective, mild or montane environments would be more adequate for human populations than very abrupt orography areas, and the reservoirs studied in this work, which would respond to the first of the ecosystems, characterized by an absolutely overwhelming predominance of rabbit remains, so we could consider the massive hunting of this animal as the subsistential model typical of the settlements of the Epipalaeolithic in the Northeast Iberian. As a result of the results presented in the thesis, it does not mean that such accumulations reflect subsistence strategies (and with them territorial, hunting and other) differentiated in each deposit and therefore the study of These remains become a powerful artifact of cultural and social interpretation, as long as it contrasts with results from other archaeological analyzes, which may allow us to deduce uses, occupation models, seasonality, etc.

Thus, the archaeological records in this thesis, and centered on the study of three key sites (Balma del Gai, Cova de la Guineu and Font Voltada), first shows that leporid accumulations (after evaluation that the sets are statistically reliable and diagenetic bias is not important) of the Catalonian epipalaeolithic are clearly of anthropic character. For this moment, palimpsests produced by large accumulations of human and non-human origin from previous phases have disappeared. Among the leporidae, almost exclusively rabbits form these assemblages. The percentages of elements that present some alteration associated with the intervention of small terrestrial carnivores are very low, and although their presence cannot be ruled out, it must be considered absolutely marginal.

Once the anthropic character of the accumulations has been confirmed, the detailed study of the alterations of human origin in each reservoir and the comparison between them leads to the conclusion that the use of leporids carcasses is multiple and for different purposes.

In the first place, on the one hand seems obvious by the size of the prey, the animals, according to their anatomical representativeness, arrived intact to the camps. The lack of small bones, usually of the autopodium, seems to be more linked to the mechanisms of archaeological recovery than to the manipulation that of carcasses could have been made in Prehistory.

Subsequently much of the animals would have been skinned, as evidenced by the marks located in bones associated with limbs, just as in the cranial area, especially in bones such as the neurocranium and mandible. In a second time, the animals would have been processed for the extraction and consumption of the meat, with marks related to the disarticulation process (concentrated in articular zones) but also with the extraction of the muscular packages and with the scraping of certain bones to extract particles of meat or periosteum (marks that are located mainly in the diaphysis and metaphysis). This activity, along with some marks that could relate the extraction of the meat in dry, would demonstrate that the consumption could be carried out on fresh animals as well as that the consumption of their meat had been postponed, by means of some type of drying, well after the separation of the muscular packages and the bone, or in some cases preparing parts of the animal without bone. However, the cut marks related of meat extraction, in spite of our experiments, are not completely conclusive in the cases that have been detected. During the process of manipulation of the carcass, in addition to the skin and the meat cannot rule out the extraction of tendons for other purposes.

Certain cut marks and fractures in the calcaneus could be interpreted in this way, also according to the contrast of archaeological marks with experimental results. However, in no case have we detected bone industry performed on rabbit bones, although in some of our deposits (Balma del Gai) this type of elements, made on other taxa, is relatively abundant.

The manipulation of the carcasses would end with the fracture of certain bones for the extraction of the marrow and even the chewing and perhaps the swallowing of the softer parts. In this respect, diaphyseal cylinders, bite marks interpreted as human, and the absence of certain epiphyses, usually the less dense ones, are abundant. The leftover remains would be abandoned and in some cases discarded in fire points, as is evident from the localized thermal changes, although some of them could be related to the culinary action. In this respect, the work demonstrates the precaution that must be taken with the identification of thermo-altered bones through colorations, especially in expositions of low-intensity heat sources (pre-cremation or calcination stains). The application of physical-chemical techniques have allowed the analyzed cases to correct biases in this sense, although it has also been demonstrated the complexity of these techniques and the need to make previous references suitable for each deposit.

Beyond detecting in general terms all this process of transformation of leporid carcasses in all the deposits, the degrees of intensity with which they are manifested in each case, allow to deduce behaviors associated to diversified strategies in each deposit. Thus at both ends we would have Balma del Gai and Font Voltada. In the first, the degree of bone fragmentation, the importance of heat-shifting and the marks seem to demonstrate a more intensive use of the meat resources with a maximization of the shells with an immediate consumption, while detecting a lesser use of the skin. On the contrary, in Font Voltada, it seems that a lower intensity could be detected in the direct consumption of the meat, although in turn the existence of a deferred consumption. Along with this seems to be detected in the Balma del Gai a greater skinning activity. La Cova de la Guineu would represent a model of transition between the two, but closer to that deduced for Balma del Gai. From a settlement model perspective, these results suggest a massive acquisition of animals in the case of the Balma del Gai and Cova de la Guineu, which would allow the generalized processing of the skins, direct consumption of meat and the collection through conservation of part of the surplus. Obtaining perhaps more sporadic or distanced in the time (not therefore casual or opportunist) of rabbits in the Font Voltada would imply to prioritize the carcasses as an alimentary resource and the maximization of them. Perhaps both models could be related to the duration of occupations (higher in rabbit farms in mass, Balma del Gai and Cova de la Guineu, and smaller in Font Voltada) as well as their logistical or residential character.

Regarding the possible evolution along the Epipalaeolithic of the exploitation of rabbits as an important resource, we can only offer the data from Balma del Gai, as it is the only site that we have a chronological development that includes the two complexes identified in this period. In this sense, no change is observed between the package that would correspond to the Epimagdalenian and that corresponding to the microlaminar Sauveterroide. This data would be consistent with the generalized view that the microlaminar Sauveterroide does not imply at cultural level anything more than the incorporation of a certain geometric component without implying major industrial or cultural changes. Finally, and beyond the chronological framework of this thesis, it will be interesting to continue studying how the exploitation of the rabbits evolves between the last hunting-gathering communities, before the advent of the Neolithic, in the northeast peninsular, that for the moment, and according to the few results that have, seems to suffer a drastic decrease. In any case, such a study is considered as a future project in the continuation of our research.

With all of this I hope to have demonstrated the importance of the study of small prey among the hunting communities of the Epipalaeolithic hunting in the Northeast of the Iberian Peninsula and the interpretative potential of the results, which implies an awareness of the community of archaeologists in the face of recovery of the remains and recording of the information of a taxonomic group for too many years forgotten of the registry, as well as the necessary comparison of the results obtained with those coming from other disciplines, which forces a second phase of discussion and sharing off results among all the specialists, in order to obtain a complete vision in the interpretation of each one of the deposits and holistic for the global reconstruction of this period in this geographical area.

PARTE IV:

SÍNTESIS

1. ¿Por qué desarrollar una tesis doctoral sobre acumulaciones epipaleolíticas de lepóridos en el noreste de la Península Ibérica?

En este año se cumplen 7 años de mi llegada a Cataluña para cursar el Master de Arqueología de la Universitat de Barcelona. No fue hasta aquel primer año de curso en el 2010, en la asignatura de *Geoarqueología* con la Dra. M^{a} Mercé Bergadà, donde descubriría lo que se convertiría mi tema de investigación por estos pasados 6 años, la tafonomía, sub-disciplina de la Paleontología, enfocada en el estudio de los procesos de preservación de los organismos y como estos influyen en la formación del registro fósil. Fue en aquel momento, durante la preparación del trabajo final de la asignatura donde empecé a interesarme en cómo los procesos de sedimentación, propios de la historia- o Prehistoria- de cada yacimiento, puede afectar la preservación de los restos óseos, y por tanto afectando su futura interpretación cultural.

En aquel momento quería centrar mi investigación en el estudio tafonómico de restos de jutías - ¡que en ningún momento debe confundirse con "judías"! Un error que la gran mayoría de mis profesores y compañeros de máster cometieron- y cómo los efectos de los diferentes tipos de sedimento podían afectar la preservación de restos óseos a nivel estructural y la identificación de alteraciones y/o modificaciones de origen antrópico a la hora de investigar sobre la explotación de pequeñas presas en contextos precolombinos en zonas circumcaribeñas. Con esta problemática en mente, empecé a informarme sobre qué tipo de alteraciones pueden estar presentes en los restos óseos como consecuencia de la exposición a los agentes meteorológicos previos al enterramiento o sedimentación de los restos y daños a nivel estructural, información que me llevó a conocer al Dr. Jordi Nadal y que junto a, el entonces candidato doctoral, Lluis Lloveras.

En aquel entonces, se hacía imposible realizar un estudio tafonómico sobre restos de jutías, debido al poco material disponible (en su mayoría restos muy fragmentados y anatómicamente indeterminables) y a la casi inexistencia de datos etológicos, como por ejemplos, comportamiento y hábitat, y sobre todo fuentes viables para la buena identificación de restos como lo son los atlas osteológicos. Los restos no solamente se encontraban en Puerto Rico, sino que además habrían de ser sorteados taxonómicamente. La situación derivada de la poca información publicada sobre este pequeño mamífero me llevó a re-plantear el sujeto de investigación, y de enfocar mi trabajo al estudio de un taxón en particular muy recurrente en yacimientos arqueológicos de la Península Ibérica, los lepóridos.

Durante el curso 2011 – 2012, recibí mi formación por parte de los doctores Jordi Nadal y Lluís Lloveras, y comencé a trabajar con los restos de lepóridos del yacimiento Auriñasience de la Riera dels Canyars (Gavà, Barcelona). El buen desempeño y resultados de mi investigación me condujeron a formar parte del SERP (Seminari d'Estudis i Recerques Prehistòriques) y a la oportunidad de desarrollar un trabajo doctoral centrado en la explotación de pequeñas presas por parte de grupos cazadores-recolectores en el NE peninsular.

En cuanto al contenido, los lepóridos, y especialmente los conejos (*Oryctolagus cuniculus*), como ya se ha dicho, son animales especialmente abundantes en la Península Ibérica desde el comienzo del Cuaternario. Vemos que por un lado, los restos de conejos son bastante abundantes en el registro arqueológico de los sitios prehistóricos de la Península Ibérica, desde el comienzo del Paleolítico hasta la aparición de las primeras sociedades productoras (Neolítico), mientras que por otro lado , esta cierta abundancia ha favorecido la aparición de toda una serie de depredadores (rapaces, diurnos y nocturnos y carnívoros) que se han especializado en el consumo de lepóridos o que, en una materia estacional, han sido consumidos intensamente por otras especies más generalizada en su dieta: Águila Imperial Española (*Aquila adalberti*) y el Búho Real (*Bubo bubo*) entre rapaces, y el lince ibérico (*Lynx pardinus*) y zorro rojo (*Vulpes vulpes*) entre los pequeños carnívoros terrestres.

Cabe señalar que tradicionalmente, cuando los restos de conejos aparecen en sitios arqueológicos, éstos han sido interpretados como evidencia de consumo humano, con todas las implicaciones que esto conlleva: explotación de presas pequeñas, estrategias especializadas, uso de tecnologías complejas de caza de redes, trampas, etc., sin que exista un análisis tafonómico previo que permita discriminar si los restos son resultados de agentes acumuladores no humanos o si existe un palimpsesto entre las ocupaciones humanas y las ocupaciones potenciales de los depredadores mencionados.

Uno de los momentos en los que hay un aumento exponencial de restos de lagomorfos, especialmente lepóridos como el conejo y la liebre europeos, en contextos arqueológicos es precisamente durante la transición del Pleistoceno-Holoceno en el noreste de la Península Ibérica, período conocido como Epipaleolítico. Como se leerá en los próximos capítulos, específicamente cuando se comparan los resultados de nuestra muestra arqueológica con otros registros arqueológicos, del mismo período y en otras áreas geográficas, hay evidencia de patrones de aumento de los restos de lepóridos desde el Paleolítico Superior final (Magdaleniense) hasta el Epipaleolítico.

Sobre los puntos previamente mencionados, este trabajo de investigación pretende resolver si los restos recuperados durante las excavaciones de algunos registros arqueológicos catalanes, con dataciones de radiocarbono del Epipaleolítico (específicamente entre el XII y III milenio BP), se puede atribuir principalmente a la caza por parte de los últimos cazadores-recolectores o si hay un cierto porcentaje de material que fue incorporado en el registro arqueológico por otros agentes tafonómicos. En el caso de ser una actividad predominantemente antrópica, el objetivo de este trabajo es elucidar los comportamientos culturales asociados con la explotación de estas presas pequeñas: procesamiento de la canal, tratamiento de alimentos u otros no directamente relacionados con el consumo animal (eliminación de la piel, entre otros). El trabajo que se pretende llevar a cabo en esta tesis doctoral se basa esencialmente en tres sitios arqueológicos.

Nuestro principal registro arqueológico, debido a la cantidad exorbitante de material recuperado en una sola unidad, y que se discute aquí es la Balma del Gai. Gai es un abrigo rocoso situado en el municipio de Moià (Provincia de Barcelona) a 740 metros sobre el nivel del mar ya unos 50 km de la actual costa. Joan Surroca, que realizó algunas intervenciones en 1975, la descubrió. El área luego fue excavada durante dos cortas campañas entre 1977 y 1978, bajo la dirección de Jean Guilaine y Miquel Llongueras. En todo caso, las intervenciones programadas a largo plazo hasta la fecha, se iniciaron en 1994, bajo la dirección de Pilar García-Argüelles, Alícia Estrada y Jordi Nadal, con la incorporación en los últimos años de Lluís Lloveras y Jofre Costa y bajo la protección científica de Seminario de Estudios y Recuerdos Prehistóricos (SERP), adscrito al Departamento de Prehistoria, Historia Antigua y Arqueología de la Universidad de Barcelona. El depósito tiene un nivel Epipaleolítico (nivel 1) en el que se pueden distinguir dos ocupaciones crono-culturales. En la parte superior de la secuencia, hasta un nivel aproximado de -130 / -135, los pisos de la sala corresponderían a una facies geométrica tipo Filador. Se encuentran entre 10.030 ± 160 BP y 8.930 ± 140 BP. Por debajo de las dimensiones mencionadas se encuentran las ocupaciones del microlaminar epipaleolítico, con una datación de 11.170 ± 160 BP y 10.260 ± 90 BP (con citas más antiguas de atribución incierta). El conjunto de arqueofaunístico tiene un porcentaje muy alto de restos óseos de *Oryctolagus cuniculus*. El material de Balma del Gai es el grueso de este estudio, con un número tan grande de restos, hemos establecido la estrategia de analizar una muestra estadísticamente representativa, específicamente, los restos de hueso de conejo de la unidad I3, una de las unidades con la menor alteración y mayor desarrollo estratigráfico.

El segundo registro arqueológico aquí tratado es Cova de la Guineu, que se encuentra en el municipio de Font-Rubí (provincia de Barcelona) a 734 metros sobre el nivel del mar ya 30 kilómetros de la actual costa. Fue excavado en 1983 bajo la dirección de Josep Mestres, hasta llegar al nivel Epipaleolítico. Este mismo nivel (nivel 3) intervino en 1988 bajo la dirección de Artur Cebrià y bajo la protección científica del Seminario de Estudios y Recuerdos Prehistóricos (SERP) adscrito al Departamento de Prehistoria, Historia Antigua y Arqueología de la Universidad De Barcelona. Aunque las excavaciones de Cova de la Guineu continúan teniendo lugar desde entonces, el nivel Epipaleolítico no ha sido re-excavado. Este nivel ha proporcionado una fecha de radiocarbono de 9,850 ± 80 BP y se registra crono-culturalmente al complejo Epipaleolítico microlaminar. Jordi Nadal estudió el conjunto de arqueofauna para su tesis doctoral e identificó restos de ciervo, cabra salvaje, corzo, jabalí y una importante acumulación de restos de conejo Europeo, con un total de 5.089 restos, los cuales son los incluidos en este estudio según la nueva metodología tafonómica desarrollada en esta tesis.

Nuestro tercer y último registro es el yacimiento arqueológico de Font Voltada, que se encuentra en el municipio de Sarral (Tarragona), a unos 600 metros sobre el nivel del mar ya unos 36 kilómetros de la actual línea costera en línea recta . El sitio fue descubierto durante la apertura de una carretera. A principios de los años ochenta, el sitio fue objeto de intervenciones programadas intermitentes bajo la dirección de Anna Mir y Antoni Freixas y tiene un nivel arqueológico (nivel 2) con una fecha de radiocarbono de aproximadamente 10.920 ± 240 BP y corresponde al complejo Epipaleolítico microlaminar. El material recuperado durante estas campañas se deposita hoy en el Museo de la Conca de Barberà, en Montblanc. En aquella época, J. Nadal también estudió esta asamblea para su tesis doctoral, entre las que se encontraban los huesos de los lepóridos que ahora están incluidos en esta disertación de doctorado. En el primer estudio de J. Nadal se contaron 1.735 restos de conejos (sin incluir ciervos, jabalíes, cabras monteses, linces y zorros).

En relación a la estructura del contenido, esta tesis doctoral se divide en cuatro bloques de contenido divididos en 12 capítulos, la parte bibliografía y anexos. A continuación, y de forma resumida, se presenta el contenido de los diversos capítulos en los que aparece dividido el trabajo.

El primer bloque es el marco teórico del trabajo, está dividido en 4 capítulos a modo de introducción, básicamente dedicado a una contextualización prehistórica sobre el periodo Epipaleolítico en el NE peninsular (Capítulo 1), donde tomamos en cuenta la inclusión de los lepóridos en la dieta humana valorando los aspectos como tamaño, peso, optimización energética, al igual que otros aspectos culturales. La explicación de los objetivos de investigación se presentan en el Capítulo 2, mientras que en el Capítulo 3 presentamos la taxonomía y sistemática de los lepóridos, al igual que sus características ecológicas y etológicas, para poder comprender sus características como “presas pequeñas” y de cierta manera poder explicar posibles técnicas y patrones de adquisición de este tipo de recursos en acumulaciones de carácter arqueológico. En el Capítulo 4 se expone la variedad de procesos de formación de acumulaciones de lepóridos con las que nos podemos topar durante una campaña arqueológica, y los diferentes tipos de alteraciones y modificaciones que nos podemos encontrar durante el análisis tafonómico de los restos. En este capítulo se hace total distinción entre aportes naturales o intrusivos, aportes exógenos (los diferentes tipos de acumulaciones no-humanas) y las características de las ocupaciones de carácter antrópico.

El segundo bloque está dedicado a la exposición de datos, resultados y discusión. Este a su vez está subdividido en dos partes: la parte IIa dedicada a la investigación experimental y la parte IIb dedicada a la presentación de los datos de nuestra muestra arqueológica.

La parte IIa se divide en dos capítulos: el Capítulo 5 y 6. En el Capítulo 5 se expone el marco teórico, metodología, resultados y discusión del trabajo experimental realizado en carcasas de conejo con el objetivo de aclarar y caracterizar, hasta cierto punto, el origen de "posibles" marcas de corte. Mientras que el Capítulo 6 está dedicado al marco teórico, metodología, resultados y discusión del trabajo experimental enfocado en el análisis de restos de lepóridos modernos y arqueológicos con termo-alteraciones, mediante el proceso *Fourier Transform Infrared Spectroscopy* (FTIR), con el objetivo de identificar, a nivel atómico, si un restos realmente está termo-alterado o no.

Los siguientes cuatro capítulos de la parte IIb se centran en el grueso del análisis arqueozoológico y tafonómico desarrollado en esta tesis doctoral. El Capítulo 7 se centra en la metodología aplicada al estudio de las acumulaciones de lepóridos arqueológicas, abordando los procesos de cuantificación y creación de una base de datos, determinación taxonómica, así como los cálculos de estimación de la edad de muerte, de representación anatómica y patrones de fragmentación, y un listado de los diferentes tipos de alteraciones y modificaciones en la superficie del hueso. Los Capítulos 8, 9 y 10 se centran en los conjunto arqueológicos, en donde se expone las principales características, como por ejemplo: situación geográfica, cronoestratigrafía, cultura material, paleoambiente (restos de flora y fauna). En el Capítulo 8 se exponen los datos, resultados y discusión para el conjunto de lepóridos de la Balma del Gai, mientras que en los Capítulos 9 y 10 se exponen los resultados y discusiones sobre las acumulaciones de Cova de la Guineu y la Font Voltada, respectivamente.

La parte III se centra en la discusión general de la muestra arqueológica y las conclusiones finales. El Capítulo 11 inicia recapitulando datos específicos sobre nuestra muestra arqueológica y planteando posibles modelos de subsistencia. Teniendo en cuenta el origen antrópico de toda nuestra muestra, hemos acopiado una relación de acumulaciones de lepóridos de origen antrópico, datados durante la transición del Pleistoceno-Holoceno (crono-culturalmente, transición entre el Magdaleniense al Epipaleolítico) y durante el Paleolítico Superior (Auriñasience, Gravetiense y Solutriense) en yacimientos peninsulares y del Suroeste de Europa (Sur de Francia), básicamente con la intención de obtener otros referentes, en cuanto a características y modelos de subsistencia, de origen antrópico. El Capítulo 12 está escrito a manera de conclusiones y recapitulación final.

Se incluye una parte IV, a modo de síntesis en idioma castellano.

2. EL PERIODO EPIPALEOLÍTICO EN EL NORESTE DE LA PENÍNSULA IBÉRICA: UNA BREVE SÍNTESIS.

Desde el primer momento, nuestra investigación estuvo dirigida a resolver un problema histórico, que es la evaluación de la explotación de los lepóridos por las comunidades humanas prehistóricas durante el Epipaleolítico en el noreste de Iberia (Cataluña). Es claro que los límites cronológicos de nuestro estudio deben definirse de mejor manera. En principio, dichos límites se establecen por las fechas absolutas obtenidas para cada uno de los sitios arqueológicos discutidos en esta tesis de doctorado: la Balma del Gai, la Cova de la Guineu y la Font Voltada. De acuerdo con las dataciones de radiocarbono para nuestro primer sitio, Balma del Gai, con una ocupación cronológica más larga, se establece aproximadamente entre XII y X milenios BP (fechas no calibradas). En la actualidad, y según investigaciones recientes, este margen cronológico, como se verá en otros capítulos de esta tesis, se sitúa suficientemente bien en el límite de fase geoclimática Pleistoceno-Holoceno.

Ya al comienzo de esta sección hemos definido claramente nuestras muestras arqueológicas como "Epipaleolítico". Pero, ¿Qué significa eso exactamente? En este sentido, el hecho de denominar esta fase "Epipaleolítico" ha suscitado algunos debates durante la evolución de la Prehistoria como disciplina académica. En nuestro caso, se considera un debate menor ya que sabemos qué registro arqueológico específico queremos estudiar, qué momento y las implicaciones históricas que puede traer: las sociedades cazadoras-recolectoras que durante los momentos finales del Pleistoceno-

Holoceno Temprano son forzadas, o quizás favorecidas, a una adaptación económica y subsistencia debido a la mejora climática que se han establecido progresivamente durante este período, unos miles de años antes de la llegada de las sociedades pre-agrícolas, estableciéndose (directa o indirectamente) dentro del territorio catalán desde el Mediterráneo Oriental . Sin embargo, consideramos oportuno hacer un breve comentario sobre por qué utilizamos el término "epipaleolítico" para definir los grupos humanos que son objeto de estudio de esta tesis doctoral.

2.1. ¿POR QUÉ EPIPALEOLÍTICO EN LUGAR DE MESOLÍTICO?

Durante el siglo XIX, con el inicio de la Prehistoria como disciplina científica, se establecieron dos períodos de gran claridad arqueológica: 1) el Paleolítico, el período más antiguo caracterizado por la economía de la depredación y la técnica de tallado de piedra, y 2) el período neolítico, La adopción de una economía de producción y el uso de sistemas de piedra pulida, y la fabricación de cerámica. Inmediatamente, y tal vez por un cierto temor de establecer límites excesivamente rígidos (durante las interpretaciones gradualistas del cambio, de la evolución geológica de Lyell a la evolución de Darwin de la especie), se definió un período intermedio: el mesolítico. A pesar de su nacimiento como una fase de transición, necesariamente requería características intrínsecas para diferenciarla en parte de las fases anteriores y siguientes. El Mesolítico fue denominado "Edad Media de la Prehistoria", como una fase de cierta degradación cultural en comparación con la fase anterior, el Paleolítico Superior, un período de abundancia alimentaria y riqueza artística y tecnológica, y antes de uno de los Grandes hitos de la humanidad, al igual que la Revolución Neolítica (Childe, 1981). El Mesolítico se caracteriza por la falta de arte paleolítico, su industria microlítica y la necesidad de adaptación a unos recursos alimenticios aparentemente "de menor calidad" (Cohen, 1977; Fullola y Nadal, 2005).

Con el tiempo, se pueden ver claras similitudes entre las fases finales del Paleolítico Superior y los cazadores-recolectores del Holoceno inicial, por lo que el término "Mesolítico" es percibido como algo inapropiado, más relacionado con un cambio geoclimático (la transición Pleistoceno-Holoceno) En lugar de un cambio cultural, a partir de ahí, la adecuación del término "Epipaleolítico" como una continuidad de la fase anterior. Un término acuñado para la prehistoria escandinava, por K. Stjerna a principios del siglo XX, pero que se extiende rápidamente a la literatura francesa y en el caso de España, llega a las manos de H. Obermaier. Su aceptación generalizada ocurriría durante los años 50 (Fullola et al., 1993).

En la Península Ibérica, F.J. Fortea, con su clasificación cronocultural de las sociedades de recolectores posteriores al Paleolítico Superior, establece claramente que todas esas facies entre el Paleolítico Superior y el Neolítico se llaman "Epipaleolítico", ambas correspondientes al complejo microlaminar (Mallaetes y Sant Gregori Facies) y complejo Geométrico (Filador y Cocina) (Forte, 1973). Este es el paradigma que perdurará por todo este tiempo en el área de estudio (costa mediterránea de Iberia). Sin embargo, la aceptación terminológica no será absoluta, y diferentes interpretaciones del modelo, con el tiempo y en particular la transformación definitiva del paradigma, con la caracterización de nuevas facies, rompe el consenso. Así, durante los años 80, la interpretación teórica del registro arqueológico de los cazadores-recolectores durante la transición Pleistoceno-Holoceno o completamente en el Holoceno hizo que algunos investigadores decantaran el término "Epipaleolítico" entendiendo que en el proceso de neolitización en nuestras latitudes las sociedades de depredación Ningún papel o motor concluyente en el proceso (teoría difusionista). Por otra parte, los investigadores que defendían las teorías autóctonas, en las que las sociedades nativas donde actúan los agentes activos del cambio, hicieron uso del término "mesolítico", explicando de alguna manera que no se encontraba estrictamente en una fase de continuidad con el paleolítico. Pero en este enfoque básico, las posibilidades eran infinitas, como mantener el término "Epipaleolítico" para los complejos microlaminar y considerar como "Mesolítico" los complejos geométricos, similarmente utilizado por los investigadores franceses (Bernabeu et al., 1993; Fullola et al. , 1993). La aparición de un nuevo complejo, caracterizado por la abundancia de elementos dentados y recortados, en la costa mediterránea y el valle del Ebro que separa cronológicamente los dos complejos geométricos, ha complicado las cosas. Además, algunos autores han explicado la relación directa entre las facies microlaminares con el período magdaleniense y, además, el vínculo claro del primer complejo geométrico, tipo Filador, con tecnología microlaminar, de modo que está separado del siguiente, tanto cronológicamente (separados Por la fase muesca y denticulada) y tecnológicamente (Román, 2012). Frente a esta nueva situación, muchos autores restringen el uso del término "Epipaleolítico" para los antiguos complejos microlaminar y geométrico Filador que los renombran Epimagdaleniense y Microlaminar Sauveterroide respectivamente (García-Argüelles et al., 2013), reservando el término "Mesolítico" para muescas y elementos denticulados, y lo que ahora se llamará estrictamente geométrico, que incluiría sólo el antiguo complejo geométrico tipo Cocina.

Nuestro trabajo, en este sentido, se centra exclusivamente en lo que actualmente se distingue estrictamente como epipaleolítico, ya que sólo contamos con ocupaciones microlaminar / epimagdalenienses (Font Voltada, Cova de la Guineu y las ocupaciones más antiguas de Balma del Gai) y Geometría Filador / Sauveterroide Microlaminar (Ocupaciones recientes de Balma del Gai). Para la ocupación más reciente, se debe decir que los sitios catalanes correspondientes a las muescas y mesolíticos denticulados suelen ser pobres en restos de lepóridos y que, además, Cataluña todavía no ha proporcionado información de sitios arqueológicos con ocupaciones geométricas, que están presentes en la Valle del Ebro o Valencia.

De cualquier manera, es necesario aclarar que para nosotros la confusión terminológica tiene poca importancia en el momento de interpretar el registro arqueológico y que, como muchos autores concluyen ya sea para los términos "epipaleolítico" o "mesolítico", uno y otro sólo se refiere a el concepto de cazadores-recolectores en Europa o el Cercano Oriente durante el Holoceno, o la transición Pleistoceno-Holoceno (Price, 1983). En líneas generales, las características que definen esta fase a lo largo y ancho del continente europeo son, la tendencia hacia la microlitización de las industrias, así como su regionalización y el uso de materias primas locales, la diversificación en la explotación de los recursos alimentarios, que por otra parte muestra especialización en ciertos sitios, por no mencionar el aumento de la explotación de los recursos marinos, y la recolección de recursos vegetales y pequeños animales. También hay un aumento demográfico, como lo demuestran el número de sitios arqueológicos y tal vez un aumento en la complejidad de las sociedades (Spikins, 2008). Más allá de esto, seguimos con sociedades de cazadores-recolectores que no parecen haber llevado un cambio hacia las economías de producción.

Definitivamente, a lo largo de esta tesis doctoral, utilizaremos el término "Epipaleolítico" para definir el período cultural de los sitios arqueológicos estudiados.

2.2. LA TRANSICIÓN PLEISTOCENO - HOLOCENO EN LA REGIÓN NE MEDITERRÁNEA: PAISAJE Y EVOLUCIÓN CULTURAL CRONO.

2.2.1. Evolución del paisaje

Después del *Último Máximo Glacial* (LGM) o *Pleniglacia*l, un período con un mínimo eustatico de 130m debajo del nivel medio real del mar debido a las capas globales del hielo en las masas de tierra (el llamado inlandsis) que ocurren en aproximadamente 23-19.0 ka BP (Cacho et Al., 2010), comenzó el último período del Pleistoceno. Este último período, *Tardiglacial*, se caracteriza por algunas importantes oscilaciones climáticas, entre períodos fríos y secos y fases más templadas. Las capas de hielo continentales se retiran, se forma el Mar Báltico y Gran Bretaña separa del continente. En el área mediterránea, se forman llanuras deltaicas; mientras que en el Cercano Oriente y Oriente Medio hay una tendencia a la aridez y a la sequía (Clarck et al., 2009). Debido a la fusión de los glaciares, el nivel del mar empieza a subir y se produce una remodelación de las costas. Finaliza entre 10.5 ka-10.3 ka BP dando paso al Holoceno, un importante cambio climático que representa condiciones climáticas y ecológicas similares a las condiciones reales.

La transición del Pleistoceno al Holoceno no debe entenderse como una transformación radical y súbita del clima general de la Tierra. Este cambio muestra una tendencia entre las fases más fría (estadios) y más caliente (interestadios). Aunque el Holoceno se considera un momento de nuestro clima actual, a lo largo de esta fase se han producido cambios de temperatura y humedad. Un aumento de las áreas forestales ocurre hacia el norte, así como árboles y arbustos. Con un aumento en la temperatura y las áreas forestales las especies climáticas frías, como por ejemplo renos y bisontes, emigran a las zonas del norte. Especies como el mamut, el rinoceronte lanoso, y los dientes de sable tigres y leones cavernícolas se extinguieron. Otras especies adaptadas a las condiciones del bosque, como ciervos, jabalíes y conejos, aumentan en número (Roberts, 2014).

En la región mediterránea de España este período no correspondía con el frío extremo, la aridez y las extensiones máximas de glaciares experimentadas en otras regiones del hemisferio norte (García-Ruiz et al., 2003a, 2010b , González-Sampériz et al., 2006, Hughes y Woodward, 2008, Jiménez Sánchez y Farias Arquer, 2002). La región mediterránea, debido a su baja latitud y ubicación fuera de la zona glacial y los efectos del mar en los ambientes costeros, puede describirse como un período de temperaturas relativamente cálidas y estables y definir por el desarrollo de la vegetación de estepa (Aura et al. 1998, Badal y Carrión, 2001, Cacho et al., 2010, Carrión Marco, 2005, Sánchez Goñi y Errico, 2005). El *Tardiglacial* comienza aproximadamente 15.5 ka BP con el aumento generalizado y gradual de las temperaturas tanto en el Océano Atlántico (≈ 5º C en el Margen Atlántico de Iberia) como en el Mar Mediterráneo (≈ 8º C). El aumento de las temperaturas se acompaña de la expansión de los bosques termófilos (Badal y Carrión, 2001; Cacho et al., 2001, 2010; Carrión Marco, 2005; Martrat et al., 2007; Pailler y Bard, 2002). También se produce un aumento de temperatura y humedad debido al desarrollo de zonas húmedas y ambientes lacustres. Según Abrantes et al. (2012) y Cacho et al. (2010), este proceso no es homogéneo en toda Iberia, el interior continental sufrió condiciones áridas más duraderas y un bajo aumento de las temperaturas mientras que el aumento de la temperatura en el sur fue rápido, también el norte y noreste de Iberia tiene un rápido aumento en ambos temperatura y humedad, pero no tanto como el sur de Iberia.

Este período de calentamiento global comienza con el final del evento frío HS-1 (GS-2) seguido por la etapa de mejora de Bölling-Alleröd (GI-1c a GI-1a), que termina con una fuerte disminución de las temperaturas sobre la mayoría Del Hemisferio Norte conocido como el *Younger Dryas* (GS-1). Esta nueva etapa de interrupción abrupta de las condiciones del calentamiento global supondrá una reorganización muy rápida de la circulación del Atlántico Norte y de la zona en contacto con el mar de Alborán, así como un enriquecimiento de la productividad primaria de esta zona marina causada por el refuerzo De la ingesta de agua en el Atlántico (Hughen et al., 2000; Jiménez-Espejo et al., 2008). El *Younger Dryas* parece haber tenido un impacto significativo en Iberia con fuertes variaciones regionales y aridez. Según Sánchez Goñi y d'Errico (2005), los registros de polen indican una disminución de las temperaturas durante este tiempo estimada en torno a los 3ºC en el Mar de Alborán y un aumento de la aridez en las regiones mediterráneas. Se registra una moderada reducción del bosque templado mediterráneo y la expansión de plantas semi-desérticas (Abrantes et al., 2012).

El período de mejoramiento climático conocido como el Holoceno comienza aproximadamente 11.7 ka BP (Walker et al., 2009). Los registros marinos muestran que la temperatura máxima en las aguas superficiales alrededor de Iberia durante el Holoceno temprano estaba aproximadamente entre 19º C (en el margen atlántico) y casi 20º C en el Mar de Alborán (Cacho et al., 2001, 2010; Martrat et al. 2004, 2007, Pailler y Bard, 2002). La expansión de los bosques de *Quercus* continúa desarrollándose y gradualmente ganando terreno sobre las formaciones pioneras de *Juniper* sp. No hay cambios radicales en la evolución de la formación de las plantas desde el inicio del *Tardiglacial* hasta el definitivo establecimiento de los paisajes forestales termo-mediterráneos. Sin embargo, la diferencia como la sustitución de la estepa por las formaciones *Juniper* y la desaparición o sustitución por los bosques de *Quercus* son evidentes en las secuencias antracológicas (Carrión Marco, 2005).

La transición Pleistoceno-Holoceno en el noreste de Iberia ha sido estudiada desde diferentes puntos de vista para comprender cómo tales cambios pudieron haber afectado la ocupación de los últimos cazadores-recolectores dentro de este territorio (Aura et al., 2010, 2002, Martínez-Moreno y Mora, 2009, Mangado et al., 2010, Mercadal, 2009). Los datos antracológicos de las secuencias arqueológicas en el Noreste de Iberia durante el Paleolítico Superior Final (15-11 ka cal BP) muestran una dominancia absoluta de *Pinus sylvestris* y un incremento en la diversidad de la flora (*Juniperus, Acer, Rhamnus cathartica / saxatilis* y *Prunus* durante el Epipaleolítico. -7 ka cal BP) (Alcalde y Saña, 2008, Allué, 2009, Allué et al., 2010, 2012, Aura et al., 2002, Martínez Moreno y otros, 2007, Morales et al., 2012, Piqué et al., 2010). La evidencia carpológica que se refiere a la transición Pleistoceno-Holoceno es puntual debido a problemas de conservación y la falta de muestreo sistemático, pero algunos hallazgos excepcionales incluyen evidencia de *Prunus spinosa, Pirus pyraster, Prunus* sp., *Rosa* sp., *Corylus avellana, Sorbus* sp., *Juglans regia, Pinus* sp., *Pinus pinea, Quercus* sp., *Malus sylvestris* y *Arbutus unedo* (Alcalde y Saña, 2008; Allux et al., 2012; Buxó, 1997; Buxó y Piqué, 2008 , Piqué et al., 2010). Los datos existentes para el Noreste de Iberia reflejan un paisaje que evoluciona bajo condiciones climáticas con tendencia a condiciones climáticas favorables con una cubierta arbórea continua constituida por coníferas en fases más antiguas y la evolución hacia las formaciones de árboles caducifolios desde el inicio del Holoceno Allué et al., 2012, Bergadà, 1998, Burjachs, 2009, Carrión et al., 2010, González-Sampériz et al., 2005).

2.2.2. Evolución crono-cultural

La evolución cultural de este período muestra dos fases cronológicas que coinciden, como ya se mencionó al comienzo de este capítulo, con la transición Pleistoceno-Holoceno. Durante esta transición, debe mencionarse que las industrias líticas pasaron por un rápido proceso de desarrollo en comparación con otros complejos tecno del Paleolítico Superior caracterizados por cambios en las técnicas de fabricación, dimensiones y morfología (Román-Monroig, 2012). Estos cambios, manteniendo al mismo tiempo la regionalización al menos al final del *Pleniglacial*, estarán vinculados a los procesos globales que ocurren en Europa Occidental en ese momento. Por 12.5 ka BP vemos las industrias líticas que se caracterizan por y el aumento de los elementos curvados con respaldo y respaldo (lámina), una reducción en el tamaño de algunos de los elementos más comunes, la horquilla ejemplo de los rascacielos y una reducción significativa del burin, hueso y elementos de cornamenta. En la costa mediterránea de Iberia, la principal característica es una importante continuidad con los complejos Magdalenienses finales. Cabe señalar que en este momento los cambios en los recursos alimentarios como la diversificación con la incorporación de un espectro más amplio de macrofauna, el aumento de la caza menor, la pesca, la explotación de los recursos marinos y la disminución de la caza de ungulados se registran en la Registros arqueológicos del sitio a través del territorio (Aura y Pérez Ripoll, 1992, Aura et al., 1998, Villaverde y Martínez, 1995). Los cambios en el espectro económico de los grupos humanos del Pleistoceno tardío-Holoceno temprano deben haber influido ciertamente en el diseño de algunos de sus instrumentos de caza.

Las industrias finales o finales del Magdaleniense Superior se desarrollaron entre 14 ka y 10.5 ka sin un claro punto de inflexión en el desarrollo de estas industrias Magdalenienses hacia el Epipaleolítico microlaminar (Aura et al., 1998, Villaverde Bonilla et al., 2012). Como ya se ha dicho, según la división tradicional dirigida por Fortea (1973), este período comienza con el final del Magdaleniense Superior, lo que conduce a un Epipaleolítico Microlaminar y Epipaleolítico Geométrico tipo Filador (ligado a facies Sauveterroides).

El Magdaleniense Superior final en Iberia se definió a partir de ciertas variaciones en las características propias de las industrias del Magdaleniense Superior y fue documentado en varios depósitos (Vaquero, 2004; Olària, 1999, Casabó, 2004, Martínez Andreu, 1989, Aura, 1995, Aura et al., 1998, Villaverde, 1981, 2001, Cortés, 2008). El grupo microlaminar dominante caracteriza a la industria de este período con las láminas, las láminas de dorso, los raspadores finales, con una presencia variable pero constante de las de pequeño tamaño. Buriles son a menudo menos presentes, aunque hay algunas variaciones que resultan de una mayor presencia en el Magdaleniense Superior. Fortea dividió los momentos post-magdalenienses en dos complejos: el Epipaleolítico Microlaminar y el Epipaleolítico Geométrico. La primera, claramente relacionada de manera tipológica y tecnológica con las industrias magdalenienses, siendo la principal diferencia la proporción relativa de los principales grupos tipológicos en los que se evidencia una disminución en la diversidad de los elementos microlaminares y la desaparición de los artefactos óseos (Aura et., 1998). Sin embargo, la mayoría de los investigadores han señalado en varias ocasiones que a nivel de la industria lítica no es posible diferenciar este Epipaleolítico Microlaminar del Magdaleniense Superior, de manera que estas industrias pudieran formar un verdadero Epimagdaleniense (Aura 2001, Casabó, 2004; Olària , 1997, Román-Monroig, 2012, Villaverde, 2001, Villaverde et al., 1998), llevando a la existencia de una gran variabilidad de la nomenclatura para referirse a este período. Algunos investigadores sostienen que la diversidad de términos utilizados para referirse a este período refleja la complejidad del momento (Aura y Pérez Ripoll, 1995). Según los datos obtenidos para su tesis de doctorado, Román (2009, 2011, 2012) reflexiona sobre el uso apropiado del término epipaleolítico de Microlaminar o eligiendo directamente el uso de Epimagdaleniense para definir las industrias después del Magdaleniense Superior y anteriores al Mesolítico.

La transición entre el Magdaleniense Superior final y el Epipaleolítico Microlaminar (Epimagdaleniense) no es un proceso abrupto sino una continuidad en la que vemos un aumento de ciertos elementos y la ligera modificación de otros. Hay un aumento en las puntas dobles (con retoques en ambos lados), un aumento de buriles y raspadores, en general una disminución en el tamaño de la herramienta lítica o microlitismo. Los sitios que proporcionaron información adicional para la caracterización del antiguo Epimagdaleniense: Cova del Parco (Fullola et al., 2004; Mangado et al., 2005, 2006), Balma Guilanyà (Martínez Moreno y otros, 2009), Molí del Salt (Vaquero , 2004), Filador (Fortea, 1973; García-Argüelles et al., 2005), La Cativera (Fontanals, 2002) y Cova del Vidre (Bosch, 2001) en Cataluña; Catete de l'Aigua (Román, 2010a), La Roureda (Aura et al., 2006, Román, 2010b), Matutano (Olària, 1999), Blaus (Casabó, 2004), Malladetes

(Fortea, 1976), Tossal de la Roca (Cacho et al., 1995, 2001) y Santa Maira (Aura, 2001; Aura et al., 2006) en el País Valenciano.

De acuerdo con los datos obtenidos a partir de materiales recuperados de los sitios arqueológicos mencionados, el período Epimagdaleniense, claramente una continuación del Magdaleniense, se puede dividir en dos fases: 1) epimagdaleniense temprano (13.7-12.9 ka cal BP) y 2) epimagdaleniense tardío 12.9-11.5 ka cal BP) (Román, 2012, Villaverde Bonilla et al., 2012).

El Epimagdaleniense temprano (13.7 ka - 12.9 ka cal BP) se caracteriza por el predominio del grupo microlaminar compuesto por láminas de dorso, puntas y raspadores, con un importante aumento en la reducción del tamaño. También hay una reducción de los elementos buril y una disminución de los artefactos fabricados en hueso. Este período es paralelo al período Aziliense de las áreas francesas y del Cantábrico (Villaverde Bonilla et al., 2012). El epimagdaleniense tardío (12,9 ka-11,5 ka cal. BP) difiere sólo con el primero en el aumento de las láminas con respaldo arqueado o puntos y segmentos. También existe la presencia de formas geométricas (triángulos) y la técnica de la micro-buril. Por ejemplo, se registra una gran diversidad de atribuciones culturales con una superposición de sitios que han sido vinculados al Epimagdaleniense, Microlaminar Sauveterroide, Mesolítico y Mesolítico de denticulados (Román, 2012) con sólo unos pocos sitios (Bosch, 2001, Fontanals, 2002, Fortea Y Jordà, 1976, Fullola et al., 1998, 2004, Martínez Andreu, 1989, Román, 2010b, 2011) que tienen buenas secuencias que permiten redefinir la fase. Los sitios arqueológicos datados del XI milenio BP que muestran un cierto número de elementos geométricos en complejos industriales dominados por la tradición microlaminar magdaleniense se incluirían en el Epimagdaleniense tardío.

A comienzos del X milenio BP (11.5 ka – 9.5 ka BP) los yacimientos arqueológicos eran menos abundantes, pero también atribuidos a una industria diferente; ligados principalmente a lo que se conoce como Microlaminar Sauveterroide, aunque algunos se atribuyen a Epimagdaleniense y Mesolítico (muescas y denticulados). Al igual que el Epimagdaleniense, hay muchos sitios situados al norte del río Ebro que tienen un gran número de elementos geométricos que los sitios situados al sur. No obstante, los componentes microlaminares en esos sitios siguen siendo el principal grupo tipológico, mostrando que están vinculados a la anterior tradición Epimagdaleniense (Román, 2012). Román (2009, 2011, 2012) reflexiona sobre el uso apropiado del término Microlaminar Sauveterroide para definir los elementos geométricos. Los principales datos para la caracterización de esta fase provienen de: Balma del Gai (García-Argüelles et al., 2009), uno de los sitios arqueológicos profundamente discutidos en esta tesis de doctorado, Filador (Fortea, 1973; García-Argüelles et al. 2005), Cova del Parco (García-Argüelles et al., 2013), Blaus (Casabó, 2001, 2004), Santa Maira (Aura, 2001; Aura et al., 2006) y Tossal de la Roca Et al., 1995); Ha sido el sitio arqueológico de Filador el que llevó a la propuesta de la existencia del Sauveterroide en el Mediterráneo Iberia.

Desde el punto de vista demográfico, en el área mediterránea del NE peninsular vemos sitios arqueológicos situados en el interior, principalmente en la Cordillera Pre-litoral (Montsant, montañas Padres y fuentes del río Boix): Abric del Filador, Colls, García-Argüelles et al., 2002, Fullola y García-Argüelles, 2006, García- Argüelles et al., 1992, Fullola, 1996, Fullola, Argüelles et al., 2007, Fullola et al., 2012), Cova del Boix, Balma de l'Auferi (Adserias y Bartrolí, 2007), Picamoixons (García-Catalán y otros, 2009), Molí del Salt (Vaquero, 2004), Balma de la Vall, Cova de las Borres, Font Voltada (Mir y Freixas, 1993), Cova de la Guineu (García-Argüelles et al., 1992) y Abric Agut (Vaquero et al. Otros sitios situados en gran proximidad a la costa son: Cova del Vidre (Bosch, 2008), Clot de l'Hospital (Esteve-Gálvez, 2000), en las montañas Tortosa-Beseit la Cativera Shelter (Fontanals et al., 2009) Balma de la Griera (Fullola et al., 1997), Cova de Mas Romeu, Cova Foradada, Can Sadurní y Marge del Moro (Fullola et al., 2011) en la costa central catalana y en las montañas del Garraf.

2.3. LA IMPORTANCIA DE LAS PEQUEÑAS PRESA EN EL PERÍODO EPIPALEOLÍTICO: EL PAPEL DE LOS LEPORÍFICOS.

Si asumimos que el paisaje influye en la forma en que las cosas se llevan a cabo, rutinariamente durante el día, y que nuestro recurso de subsistencia o alimento está, de la misma manera, altamente influenciado por cómo percibimos el ambiente, podríamos decir que el paisaje influye en los recursos alimentarios y cómo interactuamos con el medio ambiente para obtener dichos recursos. Por eso, si tomamos en consideración la naturaleza de la relación cazadores-recolectores con el paisaje, el análisis zooarqueológico de los restos faunísticos prehistóricos puede demostrar no sólo ser una gran herramienta para aprender sobre los cambios dietéticos que estas personas hicieron, sino en qué medida Interactuaron con las áreas circundantes en las que viven también.

El establecimiento de condiciones climáticas templadas facilitó la ocupación de zonas habitadas, con un despliegue a nuevas áreas especializadas. Desde el punto de vista cultural, estas culturas sumergidas en la transición Pleistoceno - Holoceno, fueron marcadas por un cambio hacia nuevas formas económicas, relacionadas con el surgimiento de nuevos paisajes y recursos naturales. El aumento del Holoceno tanto en paisajes variables como en la previsibilidad de los recursos puede haber propiciado nuevas adaptaciones de subsistencia, ciertamente un momento en el que la variabilidad climática y ambiental ha sido más o menos predecible. La capacidad de acceso a los recursos específicos antes de tiempo tendría un gran impacto en la toma de decisiones de los cazadores-recolectores. Variables como el clima y la vegetación, sin duda alguna, afectaron la distribución y abundancia de especies animales (Allué et al., 2010, Aura et al., 2002, Boyd et al., Jones, 2012, Marshall e Hildebrand, 2002).

En términos de subsistencia, el supuesto de que "una presa grande equivale a mejor" ha sido objeto de considerable debate desde el Paleolítico Superior se presenta como un tiempo de abundancia para cazadores-recolectores basado en los conjuntos faunísticos que contienen los restos de grandes herbívoros. Sin embargo, al mismo tiempo se registra un aumento en los sitios caracterizados por conjuntos dominados por taxones de talla pequeña (que para algunos se considera evidencia de un medio ambiente con recursos pobres). Las poblaciones paleolíticas de la cuenca mediterránea obtuvieron la mayor parte de su carne de ungulados hasta muy tarde en el Pleistoceno, sobre la base de datos corregidos por biomasa en abundancia de especies de presas recogidas por Stiner (2004). Es en las primeras etapas del Paleolítico Superior, y tal vez incluso en el Paleolítico Medio (Blasco, 2008; Blasco y Fernández Peris, 2009; Sanchis Serra y Fernández Peris, 2008), con proporciones significativas de conejo, pescado y mariscos incluidos en la dieta , donde se muestran signos de amplitud dietética (Allué et al., 2010, Aura y Pérez Ripoll, 1992, 1995, Aura et al., 1998, Badal, 1998, Stiner, 2004, Villaverde y Martínez, 1995). Se han utilizado factores como la demografía, los aspectos ecológicos, los aspectos tecnológicos nutricionales y la movilidad para explicar la inclusión de la dieta de los pequeños animales en la dieta prehistórica (Aura et al., 2002, Binford, 1968, Cosanagno et al, 2008, Flannery, 1969, Hockett Y Bicho, 2000, Hockett y Haws, 2002, Jones, 2006, Martínez -Valle, 2001, Stiner, 2001, Stiner y Munro, 2002, Vaquero, 2004, Villaverde et al., 1998).

Basado en la teoría de la *Revolución de Amplio Espectro* (Flannery, 1969), el modelo de elección de presa predice qué tipo de recursos un forrajero perseguirá una vez que el recurso potencial o el tipo de presa haya sido encontrado. Dentro de este modelo, se dice que los forrajeros optan por perseguir a las presas, o no, basándose en el lugar de los recursos en un conjunto clasificado por orden (Stiner, 2004). Esto se basa en las tasas de retorno de energía de las presa, o sea cuánta energía se devuelve al elegir una presa de un tipo determinado, por unidad de búsqueda y manejo. Afirma que un forrajero interesado en maximizar la eficiencia de forrajeo pasará a la presa sólo si hay una probabilidad muy alta de encontrar presas de mayor rango. Sólo cuando las tasas de encuentro con recursos de alto rango disminuyen, se tomará una variedad más amplia de tipos de presas de menor rango para compensar la diferencia. Esto significa que un número cada vez mayor de tipos de presas de rango inferior dentro de una dieta de forrajero indicará una escasez de recursos de alto rango (Jones, 2012, 2016).

El modelo de elección de presa (*Prey Choice Model*) a menudo se correlaciona con el proxy de tamaño corporal. En términos óptimos de forrajeo, "tipo de presa" no es necesariamente equivalente a una especie, sino que se define por retornos por unidad de tiempo de manejo (Hockett y Haws, 2002). La mayoría de zooarqueólogos utilizan el término de la movilidad de presa para clasificar a las presas (táxones lentos / rápidos) con el primero, suponiendo que este sea de mayor rango. Sin embargo, la movilidad de las presas sólo cubre un aspecto de la cantidad de tiempo que se necesita para perseguir, capturar y procesar, ya que los cazadores recolectores suelen usar la tecnología y otras innovaciones culturales para disminuir el tiempo de manipulación. , 2002, Jones, 2012, 2016, Kuhn y Stiner, 2001, Lupo y Schmitt, 2002, 2005, Soffer, 2004). Cabe señalar que el género y la edad de los forrajeros pueden afectar las futuras aplicaciones de los modelos de elección de presas, debido a un aumento significativo en la abundancia relativa de presas pequeñas en las asambleas arqueológicas, ya que podría indicar que las mujeres y los niños cazan (Stiner, 2004, Stiner y Kuhn, 2006).

En cuanto al clima y el medio ambiente en el Paleolítico Superior final, Iberia fue considerado un "refugio" durante los periodos glaciales (Gómez y Lunt, 2006, Jones, 2012, 2016, Naughton et al., 2007; Sommer y Nadachowski, 2006). Mientras que el resto de Europa permanecía con temperaturas frías, la fauna y de la flora de clima más templado se desplazan hacia el sur. Los ambientes de Iberia no eran uniformes, ni siquiera hoy. Se puede dividir en dos zonas bioclimáticas: a) la franja septentrional montañosa y las zonas adyacentes de elevación elevada denominadas zona euro-siberiana, y b) la zona mediterránea (Aura et al., 2002, 2010; García-Guixé et al. 2009, Hockett y Bicho, 2000, Straus, 2005, 2009, Straus y otros, 2002, Villaverde et al., 1996). Dado que los sitios arqueológicos discutidos en esta disertación se encuentran en el NE de Iberia, se discutirán los hallazgos en la región mediterránea.

Los paleoambientes parecen estar marcados por fuertes gradientes latitudinales con la rotación de especies de norte a sur. Investigaciones recientes sugieren que el ser humano también respondió al cambio climático a nivel regional. Teniendo en cuenta la diversidad geográfica de la Península Ibérica, todo parece indicar que la razón de este cambio de enfoque en las pequeñas presas debe ser considerada desde un punto de vista de los patrones de ocupación territorial (Aura et al., 2002a,b). Si bien las diferencias en la riqueza ambiental son a menudo utilizadas para explicar las diferencias en las asociaciones faunísticas entre regiones, hay un factor a considerar, y que es la movilidad forrajera (Aura et al., 2002a, Stiner, 2004). Este término implica que se espera un uso diferente del paisaje y la representación de los sitios dada las diferentes situaciones ambientales.

Según varios autores (Aura et al., 2002, Jones, 2012, Rillardon y Brugal, 2014) existen dos tipos de movilidad: residencial y logística. El término *movilidad residencial* se refiere a la acción de un campamento base cambiante; los sitios que reflejan este tipo de movilidad a menudo muestran conjuntos faunísticos que generalmente contienen una fauna estrecha con sólo unos pocos taxones. Mientras que los grupos que demuestran *movilidad logística* tienen poco movimiento residencial; en su lugar, es más probable que los individuos o pequeños grupos, con tareas específicas, se aventuren y regresen a un campamento residencial. Los sitios que exhiben este tipo de movilidad tienen conjuntos faunísticos más amplios.

Los datos arqueológicos muestran que, basándose en las asociaciones faunísticas, muchos sitios prehistóricos en NE Iberia muestran patrones de movilidad logística. Los conjuntos faunísticos amplios compuestos por animales de tamaño mediano y presas pequeñas, como por ejemplo mamíferos de tamaño pequeño, aves, caracoles terrestres y recursos marinos, lo comprueban. Este tipo de movilidad podría esperarse en una situación en la que los paisajes variables sean menos definidos o menos predecibles. En esta situación, los sitios estarían presumiblemente y predominantemente situados en sitios de elevación de rango medio. Dado que la movilidad de los forrajeros tiene un impacto en la varianza de la elevación del sitio, los sitios logísticos deben, teóricamente, estar situados dentro del rango del mayor número de parches. Por lo tanto, los sitios en una situación de movilidad logística estarían presumiblemente ubicados en sitios de elevación de rango medio, y se podría esperar que la varianza de elevación general sea relativamente baja, con recursos menos predecibles y movimientos poco frecuentes. Esto sugiere que los recursos están dispersos por toda la región.

Trabajos de investigación realizados por Jones (2012, 2016) muestran que los sitios situados en la región mediterránea tienen una menor varianza de elevación del sitio, lo que sugiere una distribución menos predecible de los recursos que en las regiones de alta elevación. Pero la elevación del sitio parece aumentar con el tiempo. La varianza de elevación se dobla durante el Epipaleolítico, lo que sugiere que la subsistencia de cazadores-recolectores en ese momento pasó por una reorganización importante concurrente con la variabilidad climática asociada a la transición al Holoceno.

Los lepóridos, especialmente el conejo europeo, como ya se ha dicho, son uno de los taxones dominantes entre los restos faunísticos en los sitios arqueológicos finales del Paleolítico Superior y Epipaleolítico en la Península Ibérica (Aura et al., 2002, Hockett y Haws, 2003, Jones, 2006; Lloveras et al., 2008a, 2008b, 2009a, Martínez-Polanco et al., 2016, Villaverde et al., 1996), aunque también están presentes en algunos sitios arqueológicos del Paleolítico Medio (Blasco y Fernández Peris, 2012; Cochard et al. Sanchis y Fernández Peris, 2008).

Como se discutirá con más detalle a lo largo de toda esta tesis doctoral, el conejo europeo se originó en el sur de la Península Ibérica durante el Pleistoceno medio (López-Martínez, 2008;. Pelletier et al, 2015), y quedó confinado a la zona y el sur de Francia hasta el cierre de la Pleistoceno (Callou, 2003; Nowak y Wilson, 1999;. Pelletier et al, 2015). No fue hasta los tiempos históricos, debido a la intervención humana, que las poblaciones silvestres se dispersaron por toda Europa, África y otras partes del mundo (Cochard, 2004).

Los conejos son pequeños, rápidos y requieren una inversión más enérgica para cazar con éxito; que se supone que son nutricionalmente deficiente debido a un bajo contenido de grasa e históricamente son vistos como alimento inanición. Incluso los problemas asociados con la ingesta excesiva de proteínas son conocidos coloquialmente como *"rabbit starvation syndrome"* (Harris, 1985). Debe añadirse inmediatamente; cuando los restos se consideran de origen antrópico estos son valorados como fuente de alimento menor, y en última instancia como un indicador de la escasez de alimentos para las poblaciones humanas (Davidson, 1976;. Morales et al, 1998; Villaverde y Martínez Valle, 1992). Durante mucho tiempo, en la investigación arqueológica, los restos de conejos han sido subvalorados ya que la mayor parte se consideran de poca importancia para las poblaciones humanas, suponiendo que su presencia en los conjuntos de se debe a la acumulación por depredadores no humanos (Lloveras et al., 2008a, 2009a; Martínez-Valle, 1996), también se consideraron de naturaleza intrusiva debido a la tendencia del conejo a la madriguera. Esta situación ha cambiado considerablemente en esta década. Numerosos autores (Aura et al., 2002, Bicho et al., 2000, Hockett y Bicho, 2000, Hockett y Haws, 2002, Jones, 2006, Lupo y Schmitt, 2002, Stiner, 2000, Stiner y Munro, 2002, 1999) han cuestionado la importancia de este grupo como recurso alimentario y proponen que un progreso tecnológico podría haber permitido capturar de lepóridos de una manera más fácil, lo que aumenta y regula la ingesta de proteínas en la dieta paleolítica, epipaleolítica y neolítica (Lloveras, 2011).

A pesar de que las faunas arqueológicas de la región mediterránea presentan características que no son típicas de otras regiones del suroeste de Europa, muchos autores (Aura et al., 2002, Jones, 2012, 2016, Stiner, 2004) han declarado que en términos de la *Revolución de Amplio Espectro*, la consistencia a lo largo del tiempo, tanto en la localización del sitio como en la composición de los conjuntos faunísticos, no parece apoyar tal "revolución". Las faunas de estas regiones sugirieron continuidad con algunos cambios menores en respuesta al clima.

3. OBJETIVOS DE INVESTIGACIÓN

Después de las reflexiones realizadas en el capítulo anterior, al respecto de la importancia de las pequeñas presas entre las comunidades cazadoras-recolectoras en la Prehistoria, en especial de los lepóridos, el objetivo general de esta tesis se centra precisamente en evaluar de manera específica la importancia de los lepóridos en la economía, fundamentalmente de carácter subsistencial, en las poblaciones depredadoras del nordeste de la Península Ibérica (Cataluña) durante la transición climática Pleistoceno final-Holoceno y más concretamente en las fases cronoculturales que experimentaron dicho cambio, conocidas como Epipaleolítico microlamicar (o Epimagdaleniense) y Epipaleolítico geométrico tipo Filador (o Microlaminar sauveterroide). Esta evaluación se hace mediante el estudio y e interpretación de los restos óseos de lepóridos, casi siempre conejos (*Oryctolagus cuniculus*) recuperados en tres yacimientos de la zona: Balma del Gai (Moià, provincia de Barcelona), Cova de la Guineu (Font-Rubí, provincia de Barcelona) y Abric de la Font Voltada (provincia de Tarragona). En algunos casos, estos conjuntos habían sido estudiados previamente (Nadal, 1998). Ahora el material se estudia en el marco de un nuevo protocolo de estudio arqueozoológico y tafonómico (Lloveras, 2011). En este sentido, los objetivos específicos de nuestro trabajo serán:

1. Evaluar, en primer lugar, si los conjuntos analizados han sufrido o no un sesgo post-deposicional (biostratinómico y diagenético) para poder considerarlos fiables de cara a ser analizados.
2. Del mismo modo, y en segundo lugar, discriminar si dichos conjuntos son de origen antrópico o pudieran haber sido acumulados por otros agentes, mayoritariamente otros depredadores de lepóridos: mamíferos del orden de los carnívoros y aves rapaces, tanto diurnas como nocturnas. En caso de actividad de depredadores, intentar identificar la especie a través de modelos referenciales neotafonómicos.

3. En caso de haber discriminado los conjuntos como acumulaciones de carácter fundamentalmente antrópico, dilucidar los gestos y actividades culturales que generaron la acumulación de restos de lepóridos, que pueden ser tipo general, es decir, que sean comunes a las diferentes ocupaciones estudiadas o particulares, que determinen características específicas de cada asentamiento, determinadas, por variables que inmediatamente relacionamos.

4. Valorar el uso de los lepóridos como productores de piel de calidad a través de la discriminación de señales que evidencien procesos de desollado de las carcasas.

5. Evaluar el patrón de consumo de la carne, teniendo en cuenta modelos de desmembración y descarnado a través de la representatividad anatómica, y de la localización y naturaleza de fracturas y diferentes tipos de marcas.

6. Discutir la posibilidad del consumo de los nutriente procedentes de las carcasas de manera inmediata o en diferido a través también de conservación diferencial de partes anatómicas, de modelos de fragmentación de los huesos (aprovechamiento de la médula de los huesos largos) o de descarnados o extracción de paquetes musculares en diversos estados de conservación (frescos o ya tratados i adheridos al hueso).

7. Intentar relacionar el aprovechamiento de la piel con los modelos de consumo de la carne descritos en el punto anterior, y que pudiera permitir determinar el objetivo principal de la adquisición de los lepóridos.

8. Intentar determinar otros usos: aprovechamiento de tendones, hueso para la fabricación de útiles, etc..
9. Detectar el uso del fuego para el tratamiento culinario de las carcasas o para la eliminación de restos no consumidos, mediante la caracterización de la termo-alteración sobre los restos óseos a través de técnicas que superen la clásica discriminación a través del color de las superficies, evitando así los sesgos producidos por la pigmentación natural del sedimento.

10. Hacer una aproximación de las técnicas cinegéticas aplicadas a pequeñas presas para esta cronología, según la importancia cuantitativa de las mismas e intentar inferir estrategias de caza (masiva, oportunista, colectiva, estacional, etc.) que pueden variar según los asentamientos.
11. A partir de la premisa anterior, y con otros datos anteriores (intensidad de la transformación de las carcasas, recursos aprovechados), extrapolar modelos

ocupacionales para cada yacimiento (estacionalidad, campamentos base, campamentos logísticos, etc.)a través de los restos de lepóridos.

12. Finalmente, contrastar los resultados coincidentes de los yacimientos estudiados con los datos procedentes de otros yacimientos de la península o del mediodía francés, en especial los situados en la cuenca mediterránea, o en entornos de clima mediterráneo-continental, en fases inmediatamente próximas (Paleolítico superior), con el fin de observar semejanzas y diferencias y así establecer un modelo general de aprovechamiento de los lepóridos entre las comunidades cazadoras-recolectoras de humanos anatómicamente modernos a finales del Pleistoceno e inicios del Holoceno en la cuenca mediterránea de la Península ibérica.

4. DISCUSIÓN Y CONCLUSIÓN GENERAL

En esta sección pretendemos abordar diferentes temas con el objetivo de caracterizar los conjuntos de lepóridos de Balma del Gai, Cova de la Guineu y Font Voltada, con el fin de definir las principales características de la explotación de los pequeñas presas durante este período. Los datos se han colocado dentro de su propio contexto cronológico y geográfico. Primero, se hace una comparación entre los resultados obtenidos en los tres conjuntos para establecer, y definir similitudes y diferencias. En segundo lugar, para caracterizar la evolución y tendencias de las estrategias, y decisiones en cuanto a la adquisición de recursos por grupos de cazadores-recolectores, comparamos nuestros resultados con otras secuencias publicadas de la Cuenca Mediterránea, prestando especial atención en la explotación de los lepóridos. Por último, comparamos nuestros resultados con datos proporcionados por otros sitios del Paleolítico Superior en Europa Occidental y del Sur.

Durante la transición del Pleistoceno y el Holoceno en Europa occidental y meridional, se producen cambios en las estrategias de subsistencia, caracterizados por una ampliación de la dieta y una explotación intensificada de pequeñas presas (Aura et al 2002, Hockett y Haws, 2002, Jones, 2006; Pérez-Ripoll, 2001, Sanchis, 2010, Stiner y Munro, 2002, Villaverde et al., 1996). Estos cambios pueden explicarse por una combinación de varios parámetros, por ejemplo: condiciones ambientales (clima, abundancia y dispersión de recursos) y factores humanos (tecnológicos, sociales, demográficos y culturales). Esta explotación intensificada de las pequeñas presas se evidencia a través de las grandes cantidades de restos lepórídos, especialmente el conejo europeo (*Oryctolagus cuniculus*), en sitios arqueológicos de este período (Fa et al., 2013). En el área mediterránea de la Península Ibérica se confirma la presencia de acumulaciones de lepóridos de origen antrópico desde el inicio del Paleolítico Superior, aunque varios estudios demuestran la explotación de conejos en sitios antiguos (Blasco, 2008; Sanchis Serra y Fernández Peris, 2008).

La explotación del conejo europeo en la Península Ibérica, es un dato clave para comprender algunos comportamientos humanos, como la movilidad de grupos, la estacionalidad de los campamentos y las estrategias de amplio espectro, entre los grupos prehistóricos de cazadores y recolectores. Es uno de los taxones más dominantes entre los restos faunísticos en los yacimientos arqueológicos del Paleolítico Superior y Epipaleolítico de la Península Ibérica. Sin embargo, los conejos son considerados la presa favorita entre un gran número de depredadores no-humanos en Iberia. Las firmas tafonómicas en restos de conejo que quedan durante el consumo por diferentes depredadores son útiles marcadores para determinar si un conjunto de lepóridos es o no el resultado de la actividad humana.

4.1. ACUMULACIONES DE LEPÓRIDOS DURANTE EL EPIPALEOLÍTICO EN EL NORDESTE DE IBERIA: NUESTRA MUESTRA ARQUEOLÓGICA.

Durante el Epipaleolítico se registran diferentes modelos de movilidad y subsistencia. Como ya se comentó en el capítulo 1, se perciben dos tipos de movilidad: residencial y logística. Mientras que la movilidad residencial se refiere a la acción de un campamento base cambiante que se caracteriza por conjuntos que generalmente contienen una fauna estrecha con sólo unos pocos taxones, los grupos que muestran movilidad logística hacen que los movimientos residenciales con menos frecuencia con individuos o pequeños grupos específicos se aventuren y regresen a un campamento residencial, caracterizado por conjuntos faunísticos más amplios (Aura et al., 2002, Jones, 2012, Rillardon y Brugal, 2014).

A los patrones de movilidad debemos añadir estrategias de subsistencia; según Saña (2013), se han propuesto tres modelos o estrategias para explicar, en algún modo, los cambios económicos y sociales que tuvieron lugar durante la transición Pleistoceno-Holoceno. La primera estrategia se basa en la obtención del conejo europeo, con la mayoría de los sitios arqueológicos que exhibiendo más del 90% del número total de restos. Una segunda estrategia se basa en la obtención de cabra salvaje (*Capra pyrenaica*), mientras que una tercera estrategia se basa principalmente en la caza de ungulados. Además, las diferencias regionales en las estrategias de caza son evidentes; mientras que en el valle del Ebro y en el norte de Iberia los sitios parecen estar centrados en una cacería generalizada de cérvidos y jabalíes, los sitios en la región oriental están vinculados a la caza de conejos, mientras que los sitios en la parte central del Levante Peninsular están asociados con la caza del Ibex.

Vemos que una estrategia enfocada en la caza de conejos se refleja en las muestras arqueológicas discutidas en esta tesis doctoral (Figura 11.1). Nuestros datos también muestran que, a partir de los conjuntos faunísticos, los tres sitios arqueológicos aquí discutidos muestran patrones de movilidad logística, ya que presentan amplias acumulaciones faunísticas, compuestas en su mayoría por presas pequeñas como mamíferos de tamaño pequeño, aves, caracoles terrestres y recursos acuáticos. Mientras que en la Balma del Gai el número elevado de restos de lepóridos comprende el 95% del número mínimo de individuos en el conjunto de la fauna, seguido de ciervo rojo (*Cervus elaphus*), jabalí (*Sus scrofa*) y pequeños bovinos, como la rebeco (*Rupicapra Rupicapra*) y la cabra salvaje (*Capra pyrenaica*), la fauna de la Cova de la Guineu, también caracterizada por un gran número de restos de conejo, representa más del 90% del número de ejemplares identificados. Si se excluyen todos los restos de conejo, los caracoles terrestres también son abundantes; y los ungulados tales como ciervos rojos, cabra salvaje, rebeco y cabra salvaje también fueron registrados. En el caso de Font Voltada, la importancia de los restos lepóridos es abrumadora y representa más del 95% de los restos recuperados, seguido por menores porcentajes de cabra salvaje, ciervo rojo y jabalí. En principio, podemos observar un patrón de explotación masiva de los lepóridos, seguido de una explotación mixta de otras dos especies, ya sea de cabra salvaje o ciervo, y de otros taxones menores. Los restos faunísticos de origen antrópico son el resultado de una serie de decisiones económicas y estratégicas, y aunque se encontró un gran número de restos recuperados en Balma del Gai, Cova de la Guineu y Font Voltada entre otros restos faunísticos, la especie *Oryctolagus cuniculus* sigue siendo el taxón predominante en los tres sitios, superando el 90% (Nadal, 1998).

Los resultados obtenidos en los sitios de Balma del Gai, Cova de la Guineu y Font Voltada, más específicamente el perfil de representación anatómica, los patrones de fragmentación, la presencia de marcas de corte y huesos termo-alterados, muestran que las acumulaciones de lepóridos en los tres yacimientos son de origen antrópico. Sin embargo, los resultados del análisis tafonómico en comparación con los datos obtenidos de estudios realistas sobre otros tres grupos potenciales de agentes acumuladores (pequeños carnívoros terrestres, rapaces diurnos y nocturnos) también muestran la posibilidad de un acumulador secundario no humano en los tres sitios arqueológicos. Unos cuantos números de restos que presentan daños en la digestión y la presencia de algunos pequeños pinchazos, hoyos y marcas de puntuación sugieren una acción de pequeños carnívoros terrestres en todos los casos, que a pesar de ser una contribución minoritaria, debe ser tenido en cuenta.

De acuerdo con los resultados obtenidos a partir del análisis tafonómico de las acumulaciones de lepóridos de los niveles epipaleolíticos de Balma del Gai, Cova de la Guineu y Font Voltada, los seres humanos prehistóricos parecen ser los acumuladores primarios en los tres sitios. La frecuencia de los individuos adultos, el perfil de representación anatómica, los patrones de fragmentación (alta fragmentación de los restos normalmente realizados en hueso fresco), la presencia de marcas de corte y restos termo-alterados muestran que estas acumulaciones en los tres sitios parecen corroborar este hecho. Sin embargo, a pesar del origen antrópico de las tres acumulaciones, también se documentan contribuciones no humanas. Unos cuantos números de restos que presentan daños en la digestión y la presencia de algunos pequeños pinchazos, hoyos y marcas de puntuación sugieren una acción de pequeños carnívoros terrestres en todos los casos, que a pesar de ser una contribución puntual, debe tenerse en cuenta.

La frecuencia de individuos adultos de nuestras tres muestras se sitúa entre 82.6 – 96.3% (Tabla 11.1). Estos resultados son similares a los obtenidos a partir del análisis de conjuntos de lepóridos arqueológicos de diferentes áreas geográficas, donde el alto porcentaje de restos adultos está asociado con la adquisición de recursos humanos

(Brugal, 2006; Cochard, 2004; Guennouni, 2001; Hockett, 1991; Y Bicho, 2000, Martínez-Valle, 1996, Lloveras y otros, 2016, Rillardon y Brugal, 2014, Sanchis Serra y Fernández Peris, 2008). Las acumulaciones antrópicas se caracterizan por más del 80% de los individuos adultos, aunque se han registrado porcentajes más bajos, alrededor del 50-60% (Martínez-Valle, 1996; Sanchis Serra y Fernández Peris, 2008). El alto porcentaje de individuos adultos en las tres muestras nos proporciona información sobre estrategias de adquisición, por ejemplo, la posibilidad de una recolección masiva de conejos. Aunque Jones (2006) sostiene que las estrategias de recolección masiva de una madriguera cercana se evidencian por un número predominante de hembras y individuos jóvenes dentro de un conjunto faunístico, datos que no están disponibles para ninguna de nuestras muestras, otros autores como Cochard et al. (2012) sugiere que la ausencia de individuos juveniles se deba posiblemente a la falta de interés en individuos tan pequeños o porque no están disponibles en una temporada específica. A esto también hay que añadir la conservación diferencial de los elementos óseos pequeños debido a procesos diagenéticos y la conservación de elementos esqueléticos propensos a la fragmentación, que pueden ocultar los patrones de recolección de masa. Además, una presencia marcada de lepóridos en el sitio, al menos con un número mínimo de individuos, entre 84 y 195 en Cova de la Guineu y Balma del Gai (en sólo 1 unidad cuadrada), respectivamente, sugiere el posible uso de algún tipo de tecnología o técnicas que permite la adquisición de una gran cantidad de este tipo de presa, como redes, trampas, etc (Bean, 1972, Lupo and Schmitt, 2005, Nelson, 1973). Teniendo en cuenta que los conjuntos faunísticos que son ricos en restos lepóridos suelen estar relacionados con ocupaciones a largo plazo y, en última instancia, implican cambios en la organización socioeconómica de los grupos cazadores-recolectores durante el Paleolítico Superior, algunos han argumentado que la mayoría de estos cambios puede estar relacionado con la innovación tecnológica, pero no hay que olvidar que la disponibilidad de presas, así como la funcionalidad del sitio y las condiciones ambientales del territorio, influirán en el espectro taxonómico del conjunto faunístico. En este caso, la abundancia de conejos se debe a sus altas tasas de reproducción y flexibilidad ecológica que les permite adaptarse a las nuevas condiciones climáticas durante la transición Pleistoceno-Holoceno, promoviendo su expansión a otras áreas de Iberia con condiciones geográficas y climáticas estables que permitirían su exitoso desarrollo.

Con respecto al perfil de representación anatómica y los patrones de fragmentación, nuestro análisis apunta a la aparición de esqueletos enteros en las tres muestras, lo que significa que no hay evidencia de transporte diferencial de ninguna parte de las carcasas de conejo (Tabla 11.2), todas mostrando valores más altos de elementos del cráneo, especialmente mandíbulas y dientes, escápulas y huesos largos; el perfil de abundancia relativa de los tres conjuntos no difiere significativamente. Los valores obtenidos en el análisis de las tres muestras son bastante cercanos al perfil anatómico esperado para una acumulación antrópica (Brugal, 2006; Cochard, 2004; Guennouni, 2001; Hockett, 1991; Hockett and Haws, 2002). Además, debe tenerse en cuenta que en las tres muestras se observa una pérdida de elementos pequeños de las extremidades distales: en Cova de la Guineu y Font Voltada esta pérdida refleja en última instancia una recuperación diferencial en el campo como consecuencia de la estrategia de tamizado utilizada, Mientras que en Balma del Gai los elementos pequeños (carpales / tarsales, falanges y sobre todo fragmentos de costillas y vertebras) recuperados durante el tamizado en húmedo del material a través de mallas de 0.5 mm han sido mezclados con el material de <5 mm.

La fragmentación intencional de los huesos largos con el objetivo de extraer nutrientes y grasas adicionales deja ciertos patrones en el registro arqueológico. Dado que esta actividad requiere la eliminación o incluso el aplastamiento total de la epífisis de las diáfisis de los huesos largos para extraer la médula, a menudo vemos patrones caracterizados por altos porcentajes de cilindros diafisarios y epífisis que muestran las características morfológicas de fracturas frescas. Datos del conjunto de lepóridos de Balma del Gai indican que se recuperaron 379 cilindros diafisarios y un total de 1127 epífisis proximales y distales de fémures, tibias y húmeros. En Cova de la Guineu, se registraron 294 cilindros y un total de 131 epífisis, mientras que en Font Voltada se recuperaron 84 cilindros y 226 epífisis. El porcentaje de fracturas frescas en los tres sitios es bastante alto, la mayoría de ellos concentrados en los extremos proximal y distal de los huesos largos. A juzgar por el porcentaje de lepóridos se mantiene por debajo de los 10 mm, el conjunto de Font Voltada parece estar más fragmentado que las otras dos muestras (Tabla 11.2), lo que nos lleva a pensar en un consumo inmediato de carne y en la fractura intencional de huesos largos destinados a obtener la médula; el gran número de cilindros diafisarios y el porcentaje de huesos completos en Balma del Gai y Cova de la Guineu sugiere la posibilidad de otras actividades de adquisición enfocadas en la extracción de carne para su eventual conservación y / o conservación directa de carne en hueso. Sin embargo, también se documenta el consumo directo de las carcasas. En general, estos resultados son consistentes con las características definidas para los ensamblajes producidos por los seres humanos (Cochard, 2004a; Hockett, 1991; Hockett and Bicho, 2000; Lloveras et al. 2009a; Pérez Ripoll, 2004, 2005).

En cuanto a otras alteraciones en la superficie del hueso, las marcas de corte debido a las diferentes actividades de carnicería y los huesos termo-alterados podrían sugerir actividad inducida por los seres humanos. Las marcas de corte, según su ubicación y orientación anatómicas, se pueden clasificar en diversas actividades que se practican durante el procesamiento de las carcasa de conejo: desollado, desarticulación, descarnado y raspado. Vemos evidencia de las tres actividades involucradas en el procesamiento de las carcasas de conejo (desollado, desarticulación y descarnado) dentro de nuestras muestras. Además, un estudio previo llevado a cabo en Balma del Gai (Nadal, 1998) planteó la posibilidad de utilizar técnicas de conservación de la carne, ya que fácilmente generarían un mayor porcentaje de marcas en el hueso. La proporción de marcas de corte, aunque puede parecer baja en las tres muestras puede encajar con este tipo de actividad.

Nuestro estudio experimental sobre la identificación de las diferentes actividades de sacrificio (véase el capítulo 5) muestra que el descarnado, el raspado y la eliminación de tendones pueden de hecho dejar marcas características que variaron en frecuencia, ubicación, orientación e intensidad, y que el número y tipo de marcas producidas durante tales actividades varían claramente dependiendo de la condición de la carne (fresca, seca, cocinada). En Balma del Gai, el 1.2% de los restos muestran marcas de corte (Tabla 11.1.); la presencia de marcas de corte situadas en las mandíbulas (parte incisiva, cuerpo mandibular + parte incisiva y diastema), cráneo (arco cigomático y neurocráneo), calcáneo, metacarpianos, metatarsianos y 1/2 falanges), indica que la piel del animal se extraía en una sola pieza, lo que indica su uso posterior para otras posibles funciones, por ejemplo, la ropa y como contenedores. Los signos de desarticulación de las canales están implícitos en las pocas marcas de corte que se encuentran en los intestinos, las escápulas y los extremos proximal y distal de los huesos largos. Las marcas de descarnado son las más abundantes y localizadas sobre todo en las pelvis y diáfisis de los huesos largos.

En el caso de Cova de la Guineu, como en Balma del Gai, la correcta identificación de las marcas de corte podría haber estado nublada por otras alteraciones superficiales, por ejemplo bioerosión por microorganismos, manchas de óxido de manganeso, disolución y marcas de roedores, sin mencionar sedimento endurecido y adherido a la superficie del hueso. En general, las marcas de carnicería sugieren actividades similares a las detectadas en Balma del Gai: un aprovechamiento de las pieles de conejo y el fileteado de los paquetes musculares, destinados a secar para prolongar su consumo, pero en menor proporción. Aunque, una vez más debemos enfatizar el asunto que la identificación apropiada de las marcas del corte pudo haber sido enmascarada por la otra alteración superficial del hueso, y de esa manera alterar los resultados verdaderos y las interpretaciones culturales.

En cuanto a la Font Voltada, las pocas marcas de corte ubicadas en una mandíbula (incisiva), metatarsianos y calcáneo apuntan a la actividad de desollado. Los signos de desarticulación de las carcasas están implícitos en la presencia de unas pocas marcas de corte en los extremos distal de los huesos largos (tibia y cúbito) y pelvis (isquión). Sólo uno de los restos muestra incisiones asociadas al proceso de descarnado. En el caso de Font Voltada, el bajo porcentaje de marcas de corte y el conjunto altamente fragmentado no apoyan la hipótesis de técnicas de conservación de la carne dentro del sitio, sino que apoya la idea de que el consumo directo de los carcasas de conejos estaba teniendo lugar en el sitio.

Continuando con el tema de las alteraciones en la superficie del hueso, los huesos pueden sufrir alteraciones importantes cuando se exponen a una fuente de calor, afectando su color, textura superficial y estabilidad estructural, que se utilizan frecuentemente para estimar la temperatura de calentamiento a la que se expusieron las muestras arqueológicas. Sin embargo, debe tener en cuenta que otros procesos tafonómicos pueden afectar a estas variables durante el entierro. Como ya se ha explicado en capítulos anteriores, las termo-alteraciones en los restos de la fauna pueden ser indicativas del uso del fuego en diferentes actividades, ya que pueden ser quemadas como resultado de prácticas de cocina, como combustible o quemadas inadvertidamente por un incendio generado cerca. Debe considerarse que, además de ayudar en el proceso de digestión y reduciendo la ingesta de microorganismos nocivos, las prácticas culinarias permiten la manipulación de las carcasas enteras, que de alguna manera pueden terminar influyendo en su cadena de procesamiento y su posterior consumo. Por ejemplo, como evidencia en nuestro estudio experimental (capítulo 5), las carcasas cocidas o rostizadas facilitan el proceso de desarticulación, por la misma razón la carne se puede extraer fácilmente del hueso sin la ayuda de herramientas contrario a extraer la carne cruda o carne seca adherida al hueso. Esto explicaría el bajo número de marcas de corte observadas en Font Voltada. Además, como ya se ha mencionado, el fuego no sólo afecta al color y la textura del hueso, sino también a su estructura, provocando una pérdida de componente orgánico que eventualmente permitirá el encogimiento y las grietas en la superficie ósea, sin mencionar el aumento del tamaño de los cristales de hidroxiapatita a nivel atómico (Shipman et al., 1984b; Surovell and Stiner, 2001; Stiner et al., 1995; Weiner, 2010). En cuanto a la identificación adecuada de los huesos quemados en nuestras muestras, al principio se consideró para el yacimiento de la Cova de la Guineu una muestra de 363 restos óseos (5.4%). Después de comparar el índice de cristalinidad (*Splitting Factor*) de la muestra arqueológica, ya que no estaba claro que estos restos estuvieran realmente quemados, sólo se consideraron un número mínimo de 63 restos pertenecientes a las categorías de daño extremo (tonalidades grises) y calcinados (blancas); esto nos deja con el 0.9% de restos quemados. Lo mismo ocurrió en Font Voltada, donde sólo se consideraron los restantes 602 restos como el número mínimo de restos quemados, pertenecientes a las tonalidades fuertes (tonalidades marrones), extremas (tonalidades grises) y calcinadas (blancas); esto nos deja con el 22.5% de los restos quemados. La acumulación de lepóridos de la Font Voltada es la más fragmentada de las tres muestras, y el que tiene el porcentaje más elevado de restos quemados. En algún momento no está claro si el alto nivel de fragmentación dentro de este conjunto es debido a una fragmentación intencional dirigida a la extracción de médula de los huesos largos o si es debido a daño causado por el lanzamiento intencional de los restos a un hogar, por razones de limpieza, o por estar muy cerca de los hogares. De cualquier manera, la muestra de restos quemados se considera de origen antrópico.

En resumen, como se ha descrito anteriormente, el modelo propuesto para la explotación intensiva de pequeñas presas, en particular los lepóridos, por grupos de cazadores-recolectores en las etapas finales del Paleolítico Superior y las primeras etapas del Holoceno en la región del Mediterráneo Ibérico se basa en un patrón de movilidad logística y ocupaciones estacionales. La estrategia de subsistencia se basa en la obtención de caza de conejos complementada por caza centrada en especies de tamaño mediano con limitada movilidad migratoria (venado y cabra salvaje) y la inclusión de otros pequeños mamíferos, aves, caracoles y recursos acuáticos (en algunos casos). Además, es muy común encontrar acumulaciones de un carácter natural aportadas por otros depredadores no humanos en las asambleas faunísticas que datan de este período.

En nuestra muestra arqueológica, la densidad de restos de conejos y los patrones de fragmentación sugieren dos tipos de ocupación con diferentes funcionalidades. En primer lugar, una ocupación intensiva (Balma del Gai y Cova de la Guineu), posiblemente centrada en la recolección masiva de conejos, evidenciada por: a) la presencia de marcas de corte correspondientes a diferentes actividades de carnicería (desollado, desarticulación y descarnado) y que (debido a la localización) también sugiere una conservación de la carne y el procesamiento de la piel de conejo, y b) patrones de fragmentación, con altos porcentajes de cilindros de huesos largos y fragmentos de epífisis, apunta a la extracción de médula, actividad que habría agregado un aumento sustancial de nutrientes y calorías a su dieta. En segundo lugar, una ocupación menos intensa o puntual, en el caso de Font Voltada, apuntaba al consumo directo (*in situ*) de los conejos, evidenciado por: a) muy pocas marcas de corte correspondientes a diferentes actividades de carnicería (desollado y desarticulación), b) elementos <10 mm (43%), lo que revela un conjunto muy fragmentado, también apunta a la extracción de la médula ósea, y c) un alto porcentaje de huesos quemados sugiere un consumo directo de las carcasas por grupos humanos y posiblemente desechando cualquier restos óseos al fuego abierto para mantener la zona limpia.

11.2. LA EXPLOTACIÓN DE LEPÓRIDOS DURANTE LA TRANSICIÓN PLEISTOCENO-HOLOCENO EN LA CUENCA MEDITERRÁNEA IBÉRICA.

En la región catalana se pueden encontrar otros sitios del mismo período y con las mismas características (en cuanto a la relación entre la representación del conejo con respecto a otros taxones disponibles en cada conjunto), por ejemplo Cova del Bolet (Nadal y Estrada 2007), Balma De la Griera (Nadal, 1998), Cova del Parco (Fullola et al., 2006), Abric del Filador (García-Argüelles et al., 2005), Picamoixos (García et al., 1996); Sin embargo, la comparación de datos entre éstas y nuestras muestras arqueológicas puede ser algo complicada. Esto se debe a la falta de datos tafonómicos sobre las acumulaciones de lepóridos, al reducido número de restos determinables (en comparación con el número de restos analizados en nuestras muestras) y una cierta ausencia de dataciones de radiocarbono. Consideramos que la mayoría de los sitios no pueden ser contrastables a nivel metodológico; por lo tanto, no hay información confiable sobre las acumulaciones de lepóridos para estos yacimientos.

Hasta la fecha, el único conjunto de lepóridos comparable proviene de los niveles del Paleolítico Superior final (Magdaleniense) y Epimagdaleniense de Molí del Sal (Vimbodí, Cataluña) (Vaquero, 2004; Martínez-Polanco et al., 2016; Rufà, 2017). Este sitio se encuentra en NE de Iberia a unos 40 km de Tarragona, a 490 m sobre el nivel del mar, entre la Cordillera Pre-litoral Catalana y la Depresión Central Catalana. La secuencia estratigráfica se compone de un paquete de 2.5 m de espesor que contiene una unidad Mesolítica (Nivel Sup) y las capas del Paleolítico Superior final (Unidades A y B) del Epimagdaleniense y del Magdaleniense final. El nivel Sup está datado entre 9,110 - 8,717 cal BP, la Sub-unidad A Sup entre 13,130 - 12,690 cal BP, y Sub unidad A entre 14,120 - 12,695 cal BP (García-Diez and Vaquero, 2015; Vaquero, 2004). A diferencia de nuestras muestras arqueológicas, Molí del Salt presenta una secuencia estratigráfica que va desde el Paleolítico Superior hasta el Mesolítico, factor que facilita la evaluación de la explotación de presas pequeñas durante la transición Pleistoceno - Holoceno. En nuestra evaluación de los resultados presentados por Rufà et al (2017), sólo centraremos nuestro interés en las acumulaciones de lepóridos del Magdaleniense final y Epimagdalenienses.

El conjunto de lepóridos de la Sub-unidad A (Magdaleniense final) muestra un predominio de restos de *Oryctolagus cuniculus* (NDR = 15.915) que comprenden el 97.1% de la fauna y una frecuencia de individuos adultos del 96.7% (Rufà et al., 2017). Estos resultados son similares a los obtenidos para nuestras muestras (Balma del Gai, Cova de la Guineu y Font Voltada) y del análisis de conjuntos de lepóridos arqueológicos de diferentes áreas geográficas, donde el alto porcentaje de restos adultos está asociado con la adquisición de recursos humanos (Brugal, 2006; Cochard, 2004a; Guennouni, 2001; Hockett, 1991; Hockett and Bicho, 2000; Martínez-Valle, 1996; Lloveras et al., 2016; Rillardon and Brugal, 2014; Sanchis Serra and Fernández Peris, 2008). El alto porcentaje de restos de conejo es seguido por menores porcentajes de restos de ciervo (*Cervus elaphus*), cabra salvaje (*Capra pyrenaica*), jabalí (*Sus scrofa*), corzo (*Capreolus capreolus*) y pequeños carnívoros terrestres. Se registraron 1.5% de marcas de corte y un 30.5% de restos quemados. Los valores de abundancia relativa muestran que las mandíbulas y los huesos largos, como las tibias y los femurs, fueron los más abundantes. Los huesos largos (tibias, fémures y húmeros) muestran una fragmentación significativa, que incluye altas proporciones de cilindros diafisarios. El daño por digestión se registró en el 0.03% de los restos. En cuanto a la presencia de marcas de punción causadas por pico / dientes por depredadores, el 1.4% muestra este tipo de modificaciones (Tabla 11.3a), presentando un agente acumulador minoritario.

El nivel A^{sup} (Epimagdaleniense) muestra un predominio de restos de *Oryctolagus cuniculus* (NDR = 3752) que comprenden el 98.3% de la fauna y una frecuencia de individuos adultos del 96.7% (Rufà et al., 2017). También se atribuye a una estrategia basada en la adquisición del conejo europeo. El alto porcentaje de restos de conejo es seguido por porcentajes más bajos de ciervo (*Cervus elaphus*), cabra salvaje (*Capra pyrenaica*), pequeños carnívoros terrestres, jabalí (*Sus scrofa*) y corzo (*Capreolus capreolus*). Se identificó un 1.2% de las marcas de corte y un 23.5% de los restos quemados. Los valores de abundancia relativa muestran que las mandíbulas y los huesos largos como las tibias y los fémures fueron los más abundantes. Al igual que en el nivel A, los huesos largos (especialmente las tibias, los fémures y el húmeros) muestran una fragmentación significativa, que incluye altas proporciones de los cilindros diafisarios. En relación a la presencia de marcas de punción causadas por pico / dientes, el 0.9% muestra este tipo de modificaciones, presentando un agente acumulador menor (Tabla 11.3a).

Una de las cosas que observamos es un aumento exponencial de los restos de lepóridos en los niveles del Paleolítico Superior, especialmente en el Magdaleniense final. En referencia a la Tabla 1 de Rufà et al (2017), se puede observar un aumento de los restos lepóridos de las unidades B1 y B2 (NIPS = 2,523) a la unidad A (NISP = 15,915) correspondiente al Magdaleniense final, seguido de una disminución de restos en el nivel A^{sup} (NISP = 3,732), que corresponde al Epimagdaleniense, hasta el nivel Sup (NISP = 457) correspondiente al Mesolítico. Además, considerando todo el conjunto faunístico, vemos que aunque hay un porcentaje creciente de restos de *Oryctolagus cuniculus*, superando el 90% de los restos recuperados, también podemos encontrar otros taxones, aunque en menor cantidad, de presas de tamaño mediano. Estos resultados están de acuerdo con los resultados obtenidos para otros sitios arqueológicos de la misma cronología en Iberia, todos los cuales serán discutidos a lo largo del desarrollo de esta sección, en la que vemos una estrategia de subsistencia basada en la explotación lepóridos seguida de la caza de ungulados de talla mediana.

En general, como en nuestra muestra arqueológica, el porcentaje de individuos adultos, los patrones de fragmentación (% de cilindros diafisarios y % de elementos completos), el porcentaje de marcas de corte y el porcentaje de marcas por termo-alteración apunta a una adquisición antrópica de conejos. Los valores bajos de daño de la digestión y las marcas de los dientes ciertamente corresponden a una contribución menor de los restos no ingeridos acumulados por los pequeños carnívoros terrestres (ya que están documentados en todo el conjunto faunístico), mientras que las carcasas completamente articuladas que han sido registradas posiblemente han resultado como consecuencia de la muerte natural. El porcentaje bajo, pero no atípico, de las marcas de corte es indicativo de actividades de carnicería, tales como desollado, desarticulación y descarnado. Además, las marcas de corte de descarnado, con una orientación longitudinal, apunta al descarnado de la carne cruda. Otra modificación importante es el alto porcentaje de restos quemados y también un alto porcentaje de fragmentos de epífisis y cilindros diafisarios que apuntan al consumo directo de carne ya la extracción de médula ósea y grasa. El número excesivamente elevado de restos quemados explicaría un porcentaje tan bajo de marcas de corte, ya que las carcasas cocidas o rostizadas permitirían un proceso de desarticulación y descarnado más eficiente. Además, esta técnica de cocción podría explicar los altos valores de fragmentación, ya que ayudará en la extracción de médula ósea. Los resultados obtenidos para Molí del Salt son bastante consistentes con los obtenidos en Font Voltada, con el objetivo de un posible consumo *in situ* de los conejos. El porcentaje de fracturas frescas y patrones de fragmentación apunta a la extracción de médula ósea, mientras que un alto porcentaje de huesos quemados sugiere un consumo directo de las carcasas por grupos humanos.

La existencia de yacimientos arqueológicos bien estudiados a lo largo del territorio valenciano y la presencia de explotación de lepóridos, desde el Paleolítico Superior final (Magdaleniense) hasta el Epipaleolítico, se detallan en varias obras (Aura et al., 2002, Morales, 2015, Pérez Ripoll y Martínez Valle, 2001). A pesar de no llegar a una serie de restos determinables parecidos a los de nuestra muestra, estos sitios se consideran importantes, permitiéndonos trazar y establecer la evolución de la presencia de estos taxones dentro de estas secuencias arqueológicas y definir la estrategia de subsistencia más frecuente.

En cuanto a la relación entre la representación del conejo con respecto a otros taxones disponibles en cada conjunto, existe un patrón de aumento en el número de restos lepóridos durante la transición del Magdaleniense final al Epipaleolítico en la mayoría de los sitios (Cacho et al., 1995; Morales, 2015). Por ejemplo, como en el caso del Molí del Salt (Vimbodí, Tarragona), en el perfil interior de Tossal de la Roca (Vall d'Alcalà, Alicante) se observa un claro incremento en la obtención de conejos desde el Magdaleniense. Los datos extraídos de Cacho et al. (1995) muestran que el número total de *Oryctolagus cuniculus* permanece en el nivel IV (Magdaleniense superior, 15.360 ± 1.100 BP), es igual a 679. En otros niveles, III y II (Paleolítico Superior final, 12.480 ± 210 y 12.390 ± 250 BP) Hay una disminución en los números (603 y 279 respectivamente), y aumentando de nuevo en el nivel I (Epipaleolítico) con un total de 1.210 restos. En el perfil exterior, el conejo permanece en el nivel IIb, correspondiente al Epipaleolítico, que en términos de cronología puede considerarse mesolítico (9.150 ± 100 y 8.530 ± 90 BP), y el nivel IIa (8. 350 y 8.050 ± 120 BP) se reduce a un Total de 8 y 244, respectivamente. En todos los niveles del perfil interior, el alto porcentaje de restos de conejo es seguido por menores porcentajes de cabra salvaje y ciervo (nivel IV), y la aparición de la cabra salvaje en niveles III y rebeco en el nivel II (Tabla 11.3a).

La misma situación se da en las Coves de Santa Maira, donde el porcentaje de restos lepóridos aumenta o disminuye según las diferentes fases culturales. En el nivel Magdaleniense (SM-5), los restos de lepóridos representan el 83.4% de los restos determinables, mientras que las proporciones de cabra salvaje se estiman en 15.6% y en otros taxones minoritarios en 0.8%. En el Microlaminar Epipaléolítico o Epimagdaleniense (SM-4.2), 13.840 – 13.080 cal PB, el porcentaje de restos de lepóridos oscila entre 95.9% - 79.3% en las capas 14 y 19 respectivamente, con un total de 84.6% de restos determinables, mientras que los restos de cabras salvajes se estiman en un 14.8%. El porcentaje total de restos de lepóridos en el Epipaleolítico Geométrico o Sauveterroide (SM-4.1), 10.200 – 11.270 cal BP, es del 78.3%, pero oscila entre 94.7 – 61.5% entre capas. Teniendo en cuenta los otros taxones disponibles, el porcentaje de restos de cabra salvaje es del 18.1%, mientras que los taxones minoritarios representan el 3.6%. Estos niveles muestran un alto número de restos pertenecientes a individuos adultos (Brugal, 2006; Cochard, 2004a; Guennouni, 2001; Hockett, 1991; Hockett and Bicho, 2000; Martínez-Valle, 1996; Lloveras et al., 2016; Rillardon and Brugal, 2014; Sanchis Serra and Fernández Peris, 2008). Las Coves de Santa Maira es uno de los pocos sitios que tienen un estudio tafonómico de restos de lepóridos, aunque el análisis está más centrado en el estudio global del conjunto faunístico. Según Morales (2015), 27.6% de los restos de lepóridos (SM-5) están quemados y la alta incidencia de marcas de corte en elementos del zigopodio se relaciona con la extracción de paquetes musculares. También la considerable presencia de escápulas, húmeros y fémures en el nivel Magdaleniense sugiere una mayor importancia de la actividad de descarnado durante este período que durante el Epipaleolítico (Tabla 11.3b), tal vez para fines de conservación de la carne, pero no se puede descartar el consumo directo de la carcasas, ya que se registraron altos valores de restos termo-alterados.

Otro yacimiento con el mismo aumento característico en los porcentajes de restos de conejo en comparación con otros taxones, y con la existencia de un estudio tafonómico actualizado de restos lepóridos, es Cova Fosca (Ares de Maestrat, Castellón). Este sitio tiene una secuencia que abarca el Epipaleolítico (11.154 – 10.740 cal BP) hasta el período Neolítico Medio, siendo el número de restos de los especímenes identificados de lepóridos los que representan la mitad de la muestra de mamíferos (Llorente, 2015). Según Estevez (1981), el conjunto faunístico está dominado, en todos los niveles, por los restos de conejo, seguidos de la cabra salvaje y el ciervo. Los datos extraídos de Llorente (2015) muestran que efectivamente los taxones de lagomorfos dominaron el conjunto faunístico Epipaleolítico en el 61.7%, seguidos por los micro-mamíferos (29%), los ungulados de talla mediana (5.3%) y los bovinos indeterminados (3.2%), mientras que el 70% de los restos de conejo se clasificaron como adultos. Con respecto al análisis tafonómico, el 3% de los restos estaban completos, sin embargo, hay evidencias de fragmentación significativa, que incluye altas proporciones de cilindros diafisarios (50%) durante el período Epipaleolítico y disminuye hacia el final de la secuencia. Un alto porcentaje de fracturas frescas sólo se registraron en los niveles Epipaleolíticos y se asociaron con la adquisición y consumo de médula ósea. El análisis de la acumulación faunística mostró poca evidencia de los efectos de los depredadores no humanos sobre los restos con un 0.07% de marcas de dientes / pico y 0.8% de daños causados por la digestión. Sólo el 0.1% de los restos muestran marcas de corte, mientras que el 15.6% de los restos estaban quemados. Además, la considerable presencia de escápulas, húmeros y fémures en el nivel Magdaleniense sugiere una mayor importancia de la actividad de descarnado durante este período que durante el Epipaleolítico, lo que sugiere, según Llorente (2015), que esta falta de marcas antrópicas podría ser debida a un tipo diferente de procesamiento de las canales de conejo (Tabla 11.3b).

En Cova Matutano (Villafamés, Castellón) y Cova dels Blaus (Vall d'Uixó, Castellón) se observa la misma tendencia (aumento-disminución y viceversa en número de restos) (cuadro 11.3c). Vemos en las Tablas 11.3b y 11.3c que la secuencia estratigráfica de Cova Matutano se extiende entre el Paleolítico Superior (Magdaleniense) y el Epipaleolítico Microlaminar (Olària et al., 1981), la acumulación de lepóridos de los niveles IV a IIC representa el 95% de los restos identificados, con fuertes variaciones entre niveles, especialmente en el Magdaleniense y el Epipaleolítico (80.4%), donde los porcentajes de conejo comienzan a descender, y es evidente un aumento en los porcentajes de ciervos. Los datos extraídos de Casabó i Bernard (2004) muestran que a partir del nivel IIB el conejo recupera importancia en los niveles correspondientes al Epipaleolítico Microlaminar (Tabla 11.3c). Lo mismo ocurre en la Cova dels Blaus (Tabla 11.3c), donde los restos lepóridos representan 92.5 - 89.3% de los restos determinados durante el Magdaleniense (Niveles V - IV) y 85.6 - 87.5% durante el Epipaleolítico (Niveles III - I) (Martínez Valle, 1996).

En la parte meridional de la península ibérica, en Andalucía (España), la secuencia arqueológica de la cueva de Nerja (Nerja, Málaga) muestra que el porcentaje de restos de conejos también aumenta desde las primeras etapas del Paleolítico Superior y vuelve a aumentar en el Magdaleniense 12.500 – 9.000) en un 65% (Aura Tortosa et al., 2002a b). En el nivel magdaleniense, los restos de cabra salvaje aumentan al 20%, mientras que los restos de ciervos disminuyen a 0.7%. Estudios recientes sobre el conjunto faunístico de la Sala del Vestíbulo (Morales, 2015), correspondientes a la secuencia Epipaleolítico - Mesolítico (niveles NV - 4 y NV - 3, respectivamente), muestran que el taxón más abundante son los lepóridos, que oscilan entre 85.3 % (NV - 4) y 42% (NV - 3). En todos los subniveles de NV-4, el porcentaje de lepóridos oscila entre 77.1 y 85.3%. Los altos porcentajes de conejo europeo, como en el Paleolítico Superior, son seguidos por la concentración de cabra salvaje. En cuanto a las alteraciones de la superficie ósea, las marcas de corte en los huesos largos responden a la extracción de los paquetes de músculos para la conservación posterior. Los porcentajes de cilindros diafisarios son altos durante el Epipaleolítico (50%), lo que podría significar que los grupos cazadores-recolectores posiblemente maximizarían la explotación de las carcasas de lepóridos mediante la extracción de nutrientes y grasa en términos de médula ósea (Tabla 11.3c).

4.2. EXPLOTACIÓN DE LEPÓRIDOS DURANTE EL PALAEOLÍTICO SUPERIOR EN EL SUROESTE DE EUROPA.

Es de gran importancia conocer el origen de las acumulaciones de lepóridos durante las fases iniciales del Paleolítico Superior en la región mediterránea, Portugal y el sur de Francia para ver si ha habido un cambio significativo en el patrón dominante de adquisición de lepóridos durante la transición de la fase final del Magdaleniense al Epipaleolítico / Mesolítico.

Con esto en mente, en la región mediterránea, la acumulación de lepóridos Auriñacienses en Terrasses de la Riera dels Canyars (Gavà, Cataluña, España) muestra una proporción porcentual entre los restos de conejo y otros taxones, en los que, al excluir los restos de conejo, la composición está dominada por herbívoros (60%) y carnívoros (40%). La muestra proveniente de la unidad M24 (MLU, Cala A), con 39,6 cal. Ka BP y muestra un predominio de *Oryctolagus cuniculus* con 3.458 restos determinados, que comprenden aproximadamente el 69.1% de la fauna. La frecuencia de los individuos adultos es del 79% (Rosado-Méndez et al., 2015), y aunque las acumulaciones antrópicas se caracterizan por valores superiores al 85% de los conejos adultos, este tipo de acumulación también podría mostrar variabilidad entre los sitios (Martínez Valle, 1996; Sanchis y Fernández Peris, 2008). En cuanto a los patrones de fragmentación, el 16.7% de los restos son <10 mm con bajas proporciones de cilindros (3.6%). Cuando se trata de alteraciones en la superficie del hueso por daño de digestión y marcas de por pico / dientes de un depredador, el 1.3% de los restos muestran daños en la digestión, mientras que el 25% exhiben marcas de dientes lo que indica la presencia de un agente acumulador no humano. El porcentaje de marcas de corte es bastante bajo (0.2%) para inferir una actividad específica de carnicería. En este caso específico (sitio exterior), variables como la representación anatómica, el patrón de fragmentación, la presencia de daños en la digestión y las marcas de los dientes, señalan la acción de los pequeños carnívoros terrestres como agentes principales, sin embargo, la abundancia relativa de huesos largos, mandíbulas, escápulas y pelvis) y la presencia de marcas de corte apunta a una contribución antrópica menor (Rosado-Méndez et al., 2015). Estos resultados apuntan a que aunque se empiezan a ver cambios en cuanto a las estrategias de subsistencia enfocadas a la explotación de lepóridos, todavía en estas cronologías se pueden encontrar yacimientos donde las acumulaciones de lepóridos se generan como resultado de la actividad primaria de carnívoros terrestres.

Por otro lado, otro ejemplo de acumulación lepóridos del periodo Auriñaciense, es la Cueva de Arbreda (Serinyà, Cataluña, España). Esta muestra un nivel evolucionado Auriñaciense (nivel G) con una presencia de 82.1% de individuos adultos de conejo. Además, la representación anatómica de la muestra denota la presencia de todos los elementos esqueléticos y una buena representación de dientes, mandíbulas, huesos largos, escápulas y pelvis. Con respecto a los patrones de fragmentación, existen un 13.3% de los cilindros y el 33.7% de fragmentos de epífisis apunta a la obtención de médula ósea. La presencia de marcas de corte (1%) y restos con daños por fuego (6.5%) encajan dentro del rango observado para las acumulaciones de lepóridos antrópicos durante el Paleolítico Superior en la región mediterránea. Además, aunque la identificación de marcas de dientes humanos no es una cuestión directa debido a toda la variabilidad (humanos y otros depredadores), al menos 23% de las marcas de los dientes podrían estar asociadas al consumo humano (Lloveras et al., 2016).

Otro ejemplo de cambio en la subsistencia en la región mediterránea es el de los niveles Gravetienses (XV-XVI) de Cova de les Cendres (Teulada-Moraira, Alicante) con signos de consumo humano evidenciados por la elevada presencia de marcas de corte (13.4%). relacionados con actividades de desarticulación y descarnado, y alto porcentaje de restos fragmentados. 90% son individuos adultos y la representación anatómica en Cendres muestra un número elevado de mandíbulas y huesos largos. Con respecto a los patrones de fragmentación, un alto porcentaje de cilindros apunta a la obtención de médula ósea. Además, un número considerable de estriaciones en la superficie del hueso largo han sido interpretadas por algunos (Villaverde et al., 2010) como producidas por dientes humanos al raspar el hueso de tejido blando. Hay un 5% de los restos que presentan daños en la digestión, lo que indica la intervención de rapaces nocturnos (Martínez-Valle, 1996; Villaverde et al., 1999). Estudios recientes sobre las acumulaciones de lepóridos del periodo Magdaleniense corroboran los resultados que destacan la abundancia de esta presa durante las últimas fases del Pleistoceno (Real Margalef, 2010).

En el caso de Portugal, los conejos han sido explotados intensamente por los seres humanos desde el Gravetiense hasta el Epipaleolítico. Los conjuntos de lepóridos de sitios arqueológicos de la zona presentan patrones de fragmentación y alteraciones de la superficie ósea compatibles con la actividad humana (Bicho et al., 2000, 2003, 2006, Brugal, 2006, Cochard y Brugal, 2004, Davis y otros, 2007, Hockett y Hawes, 2002, Hockett y Ferreira Bicho, 2000, Lloveras et al., 2011, Manne y Bicho, 2009) que implicaría una maximización del procesamiento de las carcasas. Por ejemplo, si consideramos el caso de Gruta do Caldeirão (Tomar, Portugal), la acumulación de lepóridos en el nivel Solutriense parece ser en gran parte antrópica. La representación anatómica, restos altamente fragmentados con epífisis y cilindros diafisarios (27%) asociados con extracción de médula ósea, huesos termo-alterados (3.1%) y marcas de corte (0.8%) sugieren que la mayor parte de los restos fueron acumulados por humanos con una contribución marginal de pequeños carnívoros terrestres (Lloveras et al., 2011).

La premisa de que las presas pequeñas como los conejos ganaron más importancia durante el Paleolítico Superior se apoya en los resultados obtenidos durante el análisis de otras acumulaciones de lepóridos del periodo Solutriense en la región portuguesa. Por ejemplo, Lapa do Anecrial (Tabla 11.4) presenta un conjunto faunístico dominado masivamente por *Oryctolagus cuniculus*, con 1600 números de restos óseos y dentales determinados. En comparación con otros sitios del Paleolítico Superior que exhiben acumulaciones de miles de restos de conejo, Anecrial es considerado un sitio pobre en densidad. El conjunto de conejos se caracteriza por individuos adultos (98.8%) por la presencia de todos los elementos esqueléticos, con un buen equilibrio entre los elementos derechos e izquierdos lo que evidencia la entrada de canales completas (no hay transporte diferencial) al sitio arqueológico. El porcentaje de marcas de corte es bajo (0.02%) y el 5.7% de restos termo-alterados implicaría un consumo directo de los conejos, probablemente con cocción /rostizado, lo que explicaría el bajo porcentaje de las marcas de corte. Respecto a la representación anatómica, se registra la sobre-presentación de pequeños elementos distales, en consonancia con la recuperación diferencial en el campo, y alto porcentaje de eje de los huesos largos (70%), típico de la acción humana para la extracción de médula. Como ya se ha dicho, se registraron grandes cantidades de cilindros de hueso largo, sin embargo los fragmentos de epífisis fueron asustados, indicando posible uso humano diferencial, por ejemplo carne curada (secado o ahumado) y / o huesos quebrados para la adquisición de grasa.

Otro ejemplo es Vale Boi (sur de Portugal), donde el conjunto de conejos constituye el 72% del número de restos determinados (Tabla 11.4). También se recuperaron mariscos y otros ungulados. A lo largo de las secuencias Gravetiense, Solutriense y Magdaleniense, la especie *Oryctolagus cuniculus* es el taxón dominante seguido por ciervo (*Cervus elaphus*) y caballo (*Equus caballus*). Más del 95% de los individuos eran adultos, se registraron pocas marcas de corte (<1%) y marcas de diente / pico y daños en la digestión (menos del 1%). Según Manne et al. (2012), el porcentaje de conejo determinado sigue disminuyendo a lo largo de las secuencias arqueológicas, por ejemplo, mientras que los conejos comprenden el 81% de los especímenes identificados durante el Gravetiense, la proporción disminuye a un 65% durante el Solutriense y luego otra vez durante el Magdaleniense (45%), sin embargo esta discrepancia se dice que se debe a la representación diferencial de los elementos esqueléticos (Manne et al., 2012).

La cueva de Picareiro (Hockett y Bicho, 2000), otro sitio fechado durante el Paleolítico Superior final de la Estremadura portuguesa (Tabla 11.4), muestra que el ciervo y el jabalí están entre los taxones recuperados; sin embargo, los conejos constituyen el 82.3% Donde el 99.4% de los individuos se clasificaron como adultos. En cuanto a la representación anatómica, todos los elementos esqueléticos están bien representados, lo que indica que las carcasas fueron llevadas completas al sitio. Los elementos del cráneo eran abundantes, y la proporción de los miembros anteriores y de las extremidades posteriores se equilibraba, con sólo el 3.7% de los huesos largos completos. El análisis tafonómico de los restos no muestra evidencia de acumulación natural de conejo ni evidencia de acumulaciones de depredadores no-humanos. Aproximadamente el 69% de los restos exhibe marcas por termo-alteración, más específicamente los patrones quemados consistentes con las carcasas de los conejos han sido asadas sobre o dentro del carbón caliente. Los colores diferenciales en los elementos de las extremidades, específicamente los extremos proximal y distal, evidencian esto (Hockett, 1992), también la inexistencia de marcas de corte dentro de la muestra evidencia que las carcasas cocidas fueron desmembradas y consumidas directamente. Los patrones de fragmentación indican 23.6% de los cilindros de eje y 584 fragmentos de epífisis proximal y distal, lo cual es consistente con la actividad de extracción de médula ósea.

Contrariamente a los sitios arqueológicos portugueses, en Francia, como lo expresan algunos autores (Cochard y Brugal, 2004), la importancia de la adquisición de conejos en la economía de subsistencia de los cazadores-recolectores en el sur de Francia se manifiesta claramente durante las etapas finales del Paleolítico Superior final (Magdaleniense) y Aziliense (Tabla 11.4). El dominio de lepóridos no es constante ya que hay sitios arqueológicos con una abundante presencia de lepóridos, mientras que en otros son claramente escasos. También el análisis zooarqueológico de los conjuntos faunísticos del sur de Francia sugiere un modelo de adquisición que difiere de los registrados en la región mediterránea de la Península Ibérica (Aura et al., 2002). Por ejemplo, en el nivel magdaleniense de Faurélie II (Tabla 11.4), los restos de conejos europeos constituyen el 97% de los restos recuperados (NDR = 7695), mientras que el otro 3% corresponde a otros herbívoros (Cochard y Brugal, 2004). Además, la distribución de restos de conejos es difusa en toda la zona excavada, sin relación con el único hogar presente en el área noroeste del refugio. Los datos sobre la representación anatómica muestran todos los elementos esqueléticos están bien representados, indicando que las carcasas fueron llevadas completas al sitio. La abundancia relativa de los elementos esqueléticos muestra el 81% de los elementos correspondientes a los antebrazos (escápulas, humeri, radios y ulnas), el 69% de los elementos correspondientes a los miembros posteriores (innominados, femorales y tibiales) y el 65% de elementos craneales como mandíbulas y maxilas . Más del 95% de los individuos eran adultos, el 7.5% de los cilindros diafisarios (N =146) apunta a la extracción de la médula ósea, mientras que el 1.6% de las marcas de corte evidencian actividades de despiece.

Otros sitios (Tabla 11.4), como Bois Ragot (Cochard y Brugal, 2004) contienen restos lepóridos (*Lepus timidus*) que superan el 85% de los restos recuperados. El conjunto de conejos se caracteriza por un 94% de individuos adultos y un alto porcentaje de huesos largos (6.2%), típico de la acción humana para la extracción de médula. El 6.2% de los restos presenta marcas de corte consistentes con las actividades de desarticulación y descarnado (destinadas a la adquisición de piel y carne), mientras que el 4.1% de los restos se consideran quemados accidentalmente. Además, en Moulin du Roc (Dordogne, Francia) el análisis de la abundancia relativa de elementos esqueléticos, alteraciones de la superficie ósea y patrones de fragmentación sugiere que la acumulación de lepóridos en el nivel Magdaleniense es de origen antrópico (Jones, 2012). La inexistencia de marcas de dientes / pico, y restos afectados por daño de la digestión, indica que no hubo aportación de depredadores no humanos, mientras que un 10% de las marcas de corte y un 19% de los restos quemados apuntan a un conjunto acumulado por humanos. Además, el alto porcentaje de cilindros de huesos largos es consistente con la actividad de extracción de médula ósea. Aunque *Oryctolagus cuniculus* es el taxón dominante registrado, es seguido por un número considerable de renos (Rangifer tarandus), ciervo (*Cervus elaphus*)y corzo (*Capreolus capreolus*). Otro ejemplo es Oullins (Languedoc oriental, Francia), donde el nivel 7b, correspondiente al Magdaleniense temprano, verifica la inclusión del conejo europeo en la dieta de las comunidades cazadores-recolectores de esa región (Rillardon y Brugal, 2014). 83.3% de los individuos adultos caracterizan el conjunto de conejos; el porcentaje de marcas de corte (2%) y restos quemados (8.5%), y un alto porcentaje de huesos largos (13%) y altas cantidades de cilindros de hueso largo son indicativos de roturas dirigidas a la extracción de médula.

4.3. UNA VISIÓN DIACRÓNICA: CONSUMO DE LEPÓRIDOS A LO LARGO DEL PALEOLÍTICO SUPERIOR Y EPIPALEOLÍTICO.

Los datos presentados a lo largo de este capítulo nos permiten comparar la explotación de presas pequeñas durante la transición Pleistoceno-Holoceno a escala regional (Cataluña) y luego extendernos a otras regiones ibéricas (Valencia, Andalucía y Portugal) y sur de Francia (Figura 11.2.). Nuestros resultados sobre la naturaleza de las estrategias de subsistencia entre las últimas sociedades cazadores-recolectores en el noreste de Iberia, sobre la base del análisis tafonómico de las acumulaciones de lepóridos constituyen un conjunto de datos que permitirá plantear un esquema general de ampliación de la dieta durante el período La transición del Pleistoceno-Holoceno, que se manifiesta dentro de la región mediterránea como un aumento de conejo, sigue siendo porcentajes en sitios con secuencias cronológicas correspondientes al Paleolítico Superior, pero más importante durante el Epipaleolítico.

Las razones por las que los sitios del Paleolítico Superior en el suroeste de Europa exhiben cantidades exorbitantes de conejo europeo ha sido objeto de discusión durante bastante tiempo. Varios autores (Cochard y Brugal, 2004; Davis, 2002; Jones, 2004, 2006, 2012; Pérez Ripoll, 2006) han discutido sobre: A) una caza selectiva desde 18 ka BP. Esta premisa está confirmada por datos de varios sitios localizados en la región mediterránea que exhiben un incremento en el consumo de lepóridos durante el Magdaleniense final e incluso más temprano, que comprende casi el 90% de los restos determinados recuperados en cada uno, estos altos porcentajes son seguidos por valores más bajos de *Capra pyrenaica* (cabra salvaje), *Cervus elaphus* (ciervo) y *Sus scofra* (jabalí); B) el aumento del conejo europeo durante el Paleolítico Superior favoreció su caza. Esto lleva a varios autores a proponer un modelo de caza masiva, en el cual la adquisición de conejos puede haber proporcionado una cantidad enérgica similar a la ofrecida por otros animales de mayor tamaño (Jones, 2006; Cochard y Brugal, 2004). Otros señalan que los altos valores de restos lepóridos se deben a una respuesta adaptati, por parte de los grupos de cazadores-recolectores en la región mediterránea, al crecimiento de la población o como consecuencia de un modelo de forrajeo especializado en animales de fácil caza. Al tener altas tasas de reproducción (con dos camadas por año), exhibiendo un comportamiento gregario y territorial, y fácil de capturar, la adquisición de conejos se convierte en una estrategia más conveniente; C) Desde el punto de vista ecológico, otros sugirieron que la cacería de lepóridos, puede haber resultado como consecuencia de los recursos emergentes en tiempos de escasez. Al mismo tiempo que desaparecieron las especies del clima frío como resultado de la mejora climática, los abundancia de conejo permitiría a las poblaciones prehistóricas mantener ciertas estrategias sedentarias en coordinación con la caza de mamíferos de tamaño mediano. Esta tendencia hacia la especialización, dando paso a la diversificación de presas pequeñas, sufre un retroceso durante el Epipalaeolítico Sauveterroide, con varias secuencias que muestran una disminución en los restos de conejo (como se observa a través de los niveles IV-IIC a IIB-IA de Cova Matutano y niveles NV -4 y NV-3 de Nerja), posiblemente relacionado con un cambio en la funcionalidad del emplazamiento y reorientado en la explotación de otros recursos alimentarios, como los recursos marinos como evidencia en la Cueva de Nerja.

El rol de las presas pequeñas debe ser valorado en relación con el resto de los taxones entre el conjunto faunístico en cada sitio. Las diferencias en la explotación de pequeñas presas entre el Paleolítico Medio (Musteriense) y el Paleolítico Superior temprano se han inferido a través de un modelo basado en diferentes tipos de ocupación y explotación del territorio caracterizado por una reducción en la movilidad de grupos humanos combinada con una especialización estacional de especies más gregarias con Patrones migratorios limitados como, por ejemplo, ciervos y cabras silvestres, y la adquisición de recursos alimentarios más estáticos, como conejos.

Datos obtenidos de yacimientos arqueológicos en Cataluña (Molí del Salt, Riera dels Canyars y Abreda), Valencia (Tossal de la Roca, Coves de Santa Maira, Cova Fosca, Cova Matutano, Cova dels Blaus y Cendres) y Andalucía (Cueva de Nerja) confirman el origen antrópico de las acumulaciones de lepóridos desde el inicio del Paleolítico Superior, durante el Aurignaciense, Gravetiense y Solutriense, tal vez como un recurso alimenticio alternativo a los herbívoros de tamaño medio, según algunos autores (Aura et al., 2002; Martínez Valle, 2001; Villaverde et al., 1999).

Otro factor a considerar es si la naturaleza y ubicación de estos asentamientos pueden condicionar la abundancia de presas pequeñas de cierta manera, ya que los yacimientos datados en el Paleolítico en Iberia exhiben una gran diversidad en términos de contextos geográficos, desde lugares cercanos a la costa hasta lugares más empinados, o incluso situado a más de 1 000 metros de altitud. Es posible que los cambios en la dieta respondan a las variaciones en la disponibilidad de recursos. Hockett y Haws (2002) sostienen que la explotación de conejos se basa en factores locales de densidad de recursos y condiciones climáticas. Una diferencia en el uso del paisaje implica diferentes sitios con diferentes funciones; Jones (2013) explica que los grupos con movilidad residencial están cambiando constantemente de lugar, generando asociaciones faunísticas con menos taxones, mientras que los grupos con movilidad logística se mueven con menos frecuencia, con individuos o pequeños grupos específicos que se aventuran y regresan a un campamento residencial, exhibiendo faunas más amplias. En el caso de los yacimientos arqueológicos de la región mediterránea (Valencia, Portugal y nuestra muestra arqueológica), los conjuntos faunísticos apuntan a una movilidad logística. Este tipo de sitio también se caracteriza por su ubicación, generalmente en la

elevación de rango medio, dentro de un rango de un amplio número de parches o la creciente predictibilidad de los recursos (Jones, 2013). De acuerdo con lo anterior, se cree que la explotación de pequeñas presas durante el Paleolítico Superior en Portugal está ligada a factores de densidad local y condiciones climáticas. En el sur de Francia, a pesar de que la explotación de los conejos se evidencia en las acumulaciones del Paleolítico Superior, pero no es hasta el Magdaleniense cuando este recurso es explotado de manera intensiva (Cochard y Brugal, 2004, Jones, 2004 y 2012). Existe una relación evidente entre la intensidad de la explotación de los recursos y la función del sitio, todo ello en función del número de restos lepóridos en cada sitio, que van desde aglomeraciones ricas a pobres, todo lo cual depende del tiempo de ocupación y estación.

El record arqueológico estudiado en esta tesis doctoral confirma las tendencias observadas desde el inicio del Paleolítico Superior y especialmente en el Paleolítico Superior final, en relación con la caza de presas pequeñas (lepóridos) en área del Suroeste de Europa. Esta tendencia alcanzará su esplendor durante el Epipaleolítico, como lo demuestran los datos de los sitios estudiados, así como su comparación con el registro faunístico de los sitios contemporáneos. La variabilidad de cada caso puede responder a variables de diferentes naturalezas, tales como: tipo de asentamiento, estacionalidad y localización precisa de los enclaves, entre otros. La cuestión de por qué se produce una disminución de la importancia de la cacería de los lepóridos durante el Mesolítico de muescas y denticulados, una disminución que comienza en algunos casos durante la fase de Sauveterroide, aunque no en el único registro (Balma del Gai) en nuestras muestras que cubre esta cronología.

5. CONCLUSIONES FINALES

A lo largo de este trabajo, a través de los yacimientos analizados y con la literatura consultada, hemos visto como las pequeñas presas han jugado un rol en la alimentación de las comunidades humanas desde los primeros estadios de su evolución. A pesar de ello, su importancia en la dieta ha ido variando a lo de este tiempo, en general incrementándose, debido al necesario equilibrio que debe existir entre la inversión que supone la captura y el retorno energético que se obtiene de ellas. En el caso del sudoeste europeo y en concreto en la Península Ibérica, la caza de pequeñas presas, obviamente, tiene como gran protagonista un grupo taxonómico de mamíferos, los lepóridos, y en concreto una especie, el conejo (*Oryctolagus cuniculus*), que puede considerarse endémica de la zona.

Mi trabajo se ha centrado precisamente en la valoración de este recurso en una zona muy concreta de la península, el Noreste (Cataluña), en un período especialmente significativo de la Prehistoria por sus transformaciones climáticas, ecológicas y culturales, el Epipaleolítico.

Ante lo dicho hasta ahora, se comprende que el conejo, como especie especialmente abundante y ampliamente distribuida por la zona de estudio, no haya sido presa potencial exclusiva de los grupos humanos. Muchos depredadores de la región se han especializado en su caza y consumo, desde mamíferos carnívoros, generalmente de pequeño y mediano tamaño, hasta grandes rapaces diurnas y nocturnas. Por ello, y por el hecho de que muchos de estos taxones además pueden ocupar como refugio los mismos espacios utilizados como lugar de hábitat (cuevas y abrigos rocosos) de los humanos, el primer requisito en un estudio de estas características deba ser la contrastación tafonómica de los agentes de acumulación en los yacimientos arqueológicos.

Así, hemos visto en diversos capítulos de esta tesis (estado de la cuestión y discusión) como en los estadios previos al Paleolítico superior, la explotación de los conejos es ya presente entre las comunidades humanas que ocuparon la Península Ibérica desde sus inicios, pero que a su vez son también significativos los yacimientos de esos momentos en que las acumulaciones de huesos de lepóridos deben ser atribuidos mayoritariamente a linces, zorros o búhos reales. Esta tendencia no se invertirá en nuestra región de análisis hasta el Paleolítico superior. Aunque se seguirán detectando algunos casos, cada vez más escasos, de acumulaciones masivas de conejo por causas no antrópicas (sería el caso estudiado por mí misma del yacimiento, cronológicamente auriñaciense, de les Terrasses de la riera dels Canyars, en Gavà, Barcelona, que de hecho debe considerarse una estación estrictamente paleontológica) las concentraciones de restos de lepóridos pasarán a tener un origen claramente antrópico. Las causas esgrimidas en este cambio han sido diversas: ecológicas, demográficas, cognitivas, tecnológicas. Aunque pienso que seguramente la causa final deba considerar una retroalimentación de todas ellas, el debate entre los especialistas sigue abierto y generando controversia.

Ahora bien, aunque el incremento de la importancia cinegética-alimentaria del conejo se detecta desde el inicio del Paleolítico superior, será a partir del Tardiglaciar, y coincidente con el complejo cronotipológico del Magdaleniense, que su aumento será exponencial. Así, en la zona catalana, de los modelos cinegéticos propuestos en la literatura, para este periodo y el siguiente, dos parecen dominar el registro: el de la caza especializada de cabra salvaje en las zonas abruptas y el de la caza del conejo en los ecosistemas más llanos.

Durante el sutil paso del Paleolítico superior final al Epipaleolítico, caracterizado por los complejos Epimagdaleniense y Microlaminar sauveterroide, objeto de nuestra tesis, continúa el incremento en la importancia del conejo. Cabe decir, que desde una perspectiva de la ecología humana, los entornos llanos o montanos suaves serían más adecuados para las poblaciones humanas que las zonas de orografía muy abrupta, y los yacimientos estudiados en este trabajo, que responderían al primero de los ecosistemas, se caracterizan por un predominio absolutamente avasallador de restos de conejo, por lo que podríamos considerar la caza masiva de este animal como el modelo subsistencial propio de los asentamientos del Epipaleolítico en el noreste ibérico. Con ello, y según se desprende de los resultados que se han expuesto a lo largo de la tesis, no quiere decir que tales acumulaciones reflejen estrategias subsistenciales (y con ellos territoriales, cinegéticas y otras) diferenciadas en cada yacimiento y por ello el estudio de estos restos se transforma en un potente artefacto de interpretación cultural y social, siempre que se contraste con los resultados procedentes de otros análisis arqueológicos, que puede permitir deducir usos, modelos de ocupación , estacionalidad, etc..

Así, el registro estudiado en esta tesis, y centrado en el estudio de tres yacimientos clave, Balma del Gai, Cova de la Guineu y la Font Voltada, en primer lugar demuestra que las acumulaciones de lepóridos (tras la evaluación de que los conjuntos son estadísticamente fiables y el sesgo diagenético no es importante) del epipaleolítico catalán son claramente de carácter antrópico. Para este momento han desaparecido los palimpsestos producidos por grandes acumulaciones de origen humano y no humano de fases anteriores. Entre los lepóridos, dichos conjuntos están formados casi exclusivamente por conejos. Los porcentajes de elementos que presentan alguna alteración asociable a la intervención de pequeños carnívoros terrestres son muy bajos, y aunque por lo tanto no se puede descartar su presencia, ésta debe considerarse absolutamente marginal.

Una vez confirmado el carácter antrópico de las acumulaciones, el estudio pormenorizado de las alteraciones de origen humano en cada yacimiento y la comparación entre ellos llevan a concluir que el uso de las carcasas de los lepóridos es múltiple y con diferentes finalidades.

En primer lugar, cosa que por otra parte parece obvia por el tamaño de la presa, los animales, según su representatividad anatómica, llegaban íntegros a los campamentos. La falta de pequeños huesos, generalmente de los autopodios, parece estar más ligada a los mecanismos de recuperación arqueológica que a la manipulación que de las carcasas se pudiera haber realizado en la Prehistoria.

Posteriormente gran parte de los animales habrían sido desollados, según se desprende de las marcas localizadas en huesos asociados a pies y manos, del mismo modo que en la zona craneal, especialmente en huesos como la mandíbula y el maxilar. En un segundo tiempo, los animales habrían sido procesados para la extracción y consumo de la carne, con marcas relacionadas con la desmembración (concentradas en zonas articulares) pero también con la extracción de los paquetes musculares y con el raspado de determinados huesos para extraer partículas de carne o periostio (marcas que se localizan mayoritariamente en las diáfisis y metáfisis). Esta actividad, junto algunas marcas que podrían relacionar la extracción de la carne en seco, demostrarían que el consumo tanto se podría estar realizando sobre los animales en fresco como que se hubiera pospuesto el consumo de su carne, mediante algún tipo de secado, bien tras la separación de los paquetes musculares y el hueso, bien en algunos casos preparando partes del animal sin deshuesar. No obstante, las marcas de extracción de carne seca, a pesar de nuestros experimentos, no son del todo concluyentes en los casos que se han detectado. Durante el proceso de manipulación de la carcasa, además de la piel y la carne no se puede descartar la extracción de tendones con otras finalidades. Ciertas marcas de corte y fracturas en los calcáneos podrían interpretarse de este modo, también según la contrastación de marcas arqueológicas con resultados experimentales. En cambio, en ningún caso hemos detectado industria ósea realizada sobre huesos de conejo, a pesar que en alguno de nuestros yacimientos (Balma del Gai) este tipo de elementos, realizados sobre otros taxones, es relativamente abundante.

La manipulación de las carcasas finalizaría con la fracturación de determinados huesos para la extracción de la médula e incluso el masticado y tal vez la deglución de las partes más blandas. Al respecto, son abundantes los cilindros diafisarios, las marcas de mordedura interpretadas como humanas y la falta de determinadas epífisis, generalmente las menos densas. Los restos sobrantes serían abandonados y en algunos casos desechados en puntos de fuego, según se desprende de las termoalteraciones localizadas, aunque algunas de ellas pudieran relacionarse con la acción culinaria. Al respecto, el trabajo demuestra la precaución que debe tenerse con la identificación de huesos termoalterados a través de las coloraciones, especialmente en las exposiciones focos de calor de baja intensidad (coloraciones previas a la cremación o calcinación). La aplicación de técnicas físico-químicas han permitido en los casos analizados corregir sesgos en este sentido, aunque también se ha demostrado la complejidad de dichas técnicas y la necesidad de realizar referenciales previos adecuados para cada yacimiento.

Más allá de detectar en líneas generales todo este proceso de transformación de las carcasas de lepóridos en todos los yacimientos, los grados de intensidad con que se manifiestan en cada caso, permiten deducir comportamientos asociados a estrategias diversificadas en cada yacimiento. Así en los dos extremos tendríamos Font Voltada y la Balma del Gai. En el primero el grado de fragmentación de los huesos, la importancia de la termoalteración y las marcas parecen demostrar un aprovechamiento más intensivo de los recursos cárnicos con una maximización de las carcasas con un consumo inmediato, mientras se detecta un menor uso de la piel. Por el contrario, en la Balma del Gai, parece que se podría detectar una menor intensidad en el consumo directo de la carne aunque a su vez la existencia de un consumo en diferido. Junto a esto parece detectarse en la Balma del Gai una mayor actividad de despellejado. La Cova de la Guineu representaría un modelo de transición entre ambos, aunque más cercano al deducido para la Balma del Gai. Desde una perspectiva de los modelos de asentamiento, dichos resultados hacen pensar en una adquisición masiva de animales en el caso de la Balma del Gai i de Cova de la Guineu, que permitiría el procesado generalizado de las pieles, el consumo directo de la carne y el acopio mediante conservación de parte del excedente. La obtención tal vez más esporádica o distanciada en el tiempo (no por ello casual u oportulnista) de conejos en la Font Voltada, implicaría priorizar las carcasas como recurso alimentario y la maximización de las mismas. Tal vez un y otro modelos podrían relacionarse con la duración de las ocupaciones (mayor en las explotaciones de conejos en masa, Balma del Gai i Cova de la Guineu, y menor en Font Voltada) así como su carácter logístico o residencial.

Respecto a la posible evolución a lo largo del Epipaleolítico de la explotación de los conejos como recurso de importancia, solamente podemos ofrecer los datos procedentes de Balma del Gai, en tanto que es el único yacimiento que tenemos un desarrollo cronológico que abarque los dos tecnocomplejos identificados en este período. En este sentido, no se observa ningún tipo de cambio entre el paquete que correspondería al Epimagdaleniense y el que correspondería al Microlaminar sauveterroide. Este dato sería consistente con la visión generalizada de que el Microlaminar sauveterroide no implica a nivel cultural nada más que la incorporación de un cierto componente geométrico sin que implique mayores cambios de tipo industrial o cultural. Finalmente, y superando el marco cronológico de esta tesis, será interesante seguir estudiando cómo evoluciona la explotación de los conejos entre las últimas comunidades cazadoras-recolectoras finales, antes del advenimiento del Neolítico, en el noreste peninsular, que por el momento, y según los escasos resultados que se tienen, parece sufre una drástica disminución. En todo caso tal estudio se plantea como un proyecto de futuro en la continuación de nuestra investigación.

Con todo ello espero haber demostrado la importancia del estudio de las pequeñas presas entre las comunidades cazadoras recolectoras del Epipaleolítico en el Nordeste de la Península ibérica y la potencialidad interpretativa de los resultados, cosa que implica la concienciación de la comunidad de arqueólogos de cara a la recuperación de los restos y el registro de la información de un grupo taxonómico durante demasiados años olvidado del registro, así como la necesaria contrastación de los resultados obtenidos con los procedentes de otras disciplinas, cosa que obliga a una segunda fase de discusión y puesta en común de resultados entre todos los especialistas, de cara a obtener una visión completa en la interpretación de cada uno de los yacimientos y holística para la reconstrucción global de este período en esta zona geográfica.

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