PhD Thesis

Of cereals, poppy, acorns and hazelnuts. Plant economy among early farmers (5500-2300 cal BC) in the NE of the Iberian Peninsula. An archaeobotanical approach.

Ferran Antolín

Dept. De Prehistòria, Universitat Autònoma de Barcelona

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Supervisors:

Raquel Piqué i Huerta (Universitat Autònoma de Barcelona)

Ramon Buxó i Capdevila (Museu d'Arqueologia de Catalunya)

Stefanie Jacomet (Universität Basel)

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ANNEXES (CD)

1. Introduction

The Neolithic period in the North-East of the Iberian Peninsula has received the attention of many archaeologists during the XXth and XXIst centuries, from the earliest humanists like P.Bosch Gimpera (1891-1974) who settled the basis for the periodization of the Prehistory in the region to systematic archaeologists like J. Guilaine, who contributed to the diffusion of scientific archaeological methods among scholars and “outsider” archaeologists (for a recent review see Bosch and Santacana 2009, 11-31). The production of reliable archaeological data started towards the end of the seventies and especially during the eighties of the last century, with the excavation of emblematic sites like the Gavà Mines (Gavà, Baix Llobregat), Can Sadurní Cave (Begues, Baix Llobregat), 120 Cave (Sales de Llierca, Alta Garrotxa) and Bòbila Madurell (Sant Quirze del Vallès, Vallès Occidental) (for their location see Figs. 2.7 to 2.11). In the early nineties, the surprising discovery of a lakeshore site in Banyoles, La Draga (Banyoles, Pla de l’Estany), brought to light wooden objects, piles, huge amounts of charred cereal grains and a large number of other artefacts, which allowed new approaches to the Neolithic in the region. The major construction works derived from the speculative building fever that started in 1996 also resulted in the discovery of a large number of sites, some of which were sampled and analysed within this project. Despite the major amount of data produced in the last decades, the insufficient public funding of social sciences has resulted in a very low number of publications of complete site reports and the lack of synthesis work.

The regular sampling for the recovery of botanical remains from archaeological sites started towards the late seventies of the XXth century, and became more and more widespread during the eighties and the nineties. The persisting work of many archaeobotanists like R. Buxó made an impact in archaeological methods and samples were taken from a large proportion of the excavated sites. Unfortunately, the surface excavated in many sites was small and systematic sampling was not always possible. Nevertheless, some examples of large excavations where large amounts of samples were taken should be highlighted, like Font del Ros (Berga, Bergadà), Bòbila Madurell or La Draga. Without all these pioneer works, the present study would not have been possible.

Despite the scarcity of direct evidences of crops and crop husbandry practices in the Neolithic of this region, many archaeologists used their own assumptions to propose theories on the spread of farming in the region and its evolution in the next millennia. It is time to contrast some of these hypotheses on the archaeobotanical record and attempt a first characterization of plant food economy during the Neolithic in the region.

Crop husbandry and wild plant management are two of the most labour-demanding activities that early farmers faced during the Neolithic. Their study is not only interesting as a way of approaching how these groups organized their subsistence, but it also provides information on their labour capacity, social access to products, risk reduction strategies and the evolution of social relations and gender roles in production. The relevance of the study of crop husbandry for the general archaeological discourse has been exposed by other authors (like e.g. Bogaard 2004b, 3-5). The main target in this work will be plant food production.

Several questions are aimed to answer: are we dealing with an intensive or extensive type of management? Is it primarily based on domesticates or on wild plants? Is it constant through time? If not, what factors affect its evolution? Is it homogeneous for the region under analysis? Why? What processes of labour are involved in the production of plant foodstuffs? Can one see differences in the access to particular resources within a settlement or at a regional scale? Are there differences in mountain areas?

The work is classically structured into an opening chapter **(chapter 2)**, where the theoretical framework is presented and a critical review of the state of research of the Neolithic in the NE of the Iberian Peninsula is offered. The sites under analysis are described in **chapter 3**, along with the methods of analysis, making special emphasis on the taphonomic analysis of the samples. The catalogue of identified taxa is presented in Annex 1 and the preliminary results of the experimental works are included in Annex 2. **Chapter 4** is dedicated to the presentation of the results per site. For each site, specific aims of research are presented and a complete analysis (including materials and methods, results, discussion and conclusions) is offered. The tables with the lists of samples and the results per site are available on pdf format in Annex 3. The final discussion can be found in **chapter 5.** All the data available from publications and produced in this work are included in the discussion, which starts with methodological aspects and then focuses on the history of crops, on crop husbandry, and on wild plant management. The final conclusions can be found in **chapter 6**.

Four annexes were added at the end in digital format (CD). **Annex I** is the catalogue of taxa. **Annex II** includes two experimental projects that were carried out during the elaboration of this PhD and which bring relevant information for chapter 3. All the tables with the samples taken per site and the overall results are presented in **Annex 3**. These were numbered as follows: Fig. III.1, III.2, etc. Finally, **Annex IV** presents a table with all the ethnobotanically known uses for the identified taxa in this work.

2. Plant food economy among early farmers in the North-East of the Iberian Peninsula. Definition and state of research

Non-ligneous plant resources (mainly seeds and fruits, but also tubers, roots, leafs and flowers) were widely exploited for a different range of purposes by early farmers. Of these purposes, **plant food production** requires the largest investment of labour and time. It is also the activity that leaves more archaeological traces and, for this reason, there are more chances to obtain direct evidence of its existence. Despite this fact, the exact meaning of plant food production and its social significance within early farming groups remains somewhat unclear in the archaeological literature. How important is farming for these economies? How skilled were these early farmers in managing crops? How much labour investment did farming require? Was it organized at a household or at a community level? How often did they use wild resources and what knowledge did they have of their environment? To what extent was the exploitation of wild resources part of the mode of production of early farmers?

It has been considered of interest for this work to start with the definition of what should be understood by plant food production. Then, the model of plant food production that has been identified for the Neolithic communities of Central and Southwest Europe will be presented, in order to define the working hypothesis for this research. After that, I will develop a more accurate discussion on the different processes of labour that would be implied by such a mode of production. Subsequently, the social implications of this model will be examined, in order to build a general social framework for Neolithic populations. At a final stage, this socioeconomic model will be used to make a short critical review of the most relevant aspects (for this work) of the Neolithic of the of the North-East (NE) of the Iberian Peninsula and to highlight the significant need of the archaeobotanical analyses that are included in this work to answer many of the questions that have been proposed.

2.1. Plant food production: crops and wild fruits

The main target of this work is dealing with plant food production. As clear as it might seem to the reader, the debate over the meanings attributed to concepts such as agriculture, cultivation, domestication, food procurement, gathering and food production, has originated a large number of interesting papers over the last decades. This debate has taken place as part of the discussions on the origins of agriculture which, to some authors, is the onset of food production. It is not the aim of this work to review all the many contributions to this topic from a theoretical point of view (for an overview, see for instance (Vicent 1988, Harris 1989)). It is also out of the scope of this work to discuss the reasons why the agricultural mode of subsistence was adopted in Southwest Asia (see, for example, (Bogucki 1999, 182-203, Barker 2006, McCarter 2012, 165-173). Recent anthropological and ethnographical approaches led some authors to the conclusion that the transition from foraging to farming was, in fact, a very complex process that would have involved several processes and spheres of life (Barker & Janowski 2011)

Several authors have defended that a social group can either be food producer or food procurer (for a critical review, see Smith 2001). Such simplistic classifications have been avoided by most of the researchers approaching the process of domestication. In fact, numerous authors have struggled to clarify these concepts and, at the same time, to define the many in-between stages or options of plant food production (see, for instance, Ford 1985, Harris 1989, Smith 2001, Fuller 2007). Notwithstanding, a rapid revision of the available literature on this subject highlights the poor agreement that has been reached in the meaning of words such as "agriculture" and "domestication" (Harris 2007) or "cultivation" and "husbandry" (Smith 2001). This is in fact due to the use of different variables to define these concepts. There is one idea that is common in most of these works, which is that some societies do not produce food plants. This leads me to think that the main problem resides in the lack of concern of what production is.

R.I. Ford defined plant food production as the "deliberate manipulation of specific floral species by humans for domestic use or consumption" (Ford 1985, 2). This author established several stages and methods of plant food production: "tending" (encouraging plant growth by limiting competition), "tilling", "transplanting", "sowing" and "plant breeding". Such actions are considered as "incipient agriculture". Forager groups would be excluded from all these stages. These groups would only collect what was produced by nature and consume it without much processing, thus having a very low impact on the growth of plants (Ford 1985). Ford's definition of plant food production remains slightly confusing. On the one hand, the author admits that the investment of labour on plant growth is a way of producing plant foods. Yet, on the other hand, he considers it as "incipient agriculture", as if any intervention on plant growth by human beings would end up in some sort of cultivation.

Later on, D.R. Harris (1989) contributed to this topic by presenting a more complex scheme of different strategies of plant management. This author limits the concept of plant food production to the existence of the knowledge and regular practice of planting and sowing. Something similar is observed in B. Smith's distinction of the low-level food production stage, which corresponds to those groups that do not fully rely on domesticates for their survivorship (Smith 2001). D. Fuller introduced the concept of semi-domestication after taking into consideration the archaeobotanical data obtained in the past decades. This stage would correspond to one of the in-between steps between cultivation (of wild species) and agriculture (with domestic species) (Fuller 2007).

In actual fact, all these classifications are not distinguishing between production and foraging, but between **immediate and delayed return systems** (*sensu* Meillassoux 1979, Woodburn 1988). Several authors state that immediate return systems exist but are environmentally very restricted and frequently the result of the pressure from outsiders (Woodburn 1988, Ellen 1994). Such type of social organization seems to become infrequent from the Late Palaeolithic onwards (Vicent 1991) and nowadays are considered to be extinct (Hayden 1998). In short, delayed-return systems are to be expected for Neolithic communities.

From an anthropological perspective, Tim Ingold has tried to avoid some of these misleading concepts by stating that farming is not about producing food, but *growing* food (Ingold 1996). Thus, farmers establish the conditions for growth of those plants that they decide to be the most appropriate. The distinction between gathering and cultivation is only the "relative scope of human involvement in establishing the conditions for growth of plants".

As stated by K. Marx, human beings interact with their environment through labour. The outcome of the intentional investment of labour is a product and, as a result, any intentional investment of labour to obtain a food product must be considered as **food production** (for a wider discussion on the topic of production, see, for instance, (Piqué 1999, 15-18).

Why is this debate of significance? Because plant food production is not exclusive of those groups who practice agriculture and, even in that case, it is not just about cultivated food plants. The production of plant foods is the result of an intentional action (investment of labour) on a raw material of plant origin to consume it for an alimentary purpose. For this reason, plant food production includes all the strategies of production (which may require learning, planning, experiencing, obtaining, processing, storing, sharing, exchanging or cooking) that a group can apply to survive out of resources of plant origin. Ingold adds to the formerly presented argument that the definition of the wild and the cultivated might not be so clear among early farming communities. They grow their plants in the wild. They live in the wild. The perception of the environment is a key factor to understand early farming communities and their mode of production, which is a **mixed strategy of wild and cultivated plant management**. This fact is what makes early farming a particularly fascinating mode of production (the domestic mode of production, in words of Sahlins (1977) and what singularizes it from others.

2.2. Early farming: a labour-intensive and mixed economy?

In the following chapter, the working hypothesis concerning the nature of early farming in the North-East of the Iberian Peninsula is presented. The possible processes of labour involved in such mode of production are discussed through the consideration relevant ethnographic references. For a complete understanding of the implications of this mode of production, animal husbandry practices are also considered. This holistic approach is necessary in order to fully understand the complex nature of this mode of production.

2.2.1. Plant and animal husbandry in early farming societies

Four **crop husbandry models** have been considered by most authors for Prehistoric times in Europe: shifting cultivation, extensive ard cultivation, small-scale intensive cultivation and floodplain cultivation (literature compiled by Bogaard (2004b). These models derive from ethnographic references, which were not always obtained from comparable socioeconomic case studies. That would be the case of shifting cultivation, which is mostly known at present from tropical areas (Netting 1986). Other models, like small-scale intensive cultivation, were obtained from rural areas within the Mediterranean region, central Europe and the Atlantic coast of the Iberian Peninsula. But how can we be sure that those models known at present times were the only possible ones for the Neolithic period in the area of study? How can we compare a biased archaeological record with the present ethnographical models? The actual truth is that it is very difficult to know what practices disappeared during the first millennia of evolution of agriculture. One must also take into account that the cereal varieties that were grown at those times might have equally disappeared and that their ecological requirements could be different. Likewise, the ecology of the associated weeds that developed with those crops could have been rather different to the one that is known at present. For this reason a holistic ethnographic and archaeological approach becomes necessary. It is the combination of the study of crops, weed diversity of the fields, settlement pattern, social organization of labour, environmental factors, technology, animal husbandry practices, etc., which can help to elucidate whether present ethnographic models can be applicable to case studies from the past.

An important and interesting debate on this topic has been going on in Central Europe for decades and arguments in favour of each of the above-mentioned models have been proposed (see also the literature compiled in Bogaard 2004b). If only considering archaeobotanical approaches, permanent field cultivation is usually acknowledged for all the Neolithic period. Arguments in favour of shifting agriculture are usually based on pollen records (see, for instance, Rösch 1993, Rösch et al. 2008; experimental work was presented in Rösch et al. 2002). A. Bogaard carried out an analysis of the weed flora from newly cleared experimental plots of the Hambach Forest. The results demonstrated that there are no archaeobotanical samples in the Neolithic of central Europe which yielded indicators for shifting agriculture (basically woodland perennials and woodland annuals) (Bogaard 2002). However, further debate has concerned the intensity of this cultivation. Several authors have proposed that small intensively managed plots were cultivated in this area (Bogaard 2004b, Jacomet, Brombacher & Dick 1989, Maier 1999, Maier 2001, Hosch & Jacomet 2004), while others consider that fields would not be so intensively managed. According to the latter, livestock could have been used to naturally manure the fields and prepare them for sowing (in spring) (Kreuz & Schäfer 2011, Kreuz 2012). These divergences are due to differences in methodology (see some further discussion in chapter 5.2.7).

With the purpose of distinguishing between these crop husbandry models on the basis of field weed ecology, A. Bogaard carried out an evaluation of the large archaeobotanical dataset for the Neolithic period (mainly Early Neolithic, due to the limitations of the available record) from West-Central Europe was carried out (Bogaard 2004b). Three key variables were identified in order to distinguish among the four above-presented models (Bogaard 2004b, 50): permanence, intensity and seasonality. Permanence distinguishes shifting agriculture, which is characterized by non-permanent fields. Intensity is a useful variable to discriminate extensive ard cultivation from intensive cultivation. Finally, seasonality could allow the identification of floodplain agriculture, which is characterized by spring sowing (for a more detailed discussion see (Bogaard 2004b, 51-59). The evaluation of the record was based on the ecological requirements of the weed assemblages that were identified in direct association with charred cereal remains. These assemblages were analysed with a rather new methodology called **Functional Interpretation of Botanical Surveys (FIBS)** (previous work demonstrating the uses of this method to identify crop husbandry practices had already been published: J ones et al. 1995, Charles, Jones & Hodgson 1997, Jones et al. 1999, Bogaard et al. 1999, Bogaard et al. 2001, Charles et al. 2002, Jones 2002, Charles & Hoppé 2003). FIBS is based "on the measurement of "functional attributes" – morphological and behavioural traits that measure species' potential in relation to major variables such as fertility, disturbance and moisture" (Bogaard 2004b, 7). One of the main advantages of this model is that such attributes can be measured on the same taxa growing under different crop husbandry regimes and in different geographical areas and that the data can be used to interpret the complete weed dataset, which "reduces the potential for erroneous conclusions due to major changes in the behaviour of individual species" (Bogaard 2004b, 8). When possible, the relevant attributes for all the identified taxa in the region were measured on specimens collected from at least three separate locations in Europe. The data were complimented with modern weed studies from the Hambach Forest experiment (shifting cultivation), and surveys of weeds growing in various plot types in Germany and Greece. This allowed the identification of the relevant functional attributes for the identification of the models. Other variables were considered in order to interpret the archaeobotanical assemblages, like the harvesting height or the crop processing stage represented by each assemblage, since both have a clear effect on the weed composition of the samples (Jones 1992, Bogaard, Jones & Charles 2005, Reynolds 1985). This is probably the best methodology that exists at present in order to evaluate archaeobotanical weed assemblages.

Bogaard concluded that fixed plots sown in autumn and managed using intensive methods (like weeding and manuring or middening) were used to grow cereals during the Neolithic. Under this evidence, this author also defended that early farming is economically characterized by the interdependence between small-scale crop and animal husbandry practices (Bogaard 2004b, Bogaard 2005). Bogaard's proposal does not include wild plant management, but it can be assumed that it would be equally intensive.

A. Bogaard, among other authors (e.g. Netting 1986, van der Veen 2005), defines "intensive" or "garden" cultivation as a restricted scale of cultivation with high labour inputs per unit area, as opposed to "extensive" cultivation, which involves larger areas of land with less frequent cropping (e.g. shifting cultivation) and/or less careful management (e.g. extensive cultivation with the ox-drawn ard or floodplain cultivation) (Bogaard 2004b, 41, Bogaard 2005). Intensive farming is usually combined with "intensive herding", which, according to the same author, indicates high labour inputs for a relatively small number of animals kept close to the settlement. The outcome of this combination is what can be called **"intensive mixed farming".** On the other hand, "extensive" management of large herds are compatible with extensive agricultural practices, which do not require inputs form herds (e.g. manure) (Bogaard 2005). Intensive mixed farming results in relatively high-yielding but small-scale plots that are within the labour capacity of a household. Livestock is exploited for multiple purposes (mainly meat but also milk, wool and traction). Cultivars provide forage and fodder for herds and livestock supplies manure for cultivated plots and regulates crop growth (Bogaard 2004a; Bogaard 2005). According to Bogaard, one should not discard the possibility of the use of manuring to maintain the fertility of the plots.

According to the work of G. Jones, based in recent observations of traditional crop management in Evvia (Greece) (Jones 2005), there is a positive correlation between plot size and intensity of disturbance, as well as between distance from the site and plot size. Consequently, intensively managed fields were located close to the village. The same picture is observed in other ethnographic works and historical records in the Iberian Peninsula (Peña-Chocarro 1999, 30-31). If we consider the results of the study of G. Jones as representative for the Neolithic period, these data suggest that as long as we deal with disperse households of relatively autonomous farmers (which is frequent during the Neolithic) we have more possibilities to encounter intensively managed small fields or gardens, since access to arable land would be in the immediate surroundings of the dwelling area. Netting, in fact, proposes the opposite model to that of G.Jones. This author considers that densely populated areas tend to cultivate intensively because available arable land is a limited resource. On the other hand, areas with low densities of population tend to practice shifting cultivation (Netting 1986, 69-70). Nevertheless, shifting cultivation is practiced with a large variety of crops including tubers, ground vines, bushy vegetables, stalked plants and trees with climbing vines (Netting 1986, 63). Such diversity is not documented, until now, in the Neolithic in Europe.

Nevertheless, it must be recognized that the **diversity of cultivation regimes** that could have existed during the Neolithic or the degree of intensity of these practices could have varied due to local or regional factors. Recent work carried out at the LBK site of Vaihingen showed a clear example of the different scales of intensity of crop husbandry that were practiced by its inhabitants, mainly due to the distance between the fields and the village. It was interpreted that five clans of different origins lived in this site (based on the lithic and ceramic styles), and that they were linked to particular areas in the settlement with distinct architectural features. Two groups belonged to the local Middle Neckar traditions and three came from northern regions. A systematic sampling was carried out and the weed-rich assemblages were analysed using FIBS. The authors concluded that those groups which were interpreted as local clans exploited the more intensively managed plots (probably because they had the right to grow their crops in the nearest fields) while clans from elsewhere only had access to further fields which, due to their location, were not possible to manage as intensively (Bogaard, Krause & Strien 2011). This study clearly shows the need of systematic sampling of entire sites in order to evaluate the actual diversity of crop husbandry techniques during this period, and it also stresses the fact that intensive agriculture was preferably practiced by early farmers.

Considering the results obtained in central Europe, the **starting hypothesis** of this project was defined: early farming practices in the NE of the Iberian Peninsula were of intensive type. This would include crop husbandry practices, as well as livestock and wild plant management. This hypothesis will be eventually tested under the light of the newly obtained archaeobotanical data (chapter 5). It is, for this reason, of extreme importance to first define the many processes of labour that can be involved in a mixed farming economy, so that these can be identified or discussed using the archaeological evidence. Each phase of the production process can be carried out in a more or less intensive way, depending on several factors that need to be evaluated from an interdisciplinary perspective. Some of the potential practices in intensive mixed farming economies that are known through ethnographic works are presented in the next chapter.

2.2.1.1. Intensive crop husbandry among early farmers: cereals, legumes and poppy

Among the various agricultural techniques that are known to us through classical works and recent ethnographic records, the question is which ones would be more typical of an intensive system. To answer this question we need to address each of the phases of the agricultural cycle (*sensu* Hillman 1981, Jones 1984). The archaeological methods for approaching each phase of the process will be presented in chapter 3.

In the following paragraphs I will centre the discussion on cereal crops and only at the end some comments will be added concerning legumes and poppy, which are much more difficult to study in archaeological contexts due to taphonomic reasons and any interpretation concerning husbandry methods is purely tentative.

2.2.1.1.1. Cereals

The study of the first stages of the agricultural process requires determining the **location of the plots**, the **permanence** of their cultivation and the **intensity of soil disturbance** that is practiced to grow plants. Intensive practices usually imply high soil disturbance in small plots that are close to the site and permanently cultivated on a long term basis.

Concerning the **location of the plots**, recent ethnographic work in Greece and Romania shows that fields are mostly located at less than half an hour distance from the house (Jones 2005, Hajnalová & Dreslerová 2010). Larger distances make intensive agriculture somewhat impracticable.

Soil disturbance would imply the use of specific tools, such as digging sticks, spades or hoes. It might also include some rooting by pigs (Gross, Jacomet & Schibler 1990, 110, Halstead 2006, Kreuz 2012). According to the ethnographic observations of F. Sigaut (1984 *cit.* Alonso 1999, 175), farmers who do not have the technology or the possibility to produce and use metal tools do not use hoes, since these seem to be extremely inefficient when produced on any other raw material. When this technology becomes available, hoes are usually used for the areas where the plough cannot be used or on small plots (Alonso 1999, 175). Conversely, flint hoes have proved useful in some experimental works (Guinard & Guinard 2001). Wooden hoes were equally tested and resulted efficient, especially on fields previously disturbed by pigs (Hosch & Jacomet 2004); Jacomet, pers.com.). According to N. Alonso (*op.cit.*), spades allow a deeper penetration into the soil than digging sticks and the resulting disturbance is more intense. The plough is rarely used in intensive models of farming. Nevertheless, recent ethnographic work by V. Isaakidou and P. Halstead in Greece and Asturias seems to show that ploughing with cows, unlike ploughing with oxen, is actually an intensive method of tillage, since it is slower and less thorough, and it is technologically available to any household. Manual work would still be required to finish the work, but the process would become much more efficient. As A. Bogaard (Bogaard 2011, Bogaard 2012) has put it, the cattle-drawn ard would facilitate intensive agriculture, rather than expanding the surface of arable land. Therefore, the use of the plough in the Neolithic period should not be discarded.

Drilling is prone to be the most widespread **sowing method**. Broadcasting is mainly practiced together with ploughing (usually with an ox-drawn ard), an extensive practice. As some authors already pointed out, broadcasting requires harrowing after ploughing because the seeds of pulses and cereals only germinate in the dark (Kreuz & Schäfer 2011). Drilling is practiced together with row sowing, which is more labour-intensive. Drilling is the most time consuming method but it is, at the same time, the simplest and it can easily be performed by two people, one digging holes with a digging stick or a spade and one dropping the seeds. This technique, together with row-sowing, was applied in some rural areas of Catalonia up to the first half of the XXth century (M. Pujol, pers.com.). It is the system that produces higher yields, since there is a very low loss of seed corn, and consequently it also requires a lower amount of grain (Halstead 1987).

Sowing time may vary, not only due to husbandry practices (e.g. spring sowing is practiced in regimes of floodplain cultivation) but also depending on the varieties of cereal that are being grown, some being more fast-growing than others, and the climatic conditions (Fig. 1). It is important to note, though, that autumn sowing favours higher yields (Wilkinson & Stevens 2008, 190). On the contrary, according to the experimental works carried out at l'Esquerda (Catalonia, Spain), barley, for instance, seems to produce more successful results, on the long term, if sown in spring than in winter (Cubero et al. 2008). Recent investigations on traditional agricultural practices in Andalucía, southern Spain, show that altitude (and climate) is also an important factor for sowing time. Einkorn was sown in October and November in areas around 1000 m a.s.l., but between January and February at lower altitudes (Peña-Chocarro 1999: 32). Other variables may affect sowing time. Heavily manured fields are sown at later dates (January- February) by farmers in Asturias to prevent lodging (plants may grow too much if too many nutrients are available) (Halstead 2006).

The **crops** that are under cultivation have some implications on labour and ecological demands that should be considered (Fig. 2.1). The available information is, at times, contradictory and further research on this topic seems rather necessary. The main limitations are the impossibility of identifying each of the varieties grown in the past, the fact that some of these could have gone extint and the risk that they could have changed their growing habits. Free-threshing wheat species (*Triticum durum, T. turgidum* and *T. aestivum*, according to the traditional classification) are considered winter-hardy and high yielding. They are poor competitors with weeds and need greater soil fertility than other wheat species (Van der Veen 1992, 74). Nevertheless, some authors highlight that tetraploid naked wheats, e.g. macaroni wheat (*Triticum durum*) and rivet wheat (*Triticum turgidum*) grow better as spring crops, since they have good resistance to drought but not to frost (Percival 1974, 207). Naked barley is less adapted to wet climate, since it is more prone to develop fungal diseases or ear sprouting (Van der Veen 1992, 74-75). Despite this fact, it can grow at high altitudes above 1500 m a.s.l. (Rovira 2007, 329). Emmer grows in lighter soils than other cereals like spelt and it is suited to warm, dry climates. The majority of forms are rapid-growing spring varieties with low resistance to frost (Percival 1974, 188; (Van der Veen 1992, 145) although some authors describe it as primarily autumn sown (Rovira 2007, 332). Einkorn produces a relatively low yield compared to other wheats, but it can survive on poor soils and its awns and glumes protect it from the attacks of birds (Percival 1974, 171, Zohary & Hopf 2000, 35), while its straw is highly valued for basketry and thatching in certain regions (e.g. Peña-Chocarro 1999, 36). It is primarily an autumn-winter sown crop (Rovira 2007, 333, Hajnalová & Dreslerová 2010). Hulled barley is known for its rusticity, and is considered to grow successfully on poorer soils or those soils that had been degraded after generations of cultivation (Bouby 2010, 310). It is particularly tolerant of saline and alkaline conditions (Renfrew 1973, 81). The two-rowed variety is usually sown as a spring crop (Rovira 2007, 330). As other researchers have noticed, a lot of experimental work is needed to obtain better knowledge of the ecological range of the different varieties of cereals that exist.

Taxon	**Preferred sowing season**	**Maximal altitude**	**Type of soil**	**Competitor with weeds**	**Tolerance of wet climate**
Hexaploid naked wheat	Autumn	(grows well in cold areas)	Eutrophic	Poor	No data
Tetraploid naked wheat	Spring	(does not tolerate cold winters)	Eutrophic?	Poor	No data
Naked barley	Both	Over 4000 m	adaptable	No data	No
Emmer	Spring (both)	1600 m	Lighter dry calcareous soils (adaptable)	Good	Medium
Einkorn	Autumn (both)	(grows well in cold areas)	Poor soils, dry calcareous soils (adaptable)	Good	Good
Hulled barley	Spring	Over 1500 m (grows well in cold areas)	Adaptable to very poor soils	No data	No data

Fig. 2.1. Main characteristics of the cultivated cereals considered in this text. References: (Shands & Dickson 1953, Percival 1974, Jacomet, Brombacher & Dick 1989, Van der Veen 1992, Rovira 2007, Hajnalová & Dreslerová 2010, Li et al. 2011).

Crops may be sown under different regimes (for a complete list see, for instance, Table 24.1 in Butler 1999b, 465), as single crops or as a mixture; and under crop rotation between different cereals or between cereals and legumes; or with bare fallowing. **Monocrop and maslin cultivations** have both advantages and disadvantages. As P. Halstead explains, threshing with animals (by trampling) is the most efficient method of threshing in the absence of a threshing sledge. This technique, though, requires a certain quantity of crop in order to be efficient and not to damage the grain. This, eventually, favours a tendency towards monocropping (Halstead in press), unless the crops belong to the same crop type (namely, free-threshing or hulled) and ripen at the same time. In such cases maslin crops can be harvested and processed together. Alternatively, maslins may be a risk-reduction practice (usually one of the crops grows better in years with abundant rainfall while the other does better in dry years) but they require expertise and specific efforts during threshing; for instance, P. Halstead (*op.cit.*) refers to the need of selecting wheat seed corn from barley-wheat maslins during threshing in order to keep them as maslins (otherwise, barley would overcome the whole crop in a few years).

Crop rotation (including bare fallowing) has important implications on productivity and the integrated husbandry of plants and animals within a community. **Bare fallowing** could have been practiced in the Neolithic but, in a context of intensive farming practices, where water availability was not necessarily a limiting factor, some authors have argued that **crop rotation** of cereals and pulses could have been a more common option in order to maintain the fertility of the soils (Halstead 1987).

Farmers have several options to improve the conditions of growth of their crops. Weeding and manuring are among the most commonly practiced. **Weeding** can be easily carried out when fields are sown in rows, which could be assumed for the Neolithic given the proximity of the fields to the settlement. Up to three periods of weeding have been reported in recent ethnographic work from emmer/spelt fields sown by broadcasting in Asturias (Peña-Chocarro 1999, 40). According to L. Peña-Chocarro (*op.cit.*), the observation of actual practices shows that weeding is not practiced unless there is an interest in obtaining the straw from the field. This would only be possible with highly competitive crops, such as glume wheats, since weed growth reduces nutrient availability and, eventually, productivity. Weeding becomes especially necessary towards May, when both the cereal and the weed plants have developed. At this stage uprooting weeds would be relatively easy and several tools could have been used, like digging sticks, spades or hoes (Guinard & Guinard 2001). **Middening** (or the use of domestic waste on arable land) and **manuring** (or the use of animal dung) imply the application of extra labour input into farming, and their beneficial effects may not be noticeable until years or decades after (Bogaard 2012). Their transportation is usually a limiting factor for their use and ethnographic work in Greece by P. Halstead suggests that manuring is rarely applied on fields at distances over 500 m from stalls (Bogaard 2012). Manure can be obtained in a more natural way, though. Sheep could have also entered the fields to graze unripe crops, which would prevent lodging and promote tillering, apart from naturally manuring the field (Bogaard 2004a). Both middening and manuring are more prone to take place among dispersed systems, where there is easy access to arable land (for a wider discussion on this topic see Bogaard 2012).

Harvesting techniques are diverse and they depend on several factors, as explained by F. Sigaut (Sigaut 1991; Alonso 1999, 178-179). Legumes are usually uprooted, but the techniques that are more likely to have been applied more systematically on cereal crops by early farmers are either breaking ears, by hand or using *mesorias*, or cutting ears by pressure or handfuls of stalks by friction. Of these methods, the more labour-demanding one would be ear-plucking. This method has been observed in ethnographic work carried out in Asturias but it seems to be applied to very small fields (mainly of glume wheats) where using reaping sticks is not worth (Peña-Chocarro 1999, 40). One of the main concerns when deciding what harvesting technique to use is the final aim of the straw. Harvesting with the straw also requires more labour input concerning transport, threshing and winnowing (Halstead 1987). According to Sigaut (1988, *cit.* Alonso 1999, 179) the use of a sickle only takes place when the straw is also obtained and when means of transport are available. Such statement might refer to modern sickles and might not be applicable to the use of flint sickles in the Neolithic period. In fact, L. Peña-Chocarro reports the use of sickles on einkorn fields even in cases where the straw is not wanted. In such cases, a mid-height harvest is practiced in order to obtain not only the tallest but also the lowest ears. Even though some straw is harvested, usually the cut is done above the first culm node (Peña-Chocarro 1999, 34). Ethnographic observations seem to show that ear harvesting is more widespread in the Northern Mediterranean areas due to slower ripening than in warmer southern regions (Halstead in press). G. Hillman also points out the fact that small-scale (garden) agriculture is usually processed in a small scale (at a household scale, in small spaces, mainly using human labour). In such cases, minimum quantity of straw is wanted and for this reason ear-harvesting becomes the most appropriate harvesting technique (Hillman 1984). Moreover, ear harvesting minimizes grain loss during transport (Hillman 1985). As a final remark to this issue, ethnographic work in Romania has documented the harvesting of whole plants with scythe or sickle. Sheaves are weeded by hand during harvesting and, later on, the straw is cut away from the ear (plant by plant or using a particular device to process several plants together). The final threshing is carried out on a small-scale and already free of most of the straw and weeds (Hajnalová & Dreslerová 2010). This example is of high significance because it results in a very similar product to ear-harvesting but the straw is not left on the field. It demonstrates that an interdisciplinary approach, including tools and processing products and by-products must be conducted in order to reach reliable conclusions concerning harvesting techniques.

After harvesting, farmers could either try to process the crop if the weather conditions were the appropriate or store it to process it on a piecemeal basis. Different techniques of **threshing** are known from ethnographic references and their use depends on several factors, such as the quantity of crop to be threshed, the climate, the availability of animal labour force, the type of crop and, especially, the purpose of the harvested product (Halstead in press). The most labour intensive threshing techniques are threshing by hand, either by rubbing ears against baskets, by hitting sheaves against hard surfaces or by lashing the harvested crop with a long stick. Such techniques are mainly applied when the harvest is of small size or when the weather does not allow an outside threshing. This latter case was recorded by G. Hillman during his ethnographic work carried out in Turkey (Hillman 1984). If animal force is available, threshing can be practiced either by trampling or by using different threshing implements like the threshing sledge or several types of threshing stones (e.g. Gaillard 1997). Such techniques require larger amounts of sheaves. When animal labour force is used and crop yields are low, farmers can combine crops to avoid threshing small quantities by hand (Halstead in press).

Ethnographic references from several regions show that the intended use of the harvested material may condition the method of threshing. If straw is wanted for thatching or basketry, lashing and flailing are the more convenient methods, while the threshing sledge was more appropriate if straw was aimed for animal fodder (Gaillard 1997, 34-39). Consequently, the use of the threshing sledge probably meant that extensive herding was being practiced, although other uses are known for the straw (e.g. as organic temper, as bedding material, etc.). Manual threshing was considered to be more thorough than trampling with animals, which could produce significant loss of unthreshed grain (even more than 10% of the grain) (Gaillard 1997, 42).

The crops are at risk while on the threshing floor, since they are vulnerable to climatic disasters or animal attack. For this reason, threshing is always aimed to be finished as soon as possible (Halstead in press). Some crops require a longer threshing process, especially glume wheats and hulled barley. Glume wheats must be de-husked after threshing if they are to be consumed as grain (not if they are aimed as fodder). For these reasons, they are usually stored in spikelet form and de-husked piecemeal indoors. Hulled barley has sharp awns that cause irritation, also in animals, and may require a second threshing and winnowing in order to remove them (Halstead in press).

Several **dehusking** techniques are known (e.g. Peña-Chocarro et al. 2009), all of which are labour-demanding. Barley is usually grounded without de-hulling and the fragmented hulls are retrieved at a final stage by sieving the flour (Procopiou 2003). Barley can also be de-husked by several other methods and some experimental results on their efficiency are available (see Procopiou 2003). Pounding usually damages grain and this makes the product more prone to spoilage during storage. Some experimental projects have been carried out to compare the efficiency of the different dehusking techniques and to establish ways of identifying such practices in archaeobotanical contexts (Meurers-Balke & Lüning 1992, Alonso et al. 2013). Some authors have concluded that saddle querns result in a high loss of product (they produce a higher proportion of flour and fragments) and that they would be very inefficient for this purpose (Meurers-Balke & Lüning 1992).

After threshing (and also after pounding), **winnowing** must be practiced. This is a rather simple process but it can also be carried out at different scales. In ethnographic examples from Greece, small crops are lifted with bare hands or with the aid of a sieve or tin. Larger volumes that are threshed with animals were normally winnowed in bulk with a fork and a shovel (Halstead in press). After winnowing, **coarse-sieving** and **fine-sieving** would be necessary to obtain a relatively clean product.

After winnowing (and probably after sieving), grain could be washed. There are several reasons for this process: one would be to wash away the urine and faeces of animals used during threshing; the other one would be to remove weevil-infested grains (Hillman 1984a, Hillman 1985, Halstead in press). Ethnographic observations in Greece indicate that **grain washing** is only practiced by small-scale farmers producing for domestic consumption and mostly in dry climates, when farmers know that grain can be dried before storage (Llaty 1997 *cit.* Halstead in press). There are ethnographic records of the **drying** of the grain of free-threshing cereals using a source of heat (e.g. a hearth), sometimes using a large marmite (Gall 1975, Kanafani-Zahar 1994).

Grain storage is a key step of the process. The amount of grain that is needed to maintain a family for a year is rather variable, but quantities of 1-1,5 tons have been suggested by Greek farmers. Such quantity would require between 1300 and 3000 litres of storage capacity depending on the stage of processing in which the product is stored (Halstead in press). Similar quantities have been considered adequate by other researchers: 1250 l for a family of 5 (Alonso 1999, 231); 1300-3800 l (Sigaut 1981, *cit.* Alonso 1999). In a context of small-scale productivity, farmers must foresee years of bad harvest besides sustaining the basic needs of the family and the grain needed for the next sowing (Halstead 1989a). Moreover, experimental works on crop yields seem to show that the main variable to be considered is climate (e.g. Reynolds 1999, Cubero et al. 2008), which makes bad yields nearly unavoidable and risk-reduction practices absolutely necessary. This surplus may not just be for the consumption of a particular household. Reciprocity among village neighbours is attested in ethnographic examples from Greece (Halstead 1989a). As P. Halstead (*op. cit.*) points out, this was also a good way of storing ("social storage") since surplus was consumed (and so it did not spoil or destroy) while the donator would expect to get it back when needed. Surplus grain can also be fed to animals, also as a type of storage. Usually, this decision is only taken during the course of the agricultural year (Halstead 2006).

Different storage techniques were described by several authors based on ethnographic observations (e.g. Sigaut 1988). The chosen techniques depend on what has to be stored, the purpose of the product that is being stored and the amount of time it must be stored. Surplus should be stored in a much safer way than grain for everyday consume, while grain for next sowing must be kept in optimal conditions, but only for a few months (3-8 months) depending on the sowing time. Grain for malting in order to produce beer must also be stored in good conditions to maintain its germination capacity (Sigaut 1988, Alonso 1999, 204). Ethnographic records show that grain for sowing is stored in a wide variety of containers and structures located both in dwelling areas and next to the fields (Alonso 1999, 204). F. Sigaut (1988) describes the harvesting and storage of ears in elevated storages (storage of ears in air-tight conditions seems to be rare) as the "primitive system". This practice requires a thorough drying of the crop to avoid insect infestation and it also needs a larger storage capacity (Alonso 1999, 203). A second model is the so-called "Mediterranean system" of sickle harvesting and storage in bulk, very often in underground silos. Some processing of the grain might take place in order to facilitate storage. This was observed in Tunis, where barley was roasted after a period of storage in underground pits and before putting the grain into jars. This process was considered to allow a better preservation of the grain (Ferchiou 1985).

Grain processing for consumption is equally diverse, from consuming whole grains to finely grounded flour, different degrees of modification are noticed and aimed. Likewise, different treatments can be applied to the grains, such as soaking, parboiling, toasting or fermenting (Hillman 1984a, Hillman 1985, Stahl 1989, Sigaut 2010). Grain processing is labour-demanding and it implies some loss of product, which according to P. Halstead (in press) is not affordable in times of scarcity. Other authors, though, highlight the fact that grain processing can increase the nutritional value of foods, which would pay for any costs or losses (Stahl 1989). Grinding is laborious. Experimental work with small saddle querns by D. Samuel (Samuel 2009) shows that grinding could take three hours of work per day before the introduction of the rotary quern. This suggests that flour-based products could have been a relative luxury in the past (Halstead in press). Cereal groats are easier to produce and so more widely obtained in present ethnographic observations in Greece (Halstead in press). Fermented beverages could have been another luxurious product of early farming societies consumed in the context of feastings (Hayden, Canuel & Shanse 2013). In general, A. B. Stahl (*op. cit.*) defends that increased processing of a resource can correspond to an increase of reliance on it as a staple food, and, as a result, as an indicator of intensification.

2.2.1.1.2. Legumes

Legumes can follow a similar type of harvesting and threshing processes to the ones described for cereals. Not much is known about the harvesting procedures, since all the interest is focused on cereal plants and uprooting is assumed as the most commonly harvesting technique for legumes. According to observations in Greece, much more care seems to be taken not to damage legumes during threshing. Lashing or trampling seem to be the most frequently applied methods, especially when the harvest is not very important (Halstead in press). Legumes are grown both for their dried grain and as green vegetables, as well as valuable fodder. As acknowledged by A. Butler, more ethnographic work would be desirable on cultivation and processing of legumes (Butler 1999b).

Pea, lentil, broad bean and chickpea share the same environment and farming practices in the past could have been similar for all of them (Butler 1999a). Present observations of traditional farmers in the Near East and Ethiopia show that farmers reserve the best soils for cereals (or other crops) and grow legumes in marginal plots, with a minimal investment of labour in tillage or manuring (Butler 1999a, Butler et al.

1999). Pulses may act, then, as a support to a primarily cereal agriculture and may be a risk-reduction strategy that can be essential in times of famine. Nevertheless, legumes require aerated soils, for which a digging stick with stone can be highly effective (Guinard & Guinard 2001). For this reason, they are considered to be labour-demanding.

Winter-sowing is preferred for lentils and peas, but only when the right conditions are available (low likelihood of frosts, adequate soil moisture, etc.). However, chickpeas and broad beans are frequently sown as spring crops. Mixed cropping has been documented in several regions of the Old World and some authors have highlighted the fact that these practices should not be discarded for Early farming contexts (Butler 1999a). Manure can be applied but it is not frequent. Harvesting could have been carried out by up-rooting or by cutting with a sickle. Pods can also be ripened and the stubble can be subsequently grazed (Butler 1999a). In the town of Tivissa (Ribera d'Ebre, Catalonia), up-rooting of legumes is recorded during the twentieth century, and farmers used to say that it is better to harvest legumes on a cloudy day, so that the pods do not shatter (Jardí & Jardí 2009). Pod-plucking and uprooting reduce weed infestation to the minimal and threshing becomes much easier (Fuller & Harvey 2006). After harvesting, the plants are dried but care must be taken that pods do not start shattering, which produces high grain losses. Lashing and beating are usually applied to thresh crops, especially when the harvest is small. Sometimes, very small harvests can be taken directly home to be processed by hand (Butler et al. 1999). Not all legumes are "free-threshing". As noticed by some researchers, some legumes require several threshing processes (the so-called "pod-threshing" types) (Fuller & Harvey 2006). Winnowing is an important task, since legume straw and pods are highly valued as fodder and farmers intend to have good control of the separation of the different products and by-products (Butler 1999a). Storage of legumes is usually not as significant as cereal storage and ethnographic observations mainly document the storage in pots or baskets (sealed with dung) inside the house (Butler et al. 1999). Parching/drying previously to storage has been documented in India (Fuller & Harvey 2006). Culinary processing of legumes is also diverse. Legumes are commonly soaked to hydrate or soften the seed coat (in order to remove it afterwards), where most of the unwanted tannins are concentrated (Stahl 1989). Testa removal, though, is not only limited to those legumes with toxic components, but a very generalized practiced in certain areas (Valamoti, Moniaki & Karathanou 2011). Grinding is also known in several regions (Peña-Chocarro & Zapata 1999, Butler et al. 1999).

2.2.1.1.3. Poppy

Opium poppy (*Papaver somniferum*), is the last of the several crops that were managed by early farmers in the Western Mediterranean that I will comment on in this chapter. Of all the domesticated crops we have considered, opium poppy is the only for which the wild progenitor (*Papaver somniferum* subsp. *setigerum*) is found in the Iberian Peninsula (Tétényi 1997). Nevertheless, no archaeobotanical record of its presence and use is available before the arrival of the first Neolithic populations. This is probably because of palaeoeconomic and taphonomic factors. For this reason, the domestication of local varieties of poppy should not be ruled out at this stage of research. Ethnographic work on the husbandry practices related to poppy is not very extensive and it would be rather necessary. Our data come from few sources outside the ethnobotanical or the archaeobotanical scientific world.

Poppy grows in a variety of ecosystems, including arid climates and marginal soils (Hobbs 1998, Evered 2011a), but it rarely grows well in heavy clayey soils or sandy permeable soils (UNODC

(United Nations Office on Drugs and Crime) 1950, Tétényi 1997). Fertile sandy/loamy soils with high organic matter and crumbly structure are the best suited for opium poppy (Tétényi 1997). In ethnographic and historical observations in Turkey, the planting of the poppy occurs in the late summer (early to mid-September) (Evered 2011a) although spring sowing is also possible, especially in areas where winters are very harsh (UNODC 1950). Poppy impoverishes soils. For this reason, it is usually manured or planted in rotation systems after a crop that has been manured or after legumes. Some sources say that poppy should not return to the same field for 5 or 6 years (Tétényi 1997). Consequently, poppy fields are usually small, close to the village and intensively managed (and manured by grazing herds) (UNODC 1950). Fields in Turkey used to be ploughed and then either broadcasted or sown in rows (UNODC 1950). Frost was a risk for the survival of the seeds and Turkish farmers usually covered them with manure. Protection of the fields against wild animals was necessary, since wild pigs were known to eat the plants just prior to harvest (Evered 2011b). In spring, intensive weeding is necessary so that the crop grows strong (UNODC 1950). Harvesting methods in this area in the recent past involved lancing carefully the plants' capsules with a small blade as soon as the farmers considered that the seeds had matured (usually in May, in lowland areas). This action could be done up to five times. The day after each lancing, the dried opiate-rich gum that came out of the capsules was scratched with a wooden spatula and collected in a wooden bowl (Evered 2011b). This was a labour-intensive job that lasted until the month of June (for a month or more for each household). Later on, the capsules could be left to dry in the field and only then harvested and smashed (or flailed) within the house to obtain the fully ripe seeds. Seeds could be easily separated by sieving (UNODC 1950). Harvesting is usually carried out 20 to 25 cm below the capsules (Tétényi 1997). Seeds are used to produce cooking oil and they are also crushed to make an edible paste which can be eaten with bread (like peanut butter). The seeds are also consumed without processing in baked goods (breads and pastries) (Evered 2011a). Merlin also reports the possibility of obtaining flour from the seeds and highlights that approximately 45% of the total seed weight is oil, which made it a very attractive source of fat in the past (Merlin 1984). It was also traditionally used as a narcotic to suppress pain. Poppy leaves were also consumed in salads. The stalks could also be used as temper or for thatching, in addition to fuel (Evered 2011a). The medicinal use of opium poppy was already known in Mesopotamia and textual evidences of it are known (Adamson 1991). Infusion of the capsules is documented in Ancient Greece and some authors consider that this would be the way in which early cultivators of poppy would consume it (or even at raw state) and so they would only be softly exposed to the narcotic effect of the plant (Merlin 1984, 96). For a more thorough compilation of the many uses of poppy, see, for instance, Tétényi 1997.

2.2.1.1.4. Final remarks

As a final remark on these aspects, it must be kept in mind that farmers may change husbandry techniques as a response to several situations: people to feed, need of an optimal harvest, etc. (Halstead 1987). The practice of each strategy is usually related to several variables such as the type of settlement, its total population, the size of the household unit, the available means of production, and the social organization of the group. So we must think of a flexible strategy that could have been locally adapted and temporarily modified, according to farmer's needs and environmental conditions.

This overview of the husbandry techniques that might be implied by intensive agriculture shows that the practice of farming *per se* is not indicative of the investment of labour that it requires or its environmental impact. We must try to identify the particular husbandry practices applied in each community, ideally by each household, and across time, in order to understand how these practices were arranged under the many constrains that they had to face.

2.2.1.2. Intensive animal husbandry: the integration of herds and crops in a mixed farming economy

Herding and crop husbandry practices have a great number of connections. The strategies of livestock management are never independent from agricultural practices. Animal dung can be used to manure the fields. Some agricultural by-products can, at the same time, be used as fodder. Animals can also participate in part of the agricultural work, being used as labour force. Specific crops can be grown to feed livestock. There are abundant ethnographic examples which show these influences. **Shifting cultivators** usually have a low number of small domestic animals and they never manure their crops. In highland New Guinea, farmers only kept pigs and hens and protein was obtained from fishing and hunting. Contrary to permanent field cultivation, shifting cultivations may increase game availability through the controlled burning of wooded areas and so there would be a lower need for domestic animals (Boserup 1967, 61, Rowley-Conwy 1981, Isaakidou 2011). **Floodplain cultivation** would allow nearly "self-cultivating" soils that required no tillage, weeding or manuring. Domestic animals would not play an integral role in this regime and they would only be raised for their meat (Sherratt 1980, Isaakidou 2011). As other authors already noticed, this model lacked of actual ethnographic reference (Isaakidou 2011). In **intensive garden-type farming**, limited woodland clearance would have confined small numbers of livestock to arable land, especially at night, which would result in intensive manuring (Halstead 1981). Intensive manuring may cause some problems like the appearance of more weeds or the rapid growing of cereals, which entitles some risk of lodging (Halstead 1981). To prevent this, some farmers in several regions of the Mediterranean area let sheep enter into the fields and graze the cereal plants while still on vegetative phase. This practice delays growth and makes plants grow stronger (Halstead 2006). Sheep were optimal for cleaning, weeding and manuring fields, and their sole presence on the field acted as soil disturbance (Thomas, 1957, *cit.* Rowley-Conwy 1981), while pigs could destroy every weed, bring up valuable elements from the subsoil and heavily manure the land (Seymour and Seymour, 1973, *cit.* Rowley-Conwy 1981). In intensive mixed farming models, animal exploitation is diversified: meat, milk and traction are exploited but usually not in a systematic way. Cattle would need surplus grain as fodder if used as labour force. These same animals would pull sledges and transport the harvest from fields to the village, piles of manure from byres to fields, as well as hay from meadows to village byres (Isaakidou 2011). It is important to keep in mind, though, that intensive herding would imply some periods of high investment of labour, like in spring, when most animals would give birth and the females would need to be taken care of. Risk of loss of animals not only happened at this time, but also in winter, when changes of light and temperature took place, and fodder availability reduced (Saña 2011). Unlike previous models, this model was taken from Mediterranean analogies, which makes it much more reliable than the previously presented ones. Besides, it considers a wider range of evidences and in much greater detail. The last of the models, **extensive ox-drawn ard agriculture**, does not require manuring, and so livestock can be fed outside the arable land. Numbers of livestock can increase but larger displacements of the herds (e.g. pastoralism) are necessary to obtain adequate grazing (Bogaard 2004a).

P. Halstead has highlighted the fact that the characteristic transhumance that has been observed until present times in large areas of the Mediterranean region should not be assumed for late prehistoric societies. This type of husbandry would only be needed when herds became of a rather large size, which is not observed in the Neolithic record in Greece (Halstead 1987, Halstead 1996).

Feeding livestock may be a labour-demanding activity and different feeding strategies are adopted in different herding systems. Since feeding habits are slightly different between pigs, ovicaprines and cattle, it is possible that changes in the composition of herds reflect changes in the environment and animal husbandry practices. Cattle herding would be enhanced if pastures were available. Sheep can graze small areas, since they move and feed in rather tight groups. Goats can feed on more dispersed resources (Halstead 1981). The low-productive Mediterranean garrigue has the advantage of allowing year round pasture for goats and sheep.

In extensive herding systems, animals must be taken to pastures or meadows to graze, since fallows or recently harvested fields would be insufficient for large herds. Pastures can be tended and, as a result, they can be more or less productive. Usually, the more intense the human intervention, the more productive pastures become but also the more homogeneous they turn. Diversity of resources usually results in a better alimentation (Bouby & Ruas 2005). Intensively managed herds are kept in the settlement at night and especially during winter. During those periods, they must be fed with fodder, which can consist of stalks, leafs, branches, grain or by-products of the several processing stages of the harvest. Leaf foddering usually becomes systematic among intensive herders. Farmers are interested in harvesting branches with the minimum weight of wood and the maximum weight of leafs possible. Usually, twigs are cut every 3-5 years from each tree, so the same individuals can be managed for decades. Managed trees become more productive and useful for farmers and allow a decrease of the amount of time dedicated to their obtention. The impact on vegetation around the village must have been remarkable (more detailed ethnographic references on leaf- and hay-foddering in Greece are available in Halstead 1998).

As stated by other authors (Bogaard 2004a), intensive small-scale farming is the type of husbandry that best fits the crop husbandry model that has been proposed as a hypothesis for our study.

2.2.2. The wild and the domesticated. Hazelnuts, acorns and other *wild* plant resources among early farmers

Wild plants would not only be part of human diet in the past but they would also be necessary for animal feeding and building purposes, among other uses. Some of these practices would require much labour investment and organization and their study is basic for the understanding of past societies. Despite this, most of the work that has been done on early farming societies has focused on (domesticated) crop husbandry. Partly, this is due to the difficulties of studying wild plant management among prehistoric groups: the scarce archaeobotanical evidence (due to the lower chances of fruits of becoming charred (Willerding 1971)), the lack of specific tools, the use of systems of storage that are not properly identified in the archaeological record, etc.

J. O'Shea defined several types of systems where a mixed management of wild and domestic resources could take place. This systematization was constructed on ethnographic observations in North America

(O'Shea 1989). **Simple systems** would be those where only one community would be involved. These can be of regular type, which means that wild resources would be gathered on a regular basis, as part of the year-round activities. On the other hand, they can also be of episodic type, where decisions would be made on a year-to-year basis according to the production obtained from farming activities. These systems are flexible and endurable, as long as the territory of the group is well-defended and predictably productive.

Complex systems involving more than one community can exist as well. In such cases, two models are presented, one where specialized communities exchange their products (hunted game for grain, for example); or one where several communities put their labour force together for large hunts or massive gathering of plant products. Such systems are less stable because they involve more than one community.

Simple regular systems seem to be the most appropriate for our context of analysis. This type of model was observed in ethnographic work carried out in Methana (Greece) (Forbes 1976). Here, gathering was practiced mainly by women (but also by men) and usually not as a specific task but something which was done while carrying out of other activities (caring of grazing livestock, checking the state of crop fields, etc.). The inhabitants of the investigated villages used to eat wild vegetables as much as their own crops. This percentage only decreased in recent times. This model suits an intensive exploitation of the surrounding environment of a village and goes in accordance with intensive mixed farming practices.

Early farming communities exploited wild plant resources as much as cultivated ones. As formerly stated, it must be kept in mind that the present distinction between wild and domesticated might not have existed in the past (Ingold 1996). Early farmers mostly inhabited dispersed farmsteads, they lived in the wild. Growing plants would only entitle the establishment of the conditions for their growth. Considerable labour investment could have been put to the preferential proliferation of high yielding wild plants, such as hazels, oaks or several grasses and wild legumes. Some authors (Guinard & Guinard 2001) have proposed that cultivars might have been grown around economically valued wild trees. If apple trees or hazels were found in a clearance or a potential arable area, why would farmers cut them down? The possibility that they were kept inside the fields must be considered and tending of these trees must have probably taken place. This would have occurred if new fields were not burned, as commonly assumed, but just tilled and the organic matter left on the ground, which has a number of benefits for the crops (see Guinard & Guinard 2001). Some taxa may have entered into cultivation at this point, such as opium poppy or marian thistle (Guinard & Guinard 2001). At this point, one fact must be taken into consideration. Many Mediterranean woodland species are resprouters, therefore fire and tilling might not be sufficient to open new arable land. The complete extraction of the roots would be necessary.

Some information is available for two of the main gathered fruits during the Neolithic in the North-East of the Iberian Peninsula (Zapata 2000, Buxó & Piqué 2008): acorns and hazelnuts. In the following lines we will focus on the processes of labour that may require their systematic harvesting, processing and consumption.

2.2.2.1. Acorns

As stated by several authors (e.g. Salkova et al. 2011), acorns are nutritionally comparable to cereals. They contain carbohydrates, fats and fibres, as well as proteins, amino acids and vitamin A. Mason did a major work of compilation of historical and ethnographic examples of the processing and use of acorns in the world and she also did ethnographic research, together with M. Nesbitt, in Turkey (Mason 1992, 91-93; Mason & Nesbitt 2009). Some ethnographic references to the Iberian Peninsula are also known (García-Gómez, Pereira-Sieso & Ruiz-Taboada 2002). I will mainly deal with the European/Mediterranean examples from Mason's work. It is noted by all these authors that acorns are usually interpreted as a minor resource or as a famine food (Mason 1992, 48, García-Gómez, Pereira-Sieso & Ruiz-Taboada 2002). According to S.Mason, little serious discussion of their processing requirements or their taphonomy has been carried out.

According to historical and ethnographic references, acorns were frequently gathered but not always for human consumption, since they were much appreciated for pigs, but also for other animals. Records of the use of acorns for feeding livestock in the XXth century in the Iberian Peninsula report the use of acorns of *Quercus ilex* and *Quercus suber* for pigs; but acorns from *Quercus coccifera, Q. faginea* and *Q. pyrenaica* would be better given to goats, sheep and cattle (Martín 1960). It is not clear, according to S. Mason, whether they were gathered from the trees or from the floor. Both methods were recognized as having been used by elderly people from the province of Toledo, in central Spain (García-Gómez, Pereira-Sieso & Ruiz-Taboada 2002). Knocking of the branches to make acorns fall can be quite destructive but, at the same time, this process can be beneficial, since it acts as some sort of pruning and more light will reach undamaged parts in the next years. This technique also reduces the competition of ground-feeding animals and insects. Nutritional differences between the obtained products in each case should be mild, as long as harvesting is carried out when the fruits are ripe. Green acorns are also known to have been gathered. In Turkey, acorns are mostly picked from the floor, which is the way for locals to know that they are sweet enough. In some cases, cupules are extracted in the field and only acorns are taken to the site (Mason & Nesbitt 2009). Oak yields are not constant year after year (Salkova et al. 2011) and so this has to be foreseen in the management strategies (a relatively large number of trees has to be tended or at least considered for harvesting to make sure that the production will cover the needs of the household or the community).

Storage is an essential step if wild fruits management was part of a risk-reduction strategy. Acorns would be gathered in autumn, when other resources would be available, so if one wanted to consume them when no other resource was left, this had to be calculated and optimal storage would have had to be practiced. Mason reports some references from Abu Zacaría Iahia Al-Awam, an Arab author from al-Andalus who lived in the tenth century. This author specifies that special care must be taken to dry acorns before storing them. That could be done by spreading them in an airy sunny position or by smoking them over a fire. Some studies suggest that parching/roasting is essential to prevent from any insect infestation (Mason 1992, 186) and recent experimental work in England confirmed that roasted acorns store much better, rottening being the main problem (Cunningham 2011a).

Several methods of preparation of acorns are recorded in Europe (Mason 1992, 82 and 86-88), especially destined to remove their tannins (which have a bitter taste and are slightly toxic). The method that is used depends on several factors: availability of time and labour force, of fuel, of the instruments for boiling, etc. Sweet acorns, e.g. from *Quercus ilex*, can be eaten raw. They can be peeled manually (with a knife) (Mason & Nesbitt 2009).Washing acorns or burying them in soil, boiling them in water or milk, drying and parching them before turning them into flour are several of the methods that were used. Acorn flour could be used to produce bread. In Sardinia, shelled acorns were boiled in water, then crushed and red clay was added (clay absorbs the tannins). Boiling could take several hours. The resulting substance was solid enough to be cut into slices. According to Al-Awam, shelling of acorns could be done by placing them in a bag and hitting it carefully with a mallet. Roasting of acorns is also reported. The use of acorns also as a source of oil has been recorded in NW Africa and in the Iberian Peninsula. Acorns are smashed and cooked in water. Then the oil floats to the surface of the water and it is recovered with a small bowl or a spoon (García-Gómez, Pereira-Sieso & Ruiz-Taboada 2002). Experimental processing by S. Mason (1992, 188) showed that leaching and roasting increase the content in proteins of acorns, while the cooking of bread decreases fat contents. More experimental work is needed on this field.

According to S. Mason, roasting of acorns is more common with sweet types of acorns, which are eaten in small quantities, as a snack. Most archaeologists consider that this is the main cause for the charring of acorns. Mason considers that this practice might only happen in sites where acorns were a less important element of the diet (Mason 1992, 192).

Historical records tend to emphasize the importance of acorns in the Western Mediterranean, especially, reaching a considerable percentage in the human diet, particularly among poor people (Mason 1992, 83).

2.2.2.2. Hazelnuts

Hazelnuts are rich in oils (50-66%), proteins and calories, as well as in vitamins (especially B1 and B3 and minerals (phosphor, iron, calcium and potassium) (Boada 2005).

Available information of historical or ethnographic records on traditional management of hazels is scarce. Most of the information presented in this chapter is based on the work of A. McComb and D. Simpson (1999) in Ireland.

According to McComb and Simpson (McComb & Simpson 1999) the ideal moment for gathering hazelnuts is when the seed is formed but the shell is not fully ripe. Unlike oaks, hazels are shrubs and this makes fruits more easily available to human and other animals. Thus, strategies to avoid loss of product due to competitors must have been applied. After harvesting, the fruits can be sundried. In order to maximize the harvest, collection should be carried out in several days during the period of maturation, since fruits ripen at different frequencies.

Hazelnuts are easily stored. Recent experiments have concluded that over 50% (and sometimes up to 80%) of the harvested product stays edible after 5-8 months of storage in pits and baskets (Cunningham 2011a). Losses must have been already considered by farmers in the past and probably more than what was strictly necessary would have been collected.

Hazelnuts can be eaten in raw state but several authors have highlighted the benefits of roasting (Zapata 2000, Holst 2010). Several roasting techniques are known through ethnographic examples (for an overview, see Holst 2007). This process adds labour input to the costs of obtention of the product but there are other advantages, like the fact that heat can kill insect larvae and so improves the durability of the fruits. Besides that, they are less likely to be attacked by fungi, especially if gathered in unripe state. Taste may also be improved and fruits become easier to break and grind. Processing of the fruits can also reduce the volume of the final product up to 50% (Holst 2010). Hazelnuts could have also been eaten crushed, ground, soaked and mixed with other foodstuffs. Processing would also contribute to their digestibility if large amounts were to be consumed (McComb & Simpson 1999).

As can be observed in both cases (acorns and hazelnuts), gathering wild fruits was probably a well-planned regular practice that could have implied the tending of wild plants and the construction of storage structures. Significant investment of labour could have been paid to their culinary processing, which, according to Stahl, should be interpreted as a sign of their perception as staple foods (Stahl 1989).

2.3. The social significance of an intensive mixed economy: a hypothetical characterization of early farming communities

Despite the economic meaning connoted by the expression “early farmers”, this concept is part of a theoretical model that includes other aspects regarding group size, decision-making structure, social complexity and gender roles. This is because early farming economies can only be understood within the general framework of the **Neolithic Revolution** (understood in social terms, not in purely economic terms (see below)). In the following paragraphs, a hypothetical social model that was taken as a framework for understanding plant food production during the Neolithic in the NE of the Iberian Peninsula will be presented. This model is based on ethnographic references from modern societies with a similar settlement pattern, social structure and means of production to those assumed or known for the Neolithic period. Archaeological references are also mentioned, especially when they tried to verify these ethnographic models.

Several authors like J.M. Vicent have tried to re-explain the exact meaning of the Neolithic Revolution, as Gordon Childe defined it. This revolution is not a technological one and it is not about subsistence. The revolution is a social one, one by which new forms of social organization arose. This revolution is, according to this author, the last phase of the Upper Palaeolithic Revolution (Vicent 1991). This view is not shared by many other authors who consider that the transition from hunting and gathering to farming is the revolutionary change *per se* (e.g. (Bar-Yosef 1998). This has been criticized by many other authors, who propose that such transition was more evolutionary than revolutionary (e.g. Fuller 2007, Purugganan & Fuller 2009, Fuller, Willcox & Allaby 2012). This sort of reduced understanding of the concept of the Neolithic Revolution is not used in this text.

Sahlins expressed that the **household** is the basic unit of the domestic mode of production (Sahlins 1977). But what is a household? What size were households in the Neolithic? How was their production and reproduction capacity managed? Several definitions can be found in the literature, and ethnography yielded a rather diverse number of possible ways of structuration of these units. Only some examples which are suitable for our economic model are mentioned in this text. As defined by P. Bogucki (Bogucki 1993) “household members share cultural values and expectations, and by definition live in similar physical and social environments. Economically, the household is a co-operating group that jointly makes production decisions (Barlett 1982, *cit.* Bogucki 1993). Socially, it is the unit of reproduction and the focus of social interactions and obligations". As pointed out by other authors, it is important not to confuse the concepts of households and houses or domestic spaces (Doppler 2013, 50). Households do not equal dwelling units in all societies and, on other cases, one household can own and use several adjacent buildings (Wilk & Rathje 1982). According to M. Sahlins (1977, 92-94), households organized production and labour capacity, as well as the economic goal of the whole process. The limiting factor for their production is the availability of labour force (Bogucki 1993, Bogucki 1988). Besides, Meillassoux, based on ethnographic examples of self-sufficient farmers of Africa, emphasized that the domestic unit is the only economic and social system that controls social reproduction (Meillassoux 1979).

The available archaeobotanical evidence from central Europe is considered to support this social structure during the Neolithic period. A. Bogaard affirms that small-scale intensive farming appears better suited to nuclear households and the concept of "transegalitarian" societies as developed by B. Hayden (Hayden 2003), which provides a theoretical framework in which households may invest high amounts of labour to compete with other households (for a more complete discussion on this topic see Bogaard 2005). Animals can be kept close to the dwelling area (long-distance herding is unnecessary) which is compatible with childcare and the use of child labour. Larger herds would require larger amounts of labour force (Bogaard 2005). There is also, according to ethnographic observations among the Kofyar in northern Nigeria, a connection between intensive agriculture and household size (Netting 1986, 76, Netting 1993, 6). Usually, small households are more productive (per person per unit of land) than large households because they are more efficient with linear tasks (processes of labour that can be carried out by one or two people) (Wilk & Rathje 1982). It is possible, then, that small households persist as long as intensive agriculture is practiced and vice versa.

The archaeological evidences from Neolithic sites in Italy and Greece were equally considered to support this model. J. Robb carried out some analyses on the size of households in the Italian Neolithic that might be applicable to the Iberian Peninsula, considering the meagre available record on house and village size (see chapter 2.5). Typical huts in the Neolithic in Italy had an area of 15-40 m^2. Based on Narroll's rule, Robb states that this would agree with nuclear families (2-4 people). Most communities would be constituted by less than 100 people (sometimes much less). Similar conclusions were reached by P. Halstead for Neolithic Greece (Halstead 1981). Robb applied this data according to a demographic model developed by K.M. Weiss (1973, *cit.* Robb 2007, 40-41), estimating 50% of child mortality and a life expectancy at age fifteen of 25 years. The results are of great interest. In a community of 25 people there would be 10-12 children (under 15) and six adults of each sex. Only two elderly people (over 50) would be expected. As Robb points out, such settlements would have needed to bind social relations with neighbouring communities in order to survive. Marriages must have always been with members from outside the community in order to make it viable on a long term. According to H. Wobst (1974, *cit*. Robb 2007, 42), a community would have needed to be in contact with seven to nineteen groups (175-475 people) to form a stable mating network, which would have required a territory of 80-200 Km^2 (as a minimum area at a particular moment in the past) (Robb 2007, 100).

According to M. Sahlins (Sahlins 1977, 92-94), production was oriented according to the needs of the household and everything that was produced was for their own benefit. It is assumed from ethnographic references that production is characterized by the **sexual division of labour** and that age would also determine the labour capacity of individuals.

The existence of sexual division of labour during the Neolithic in the Iberian Peninsula was recently reviewed by R. Piqué and T. Escoriza. These authors presented a preliminary evaluation of the tasks represented in Levantine rock art in comparison with the archaeological record, especially from the site of La Draga (Banyoles, Pla de l'Estany), where the waterlogged conditions of preservation allowed the recovery of a large number of tools and, consequently, a large number of activities were recognized. Feminine representations are scarce and related to agricultural and gathering activities, while most of the representations focus on men and hunting activities. On the contrary, the archaeological record shows a low importance of hunting activities and a major representation of agricultural tools and products. Therefore, it seems that sexual division of labour existed during the Early Neolithic and that it undervalued female work (Piqué & Escoriza 2011). A systematic review of these evidences for the NE of the Iberian Peninsula is currently ongoing (S. Duboscq, PhD in progress, Universitat Autònoma de Barcelona). Similar conclusions were obtained for the Upper Palaeolithic in Europe (Owen 2009).

If some techniques were gender-specific, only a low number of adults would have had the knowledge and experience to carry them out and the transmission of this knowledge was basic for its survivorship within the group (Robb 2007, 42). On particular events, production could be organized at different levels, also above the household level (communities, lineages, etc.). It has been calculated that some works, like the digging of a ditch around a village, could involve the full-time **work of the entire community** for about a month (Robb 2007, 94). It has also been argued that certain production processes like pottery or shell bead manufacture could imply more than a single household. Similar conclusions were achieved for the site of Arbon Bleiche (Lake Constance, late IVth millennium cal BC) after considering the animal bone and artefactual evidence (Doppler et al. 2011). Moments of social aggregation for production and consumption would bring households together as a community (Tomkins 2004).

Who was in charge of **plant food production** among early farming communities? The production process included a large diversity of tasks that were carried out by all the members of the household. In some ethnographic examples, children and elderly people keep an eye on herds or scare wild animals from the crop fields (Boserup 1986, 15, Alonso in press). Very recently, N. Alonso performed an evaluation of the ethnographic evidence gathered by G.P. Murdock concerning farming societies who depended on agriculture for at least 55% of their subsistence. The author concludes that women have a prominent role in most societies who practice shifting agriculture and intensive agriculture (or horticulture). The role of men in the production process is usually more important at particular stages, like the opening of new fields or the harvest (where the whole household would participate). Conversely, women would be in charge of soil disturbance, sowing and weeding, as well as domestic food processing (milling, dehusking, etc.). It is likely that the role of men in plant food production only became important after the introduction of the plough. The extensification of crop husbandry practices derived the female role to that of domestic work and child breeding. It is possible then, that a profound change in the social role of men and women took place in the societies which introduced the use of the plough and, in general, animal traction, as already noted by some archaeologists (Sherratt 1981).

Such mode of production puts women in the centre of the productive activities. They are responsible for the continuity of agricultural practices and they become the central pole of the household. Nevertheless, families would usually need to incorporate new women, especially in those cases where no female offspring was obtained. Wars and kidnapping would be originated by the need of incorporating women into small communities. Despite the important **role of women** in the subsistence of the household, their labour force is not valued within the community (Meillassoux 1979, 48-50).

The role of women in plant food production has not been systematically targeted in Neolithic archaeology in the Western Mediterranean region. Nevertheless, as mentioned above, rock art seems to show that such activities were mostly carried out by women (Piqué and Escoriza 2011; Alonso in press).

As J.M. Vicent clearly states, **"farmer"** does not necessarily mean "person who practices agriculture". Farming life is characterized by the immediate linkage of the individual with the land through the investment of her or his own labour in order to transform it into a mean of production. This investment of labour is high enough to reduce the interest in its abandonment (Vicent 1991).

The question of **sedentism** is also a matter of debate in archaeology, since radiocarbon dates are not as accurate as would be desirable and the partial excavation of the majority of archaeological sites leaves many blanks in our record. Callmer, considering the archaeological data of south-east Scandinavia, proposes that there are different degrees of settlement mobility. Mobility within less than 500 m (considered as a flexible threshold) from the original location of the house can be considered as sedentism, since it "does not take people out of the area with which they identify" (Callmer 1991). Whether one agrees or not with this statement, it should be recognized that sedentism of dispersed farmsteads cannot be compared to nucleated settlements.

Intensive cultivation may derive in an attitude towards the **property** of plots and their inheritance (Bogaard 2004a). Consequently, it may also derive in a tendency towards sedentism (Jones 2005). When land is privately owned, the organization of agriculture seems to take place at a household level. Communal farming has been recently studied in Northern Jordan but only among nucleated villages surrounded by extensively managed fields without permanent boundaries (Palmer 1999). In this regime, farmers do not decide what to grow, the decision was taken by agreement, including fallow practice. For this reason, C. Palmer considers that continuous cropping should be more typical of systems with privately owned land (Palmer 1999).

2.4. The North-East of the Iberian Peninsula: an introduction to the area under study

2.4.1. Geomorphologic and climatic setting

The NE of the Iberian Peninsula (Fig. 2.2) is a very diverse area, with very high mountains towards the North (the Eastern Pyrenees) and large interior plains, as well as long coasts (*c.* 700 km). The region of Catalonia, which is more or less the region under study (which also includes Andorra and one site in Castelló), is over 30,000 km^2 (for a more detailed description of the information that will be given below, see Folch, Franquesa & Camarasa 1984, 215-329).

Fig. 2.2. Location of the area under study.

Five main geomorphologic units can be identified (Folch 1990) (Fig. 2.3): the Pyrenees and the pre-Pyrenees, with an alpine, subalpine and submediterranean climate (following an altitude gradient), run in east-west direction and they become higher and wider towards the west (reaching over 3000 m a.s.l.); the pre-Littoral chain, which runs parallel to the Mediterranean coast, but at a certain distance (c. 50-70 Km) and has some high peaks over 1000 m a.s.l.; the Littoral chain, which runs very close to the coast, with a typical Mediterranean (or mountainous Mediterranean) climate; between these two chains (which are known as the Mediterranean system), the pre-Littoral depression is found, a fertile basin that has been used as a corridor for communications since Prehistory; further inland, the Central Depression, a large plain with continental climate, fills up the space between the pre-Littoral chain and the pre-Pyrenees.

The hydrographical network is divided into two major sectors: to the west, the Ebro river and its tributaries, the Segre and the Noguera Pallaresa and Noguera Ribagorçana, all of which are important rivers that start in the Pyrenees and confluence with the Ebro river; and, to the east, one can find minor rivers that flow to the Mediterranean sea along the Catalan coast. In the eastern sector, the fluvial regime is irregular, being dry much of the year (except major rivers like the Llobregat and the Ter).

The Western Plain (or Central Depression) is crossed by the Ebro river on the South, the Llobregat river on the East and the Segre river on the West (Fig. 2.3).

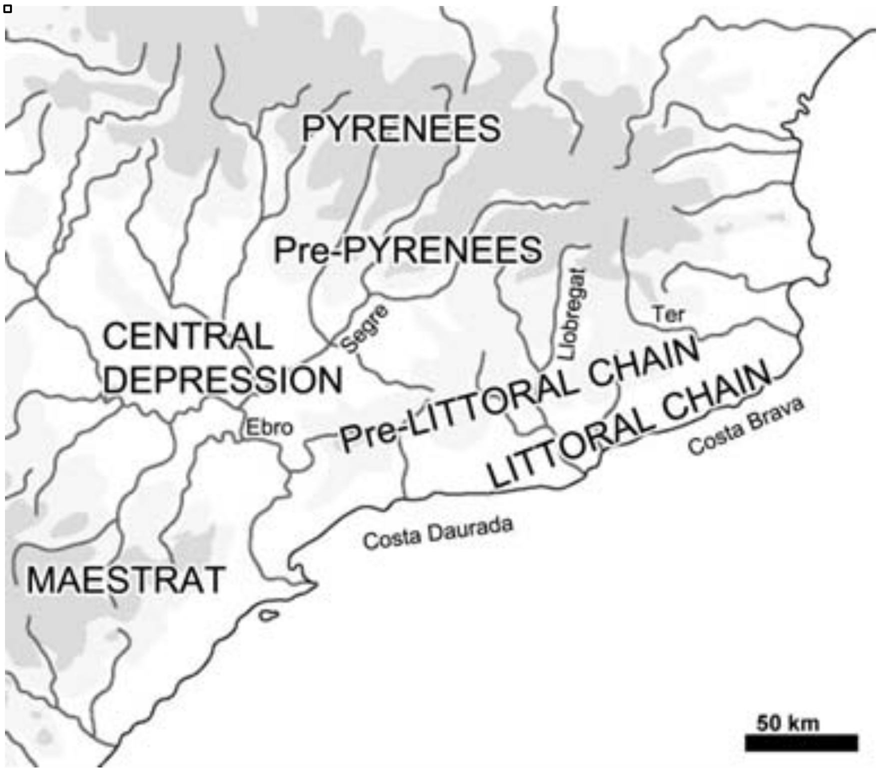


Fig. 2.3. Main geomorphologic units and rivers of the NE of the Iberian Peninsula.

The coastline is characterized by the alternating areas of *Costa Brava* (approximately 40% of the coast), where the rock comes directly in contact with the sea, and *Costa Daurada* (approximately 60%). The coastline during the Neolithic was significantly different, especially concerning the deltas of the Llobregat and the Ebro, which did not exist (Gàmez et al. 2011), but also the rest of the coastline, which is currently under water. No reconstruction of the palaeoshoreline is available.

The studied region is situated within the temperate zone of the northern hemisphere. Besides the climatic characteristics derived from its latitude, this area has some particular features, which both derive from the influence of neighbouring territories (Mediterranean, Atlantic Europe, and mainland continental areas) and the diversity of the relief, which emphasize the variety of climate. In alpine and subalpine regions, the highest precipitation is expected (700-1000 mm), especially during spring. Usually, winters are very cold and summers are rather cool. In submediterranean regions the summers are hot, but occasional rains keep temperatures a bit lower than in Mediterranean regions. Precipitation stays over 500 mm. Mediterranean climate is mostly dry all year round, with mild winters and very hot summers. Most of the heavy rains concentrate on September and October (Folch 1990). Continental and coastal Mediterranean precipitations stay very low (below 500 mm). In general, the lack of water is a limiting factor in agricultural production in large areas. Areas with one or two months of drought are very extensive. In the interior plains, arid conditions are found from June to September.

Average annual temperatures are relatively high: ranging from 4° C (the coldest areas of the Pyrenees) to 17° C (the southern coastal area). The thermal contrast is more marked in the interior plains (with an amplitude of about 18-21° C), while the coastal oscillation is lower (13-15° C amplitude). This means that there is danger of frost in the interior from November to May, whereas frosts are incidental in the coastal areas.

Concerning lithological diversity, the primary terrains of the Pyrenees-Mediterranean system consist of schistose and granitic material (siliceous rocks), the secondary terrains are predominantly calcareous (pre-Pyrenees, Garraf mountains, etc.) and the tertiary and quaternary lands are composed of loams, clays, sandstones and conglomerates.

2.4.1.1. Vegetation

The NE of the Iberian Peninsula is located within the Holarctic ecozone. The vegetation of this region is extremely varied and includes representation from virtually all major types of vegetation that exist between the Arctic Ocean and the Mediterranean Sea. **Arctic-Alpine formations** are almost exclusively restricted to the Pyrenees. Grasslands occupy the higher lands of the entire Pyrenean massif, roughly between 2300 and 3000 m. In the **subalpine zone**, the boreal coniferous forests of mountain pine (*Pinus mugo*) and fir (*Abies alba*) are found. The former extend throughout the Catalan Pyrenees, between 1600 m 2300 m, approximately. The latter are especially important on the northern slopes, more or less between 1200 and 1600 m. The **sub-Mediterranean region** expands from the southern slopes of the Pyrenees to the medium height mountains of the Mediterranean system (800/1000 – 1600/1800 m a.s.l.). There are mixtures of pine and deciduous trees (oaks, hazels and beech) in the middle mountain altitudes and inner valleys of the Pyrenees (Folch, Franquesa & Camarasa 1984). Deciduous oak woods (*Quercus* sp. deciduous) are found in low acidic grounds on the southern slopes of the Pyrenees, mainly on limestone and the more humid areas of the plain. **Meso-termomediterranean vegetation** occupies most of the region (most of the territories below 800/1000 m a.s.l.), especially towards the southern, coastal and inner lands. Evergreen shrubs and trees are the most frequent in these formations. The vegetation of the Mediterranean system and the north-eastern part of this region are dominated by evergreen oak (*Quercus ilex, Quercus coccifera*) woods, while the southern coast, from the Llobregat to the Ebro delta, mastic (*Pistacia lentiscus*) and *Chamaerops humilis* (Mediterranean dwarf Palm) are the main taxa. In the inner lands, one can find other sorts of evergreen oaks (especially *Quercus rotundifolia*) and buckthorn (*Rhamnus* sp.). Barely any woods are found in the dryer regions of the western sector (Folch, Franquesa & Camarasa 1984).

2.4.1.2. Administrative organization of the territory

The territory of Catalonia is subdivided into four regions (Lleida, Girona, Barcelona and Tarragona) and 41 *comarques* or districts (see Fig. 2.4). The name of the *comarques* will be used to locate archaeological sites mentioned in this text. The formula that will be used will always be: first the town where the site is located and then the *comarca* (for instance, La Draga is in Banyoles, Pla de l’Estany). This system has been used with the aim of helping the reader to locate the sites within a rather precise territorial unit.

*Fig. 2.4. Administrative divisions (*comarques*) of Catalonia at present (source: ICC).*

2.4.2. Palaeoenvironmental setting (5400-2300 cal BC)

The palaeoenvironmental record for the region under study is particularly rich, both considering pollen records and anthracological analyses. More recently, pedo-anthracological analyses have started to approach the vegetation history of high mountain areas (Cunill 2010, Cunill et al. 2012). Many researchers like E. Allué, F. Burjachs, I. Euba, C. Mensua, R. Pérez-Obiol, R. Piqué, S. Riera, M.T. Ros or S. Vila have contributed to a better knowledge of the vegetation of this area during the Holocene. In this work, we will deal with the Early Atlantic (6900-4700 BC), the Late Atlantic (4700-3500 cal BC) and the subBoreal (3500-750 cal BC) periods. The so-called "Mid Holocene" phase (*c*. 5000-3000 cal BC) refers to the Late Atlantic and the beginnings of the subBoreal periods.

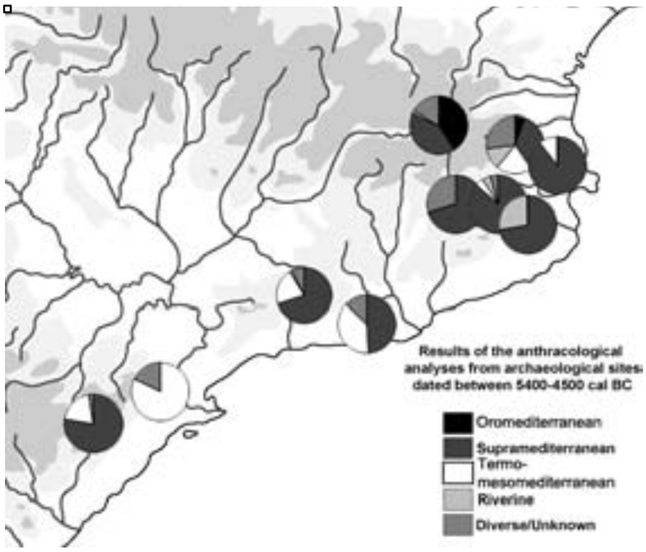


Fig. 2.5. Results of the anthracological analyses (>100 NR) from archaeological sites dated between 5400-4500 cal BC (see references in the text).

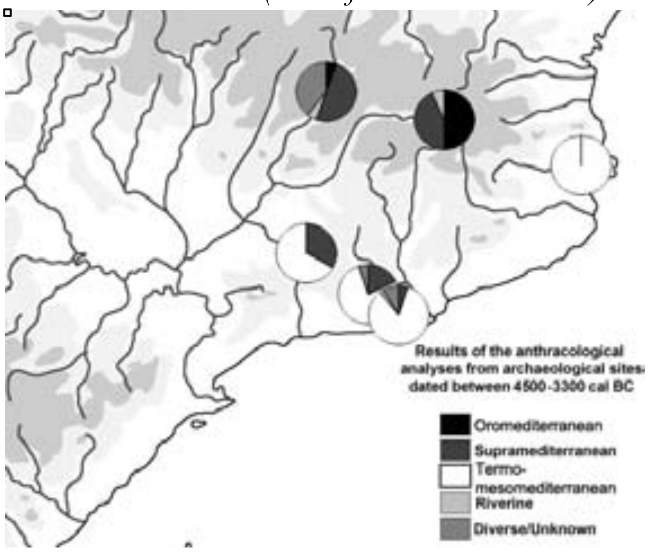


Fig. 2.6. Results of the anthracological analyses (>100 NR) from archaeological sites dated between 4500-3200 cal BC (see references in the text).

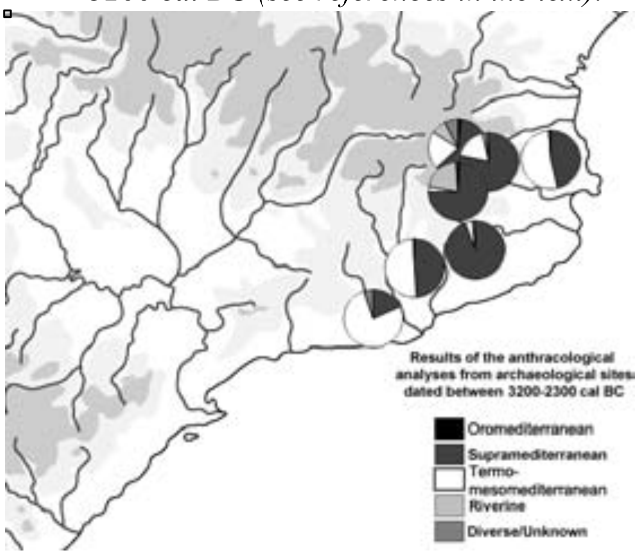


Fig. 2.7. Results of the anthracological analyses (>100 NR) from archaeological sites dated between 3200-2300 cal BC (see references in the text).

Anthracological analyses have been performed at a large number of sites, and it has been considered of interest to plot in maps the amalgamated results for settlement phase (for the location and typology of the sites see Figs. 2.8 to 2.12). Only those sites with more than 100 charcoal fragments identified have been considered as representative. The data have been grouped into three large chronological phases: 5400-4500 (roughly, the Early Neolithic), 4500-3200 (the Middle Neolithic), and 3200-2300 cal BC (the Late Neolithic). Ten sites have been considered for the first phase (Fig. 2.8): Balma Margineda (Leroyer & Heinz 1992), Can Sadurní Cave (Antolín et al. 2013, Antolín et al. 2013); 120 Cave, Pau III Cave, Barranc d'en Fabra (Ros 1996), La Draga (Piqué 2000), La Dou (Mensua and Piqué, unpublished), Plansallosa (Bosch et al. 1998), Guineu Cave (Allué, Vernet & Cebrià 2009) and Fosca Cave (Antolín et al. 2010). For the second phase, six sites were available (Fig. 2.9): Sardo Cave (Obea et al. 2011), Can Sadurní Cave (Antolín et al. 2013), Ca n'Isach, Feixa del Moro, Gavà Mines (Ros 1996, Piqué 2010) and Vilars de Tous (Clop et al. 2005). And, finally, six more sites were available for the last phase (Fig. 2.10): Bòbila Madurell, Ca l'Estrada (Piqué unpublished), 120 Cave (Agustí et al. 1987), La Prunera (Ferré & Piqué 2002), Can Sadurní Cave (Antolín et al. 2013) and Serra del Mas Bonet (Antolín, López-Bultó & Piqué in press). It is clear that more analyses are needed in the southern and interior areas of the region under study. These blanks mostly reflect areas where archaeological work has not focused on these periods.

In-site anthracological analyses give a reliable approach to the arboreal component of the landscape of the studied regions, since availability is a key factor in the final composition of charcoal assemblages. This is especially the case of cave sites, where R. Piqué noted a more opportunistic fuel gathering strategy (Piqué 2005), which means that the charcoal record probably yielded a representative spectrum of the immediate vegetation surrounding the site. The results of the anthracological analyses per site phase are presented in Figs. 2.5, 2.6 and 2.7. It is rather clear already in the **Early Neolithic** (5400-4500 cal BC; the final phase of the Early Atlantic) (Fig. 2.5) that ecological availability largely determines the spectrum of consumed taxa. Termo-mesomediterranean woodland is mainly exploited south of the Llobregat River (also observed in Ros 1996). At the north of the Llobregat River, in sites located at low altitudes with more Mediterranean influence, and at the North-East of the region supramediterranean vegetation dominates: deciduous oak (*Quercus* sp. deciduous) is the dominant taxon in the north, but the presence of evergreen oak (*Quercus ilex/coccifera*) is recorded also and it has some significance in coastal sites. However, oromediterranean taxa are relevant in high altitude sites located in the central Pyrenees (Obea et al. 2011).

A more extreme pattern is observed during the next period (Fig. 2.6), the **Middle Neolithic** (4500-3200 cal BC; roughly, the Late Atlantic phase, also known as the Mid-Holocene**)**, when termo-mesomediterranean taxa become widely used in the littoral and pre-littoral areas, while supramediterranean and oromediterrenan taxa continue dominating the record of pre-Pyrenean and Pyrenean sites.

At the final phase, the **Late Neolithic** (3200-2300 cal BC; the first phase of the subBoreal period; Fig. 2.7), the consumption of termo-mesomediterranean taxa is maintained in the coastal areas while supramediterranean vegetation keeps its preferential role in pre-Pyrenean regions.

Though patchy, these results might be reflecting a tendency towards climate aridification during the Mid-Holocene, which would be especially noticed south (and west?) of the Llobregat River and the littoral and pre-littoral areas. A tendency towards the exploitation of more shrub taxa is observed north of the Llobregat River as well (Piqué 2005, Buxó & Piqué 2008). These changes will continue during the Bronze Age where a more significant role of Termo-mesomediterranean taxa is observed north of the Llobregat River (Ros 1996). In general terms, when we speak of supramediterranean taxa, deciduous oaks (*Quercus* sp.) and Scots pine (*Pinus sylvestris*) predominate in the record, while termo-mesomediterranean taxa are more diversified: evergreen oaks (*Quercus ilex/coccifera*), Aleppo pine (*Pinus halepensis*), mastic (*Pistacia lentiscus*), buckthorn (*Rhamnus/Phillyrea*) and wild olive trees (*Olea europaea* var. *sylvestris*) are frequently encountered. Among oromediterraena taxa, Scots pine (*Pinus sylvestris/nigra*) and fir (*Abies* sp.) are the most frequently recovered taxa (for further discussion on these data see (Piqué 1998, Piqué, Barceló & Noguera 2002, Buxó & Piqué 2008, Obea et al. 2011).

Palynological analyses were also carried out in the region. Seven pollen cores from the coastline of the region under study have been analysed (for a recent synthesis, see (Riera, López-Sáez & Bosch 2004). Two more cores have been analysed in the eastern Pre-Pyrenean region (Burjachs 1994, Pérez-Obiol, 1988, *cit.* Riera 2006) (for some overviews on off-site pollen records from this region see Burjachs & Riera 1996, Riera 2006, Riera, Esteve & Nadal 2007). More recently, two pollen cores from the central Pyrenees have been published (Pèlachs 2004, Pèlachs et al. 2007, Miras et al. 2007, Miras et al. 2010) and several in-site analyses have been conducted in archaeological sites like Font Major Cave (Ballesteros 2009), Sardo Cave (Gassiot et al. 2012b), La Draga (Burjachs 2000), Plansallosa (Bosch et al. 1998) and Bauma del Serrat del Pont (Alcalde, Molist & Saña 2002), among others. Finally, pedo-anthracological data from high mountain areas has been presented in some works (Cunill 2010, Cunill et al. 2012).

In general, percentages of arboreal pollen are much higher in the northern coast (from *c.* 90% in the VIth millennium cal BC to *c.* 75% towards the IIIrd millennium). It must be said, though, that less wooded areas are detected in in-site palynological analyses at the eastern pre-Pyrenees (Bosch et al. 1998, Alcalde, Molist & Saña 2002), although one should take into consideration several agents of pollen transportation into sites (humans and animals, for instance). In the central and southern coast of our region of study, arboreal pollen stays between 50 and 75% all over the sequence (Burjachs & Riera 1996).

In the central Pyrenees, the pollen record of Lake Burg (1821 m a.s.l.) shows a dominance of birch (*Betula* sp.), hazel (*Corylus* sp.) and elm (*Ulmus* sp.), which had spread during the Climatic Optimum, throughout the first two chronological phases mentioned above (5400-4500 and 4500-3200 cal BC). In the final period, human intervention produces a noticeable reduction of these taxa and favour the spread of juniper (*Juniperus* sp.) and fir (*Abies* sp.). This confirms that vegetation change in coastal areas has comparable effects also in high mountain regions (Pèlachs et al. 2007).

In the coastal area north of the Llobregat River, deciduous oak forests predominated during the middle Holocene (Burjachs & Riera 1996, Riera 2006). However, between the Ebro and the Llobregat River, a mixed forest of evergreen and deciduous oaks is detected from the early moments of the Neolithic. Maquis formations increase their significance towards the IVth and IIIrd millennium cal BC (Riera 1996, Riera, López-Sáez & Bosch 2004, Riera 2006, Riera, Esteve & Nadal 2007). The in-site pollen analysis from Font Major Cave (l'Espluga de Francolí, Conca de Barberà), which is located rather inland and half-way between the Llobregat and the Ebro rivers also shows a mixed forest of evergreen (dominant) and deciduous oak woodland (also with pine) (Ballesteros 2009).

In general terms, anthracological and palynological analyses give rather parallel results. Termo-mediterranean vegetation is well represented in the southern half of the region and it increases its importance in younger phases. The coastal areas to the north of the Llobregat river witness the progressive expansion of evergreen termo-Mediterranean taxa, especially during the Middle and Late Neolithic. In the Pyrenean and Pre-Pyrenean regions, supra and oromediterranean taxa are identified and only towards the Late Neolithic, some significant changes can be observed.

2.5. Introduction to the studied region. The first farming communities of the the NE of the Iberian Peninsula (5400-2300 cal BC)

There has been quite a lot of discussion on the nature of early farming in Europe and, more specifically, in the Iberian Peninsula, and its relation to the spread of the Neolithic "way of life". As it will be presented here, the degree (or lack) of "sophistication" of crop husbandry has been considered by many authors as one of the reasons for the rapid spread of farming across the Mediterranean, as well as the cause for the onset or the collapse of some societies. Wild fruit management has also entered in this discussion, especially as a way of demonstrating either the continuity with Mesolithic traditions or the insufficiency of farming techniques to provide enough food for the subsistence of Neolithic groups. This discussion has not always been based on direct evidences, but mainly on the elaboration of theoretical models that can explain the expansion and evolution of Neolithic groups. As will be shown, archaeobotanical studies are very scarce for this period and they mainly concentrate on the Early Neolithic phase, with the objective of documenting the earliest evidences of the practice of agriculture in the region. Nevertheless, the available archaeological evidence can be interpreted in rather different terms. The aim of this chapter is to review recent interpretations of the Neolithic in our region and propose a more coherent discourse, under the interpretative framework that has been presented in previous chapters.

I do not intend to review all the many theoretical approaches to the Neolithic in the north-east of the Iberian Peninsula. They can be found elsewhere (for instance, Bosch 1991, Bosch 2005, García-Atiénzar 2007, Bosch & Santacana 2009). Instead, in the following chapter, a discussion of the relevant archaeological evidences and interpretations carried out for this period especially concerning plant food economy will be reviewed.

2.5.1. Farming in the Neolithic of the NE of the Iberian Peninsula

2.5.1.1. When, where and how does farming start in the area? Is it possible to identify a local role in the process?

Different dates have been given for the onset of farming in the NE of the Iberian Peninsula. This is basically due to the use of different criteria to judge C14 dates. I regard the "sample ranking" proposed by Zilhao (Zilhao 2011) is the optimal system. Consequently, the first evidences of farming in the region (dated on remains of domestic animals or plants by AMS) date back to c. 5390 cal BC, in Can Sadurní Cave (Begues, Baix Llobregat) (Zilhao 2011, Edo, Blasco & Villalba 2011). Somewhat earlier dates are available for this period from other sites, but these were obtained on human bone (in Plaça de la Vila de

Madrid (Pou et al. 2010) and charcoal (in El Cavet (Fontanals et al. 2008)). In the same century, simultaneously or just slightly later, other sites were probably occupied: La Draga (Banyoles, Pla de l'Estany) (Bosch, Chinchilla & Tarrús 2000, Bosch, Chinchilla & Tarrús 2011), Balma Margineda (Sant Julià de Lòria, Andorra) (Guilaine et al. 1987, Guilaine & Martzluff 1995), Bauma del Serrat del Pont (Tortellà, La Garrotxa) (Alcalde, Molist & Saña 2002), the plain of Barcelona (Barcelonès) (Pou et al. 2010, Molist, Vicente & Farré 2008) and Font del Ros (Berga, Bergadà) (Pallarès, Bordas & Mora 1997). All these sites are distributed in the central coast and the north-eastern and northern areas of Catalonia (see Fig. 2.7).

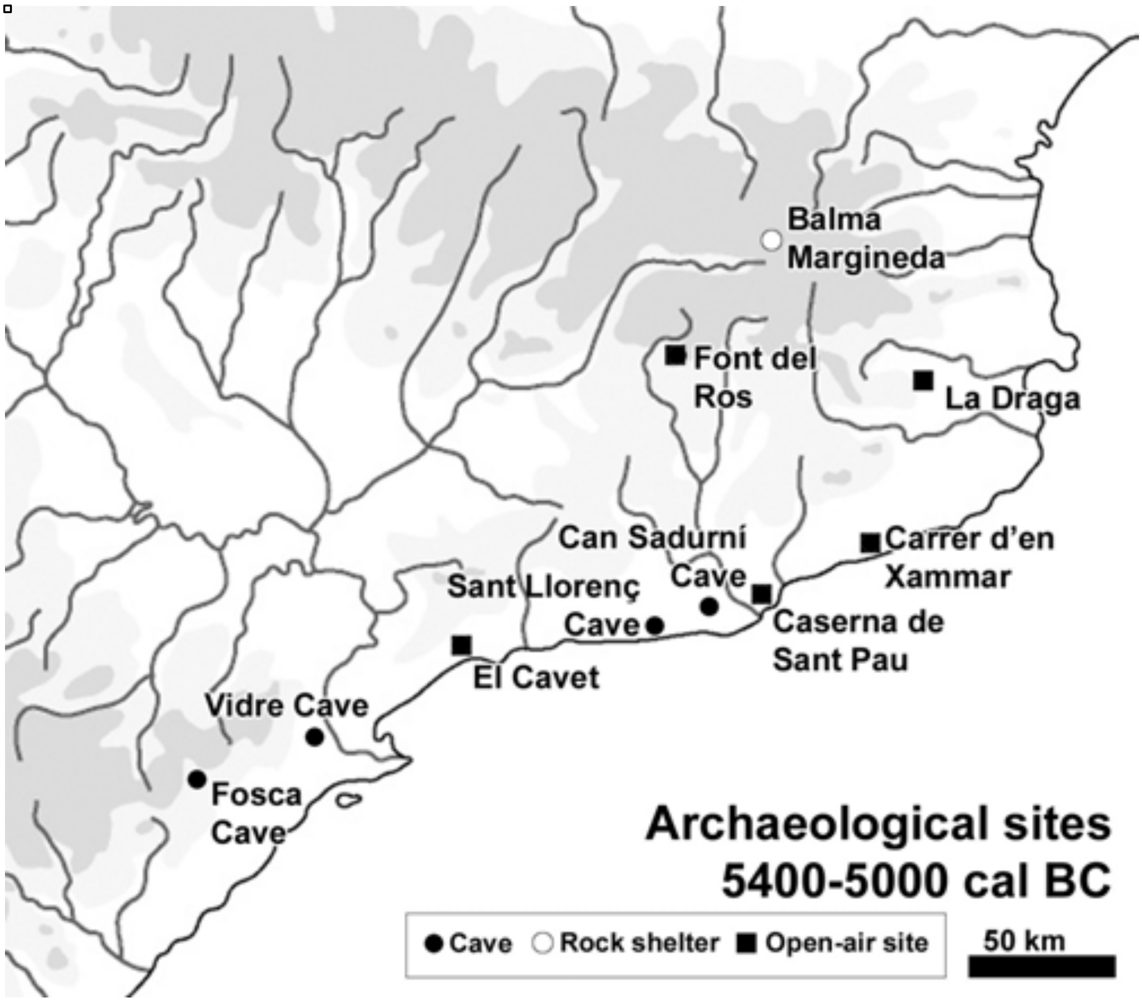


Fig. 2.8. Map of sites dated to 5400-5000 cal BC and mentioned in the text.

For all these sites, except Bauma del Serrat del Pont (where no domestic animals or plants have been identified, see (Alcalde, Molist & Saña 2002)), the evidences of farming do not just come from the presence of charred grains (or waterlogged plant macroremains in the case of La Draga site) of domestic cereals, but also bones of domesticated animals and (mostly) Cardial pottery of largely local production (Martín et al. 2010), except for Can Sadurní Cave, where some pots could have been brought to the cave from elsewhere (Clop, Manen & Convertini 2011). Apart from La Draga, these sites are located on (or close to) previously settled areas (during the Mesolithic) but the time lapse between the last Mesolithic occupations and the first Neolithic ones is too large to even consider the possibility of a local evolution (see below). All contexts dated after 5400 cal BC in this region correspond to farming communities. Considering this situation, can we tell whether there was a local role in the development of the Neolithic in the NE of the Iberian Peninsula?

A recent statistical evaluation of the available C14 dates for the NE of the Iberian Peninsula shows that there is a lack of dates between 6500 and 5500 cal BC (Barceló 2008), so no evidences of Late Mesolithic populations are found in this area. At least three new dates (on fragments of charcoal) within this period have been obtained since the publication of the paper by J. A. Barceló: the date for layer 20 in Can Sadurní, which is dated to 6330-6320 and 6230-6090 cal BC (Edo, Blasco & Villalba 2011); the one from layer 4 in Vidre Cave, which is dated to 6350-6310 and 6265-6015 cal BC (Bosch 2010, Bosch in press) and the one from layer IV.1 in Bauma del Serrat del Pont, which is dated to 6240-6075 cal BC (Alcalde & Saña 2008). Despite these new results, the blank of several centuries between Mesolithic and Neolithic contexts still exists and more research is needed.

It has recently been proposed that this absence of data just before the arrival of the first Neolithic groups can be related to the cold climatic episode that takes place around 6200 cal BC (Guilaine 2011). In fact, some authors see this phenomenon as a general one in the Mediterranean region (Berger & Guilaine 2009). The time span of this episode was rather short, around 150 years (e.g. Kobashi et al. 2007), and the real consequences (if any) of it in the Mediterranean region are still not well understood. Some authors have proposed that it is possible that this event produced dramatic taphonomic processes on karst and valley-bottom areas. This would make it almost impossible to record any human occupation from this period (Berger & Guilaine 2009). In any case, this argument does not explain the absence of Mesolithic occupations after the arrival of the first farmers.

This situation is observed all over the western Mediterranean basin. Lack of Late Mesolithic occupations is reported in most of Italy ((Biagi, Spataro 2002, Biagi 2003; Robb 2007, 24-27) and south-east France (Binder 2000), as well as the eastern coast of the Iberian Peninsula (Bernabeu 2006, Bernabeu et al. 2008, Bernabeu, Molina & García 2010). The distribution of those late gatherer-hunters seems to be concentrated in specific areas (or in coastal sites that have not yet been discovered). The Late Mesolithic occupations of the Ebro Basin would be the only possible case of long-term interaction between Mesolithic and Neolithic populations in this large area, if we do not take Southern Portugal into account (Zilhao 2000). And even in the Ebro basin, a lot of discussion has been going on, especially in those sites where pottery has been documented in hunter gatherer contexts (for supporting arguments see, for instance, Alday 2005, Alday 2009, Alday 2011, Alday et al. 2012; for critical positions see Bernabeu 2006, Zilhao 2011).

It is not the aim of this work to re-evaluate the different theories that have been proposed to explain the neolithisation of the Iberian Peninsula (see Hernando 1994, Hernando 1999, Zilhao 2000, Zilhao 2001, Zilhao 2003, Bernabeu 2006, Rojo et al. 2008, Zilhao 2011). Two main approaches have had a wider acceptance among archaeologists: those who see the rapid spread of the Neolithic as an evidence of a large-scale process of migration of farming populations who would not find much of a local resistance (maybe because most areas were largely uninhabited after the onset of the Holocene) (Zilhao 2000, Zilhao 2011); and those who do not accept such a purely diffusionist model and consider that local populations had a role in the process (e.g. Martín 1992, Bernabeu, Aura & Badal 1993, Bernabeu 1996). The total absence of Late Mesolithic populations is unlikely for the entire Western Mediterranean region (without considering the Atlantic façade of the Iberian Peninsula), but these could have mainly been circumscribed to coastal areas, currently under water (Bocquet-Appel et al. 2011). In any case, the similarities between the Neolithic communities of the VIth millennium cal BC in the Western Mediterranean region seem to give local population a minor role in its subsequent evolution.

It is widely assumed, in the more recent publications at least, that arriving populations were the main responsible for the onset of farming in the NE Mediterranean coast of the Iberian Peninsula and that no clear traces of interaction or presence of Mesolithic groups have been identified in those areas where these early farmers settled (for instance, Bernabeu 2006, García-Atiénzar 2010, Guilaine & Manen 2007, Buxó 2007a, Bocquet-Appel et al. 2011; though see former works Martín 1992, Pallarès, Bordas & Mora 1997, Hernando 1999, Bosch & Tarrús 2003, Molist, Saña & Buxó 2003); and also other perspectives (Alday 2009, Alday et al. 2012)). The preliminary work on aDNA carried out in several sites of this region seems to support the migration hypothesis (Gamba et al. 2011) and recent work with Mesolithic populations from the Iberian Peninsula seems to prove no genetic connections with later Neolithic communities (Sánchez-Quinto et al. 2012). Much more research is needed to consider these latter results as concluding.

Recently, the role of several Neolithic cultural groups with different pottery traditions in the introduction of farming into the region has been proposed by some authors (García-Atiénzar 2010, Bernabeu et al. 2009): the Ligurian impressa culture and the Cardial ware culture. Nevertheless, in the north-eastern region, the earliest evidences of farming practices seem to be associated only with Cardial ware pottery.

Keeping this in mind, I do think it is a good scientific exercise to take this as a "state of research" basis and proceed with this work taking into account that there are no evidences of real contact between farmers and hunter-gatherers in the region under study. For this reason I refuse using concepts such as the transition to agriculture for this area, at least until we have evidences of a transition. And at the same time I equally reject the concept of a "fast process of Neolithisation". If we accept that this area was mostly uninhabited, the archaeological evidences of Neolithic groups are just evidence of their gradual spread throughout the region, but not of the rapid way in which they managed to settle among (and acculturate?) local populations. If new and threatening evidences are confirmed in the future, new models will have to be developed and an equally interesting phenomenon will need to be explained on a scientific basis.

In the following chapters, a short review of the Neolithic in the area under study will be presented, especially dealing with aspects relating to socio-economic evolution, rather than lithic technology or pottery decoration *per se*, which can be found elsewhere (Bosch 1991, Bosch & Santacana 2009, Palomo 2012). I have concentrated on: settlement distribution and size, permanence, crop and animal husbandry, plant food consumption and social structure. For this reason, only a selection of sites is mentioned in the text: those that yielded better records to carry out interpretations on such issues. This is, in short, the archaeological context I will consider for the elaboration of Chapter 5. For this reason, this is not just a synthesis of what has been published to date, but a critical review of the accessible evidence under the light of the model for early farming societies that has been presented above. Of course, this would require much more work (like a thorough revision of the archaeological data obtained site by site). But this is not the aim of this work, and yet a coherent framework was still needed in order to develop a discourse. Archaeobotanical publications produced until 2008 are included in this discussion. Later works will be presented below (Chapters 4 and 5). The chronological divisions used largely follow the intervals of probability established by J. A. Barceló (2008) after correlating the presence of pottery styles and reliable C14 datings. I am aware that these divisions are still arbitrary but they are more useful that the traditional partition into Early Neolithic 5400-4200 BC, Middle Neolithic 4200/4000-3300/3000 BC, and Late Neolithic 3300/3000-2300 BC.

2.5.1.2. 5400-5000 cal BC. Crops and livestock. The first (yet experienced) farmers of the North-East of the Iberian Peninsula

This phase is roughly coincident with the presence of Cardial ware in the pottery record of our region and, for which it is commonly known as the **Early (Cardial) Neolithic**. As already noticed by other authors (Manen 2002), many Cardial sites are usually mentioned by archaeologists based on the type of decoration of potsherds recovered from old excavations or surface prospections in sites where no stratigraphy or archaeological context is known. These sorts of evidences will be avoided in this text. Our interest is not on the distribution of potsherd fragments in our region but on the distribution of social formations, and these cannot be studied without a context.

The major focus of occupation seems to take place at the mouth of the Llobregat River (Fig. 2.8). Several sites like Can Sadurní Cave (Begues, Baix Llobregat) (Edo, Blasco & Villalba 2011) and Caserna de Sant Pau (Barcelona, Barcelonès) (Molist, Vicente & Farré 2008), an open-air site, were settled. The Llobregat River was used to penetrate into the more interior plains of the region. As a result, other open-air sites like Font del Ros were occupied (Pallarès, Bordas & Mora 1997). As already mentioned, the north-eastern region was also inhabited shortly after. In this area, La Draga (Banyoles, Pla de l'Estany), the only lakeshore site that is known in the Iberian Peninsula, is recorded (Bosch, Chinchilla & Tarrús 2000, Bosch, Chinchilla & Tarrús 2011, Tarrús 2008). The number of settlements rapidly increased in both areas in the subsequent centuries. Some sites in mountain areas have also been detected. Balma Margineda (a rock shelter) is located in the Pyrenees (Andorra) and is interpreted as a singular phenomenon (Guilaine & Martzluff 1995). Recent work has also uncovered other early coastal open-air sites like El Cavet (Cambrils, Tarragona) (Fontanals et al. 2008) or Carrer d'en Xammar (Mataró, El Maresme) (Pou & Martí 2005). The Ebro River might have been another focus point, which would be responsible for the occupation of some caves like Vidre Cave (Tortosa, Baix Ebre) (Bosch 2008, Bosch in press).

The distribution of the sites during these first centuries is primarily explained by the maritime migration of farming populations and the use of rivers as waterways to settle in suitable locations. The importance of waterways in the spread of the neolithic communities has been successfully evaluated by other authors at a European scale (Davison et al. 2006).

The duration of the occupations (or settlement phases) is thought to be short and this is considered to be the result of the loss of fertility of the soils after growing cereals (Martín *et al*. 2010) or the over-exploitation of the available pastures in the immediacies of the settlement (Martín 1992). These hypotheses are partly based on the pollen records of the Mediterranean coast of the Iberian Peninsula, which show repeated episodes of fires during the first 1500 years of the Neolithic (Riera, López-Sáez & Bosch 2004). These fires were initially interpreted as evidences of shifting agriculture (Riera 1996) but later works (Riera, López-Sáez & Bosch 2004) have allowed the location of their onset within a Mesolithic context (already around 7500 cal BC) which demonstrates, at least, that these practices were not exclusive of farming communities and that they could respond to other factors. There is, in fact, abundant ethnographic evidence of the burning of vegetation by hunter-gatherers from North America for a variety of purposes, such as the increase in species diversity or to attract game and hence facilitate hunting practices (see references, for instance, in Smith 2009). Early farming economy could have been in jeopardy for many other more important reasons than the availability of land for farming (see, for instance, Halstead 1999). Small groups needed to survive and reproduce themselves in order to build networks in new territories. Crops and livestock could suffer from pests, drought or other catastrophes. The greatest risks, then, were not in the depletion of fertile soils and pastures.

Settlement and house size are even more problematic issues to solve for the Neolithic of the region. Interpretations on the size and time span of open-air sites are usually questioned due to limitations in archaeological methodology, but this brings our discourse to a dead end. Why should we continue digging if we cannot interpret what we uncover? Four open-air sites must be considered for this first phase of the Neolithic: La Draga, Caserna de Sant Pau, Font del Ros and Carrer d'en Xammar. La Draga seems to have been occupied during c. 300 years (c. 5300-5000 cal BC), although it is likely that several shorter settlement phases took place within this period. In fact, recent archaeological work has identified two settlement phases (Palomo et al. 2012). The difficulties to apply dendrochronology on the wooden posts of the huts and the relatively small extension of the site that has been excavated to date (818 m^2, c. 10%) make it impossible, at this stage, to state with certainty how many huts would have coexisted and for how long. Fortunately, some hypotheses have been proposed: dendrologic analyses confirmed that there are up to six phases of house building; besides, considering the total area of the site, the archaeologists calculate that c. 16-20 huts (two rows of 8-10 huts of 10 x 3-4 m) would have coexisted along the chronology (Tarrús 2008). Despite being preliminary, these results could mean that an average of 80-100 people would have dwelled at this site. Font del Ros and Caserna de Sant Pau were excavated as rescue excavations and the total size of the settlement area is unknown. Negative structures were distributed in an area of 1300 m^2 in Font del Ros (Pallarès, Bordas & Mora 1997) and in 800 m^2 in Caserna de Sant Pau (Molist, Vicente & Farré 2008). Considering that these were partial digs, these sites could have corresponded to small villages of relatively dispersed farmsteads of 50-100 individuals, like in other regions of the Western (Robb 2007, 40) and the Eastern (Halstead 1981) Mediterranean. Smaller villages would also exist but the record is still very limited or remains unpublished. Recent finds from Mataró uncovered two huts and two possible silos dated to this phase (Pou & Martí 2005).

The evidence on plant economy for this period was rather reduced until very recently. Three open-air sites have yielded interesting data for this phase: Font del Ros (Pallarès, Bordas & Mora 1997), La Draga (Buxó, Rovira & Sauch 2000, Antolín, Buxó 2011b) and Caserna de Sant Pau (Buxó, Canal 2008). Font del Ros was systematically sampled by V. López and only partially published (due to his premature death). The unpublished results per context will be included in the general evaluations carried out in chapter 5 thanks to P. González. Hulled barley (*Hordeum vulgare*) and emmer (*Triticum dicoccum*) seem to be the best represented taxa, but the overall number of reported items is rather low (n: 222). At La Draga, thousands of charred grains, mainly belonging to naked wheat (*Triticum aestivum/durum/turgidum*), were recovered, as well as other taxa like hulled and naked barley (*Hordeum vulgare* var. *nudum*). Pea (*Pisum sativum*) and broad bean (*Vicia faba*) were also documented. The results mainly come from sector A, which is likely to correspond to the youngest phase of occupation at the end of the VIth millennium cal BC. A very similar crop spectrum was documented in Caserna de Sant Pau, but the record was much poorer, and hulled barley and emmer seemed to be better represented. Caserna de Sant Pau and Font del Ros have very parallel records, except for the fact that no cultivated legumes were identified in the latter. This speaks against the supposed singularity of the crop spectrum of Font del Ros (Pallarès, Bordas & Mora 1997).

There are many assumptions concerning the nature of the first type of farming that was practised in the Iberian Peninsula. Some authors consider that the rapid movement of Neolithic groups throughout this vast region responds to their primitive agrarian techniques (without the knowledge of the plough or the use of manure). For this reason, wetland areas and floodplain alluviums would be preferred (Rojo *et al.* 2008, 321). These positions lack of actual archaeological evidence. J. Bosch, based on ethnographic references from the African continent, considers that small plots (*c.* 0,5 ha) could have been deforested and burnt systematically and that minimal investment of labour would be applied on them. Fields would be abandoned after 3 or 4 years. According to this author this model would suit the investigated area considering the available means of production and the results of the pollen data that we have already mentioned (Bosch & Santacana 2009), 43-44). J. P. Bocquet-Appel and others also consider that the Mediterranean region would be characterized by the practice of extensive agriculture (Bocquet-Appel et al. 2011). J. Bernabeu and others took the model from P. Halstead (Halstead 1987, Halstead & Jones 1989, Halstead 1989b) and proposed the practice of intensive farming for the Neolithic period in the Iberian Peninsula (Bernabeu, Aura & Badal 1993), which did not have the desired impact on Neolithic archaeology, maybe because the appropriate archaeological evidences were still lacking. N. Alonso, based on ethnographic and archaeological data, recently proposed a combination of horticulture and shifting agriculture for the early Neolithic, which would involve more work per unit of land and a preeminent female role in the production of food (both in agricultural and herding practices) (Alonso in press). The main drawback for the acceptance of any of these proposals is the lack of archaeological basis to support them. From the archaeobotanical point of view, it is the lack of weeds in the available record, which makes it impossible to directly evaluate the crop husbandry techniques applied (Buxó 1997, Zapata et al. 2004).

Concerning crop husbandry, and taking into consideration empirical data, R. Buxó, already in 1991, with a very scarce archaeobotanical record, put forward the hypothesis that a crop rotation system of legumes and cereals could have been possible for the early stages of the Neolithic (Buxó 1991). This was based on the fact that legumes appeared with some regularity in the archaeobotanical record but no particular evaluation of the assemblages was carried out in order to support the argumentation. This author more or less maintained this position in subsequent publications (Buxó 1997), but not in the last ones (Molist, Saña & Buxó 2003, Buxó 2007a), where a secondary role was given to legumes. Some archaeologists have disagreed because such practices would imply an intensive agrarian system, which was not to be expected at such an early date in the Neolithic (Martín 1992). R. Buxó considers, in fact, that the rotation could have been involuntarily practiced and that short fallows (of 1 or 2 years) would not be an option for itinerant farmers (Buxó 1997, 171). Therefore, the author does not support permanent cultivation of the fields, even though no particular archaeological reasoning for this was presented. Finally, Buxó believes that while the first evidences of agriculture in Valencia might reflect maslin cultivations (due to the diversity of crops found in the occupation layers of Cendres Cave or in the "cache" of Or Cave), later findings of charred stores in La Draga seem to point towards the existence of monocropping. Similar conclusions were achieved for Font del Ros. Here the recovery of grains of hulled barley and emmer in separate pits led to conclude that they could have been grown separately (Pallarès, Bordas & Mora 1997). The lack of a taphonomic analysis of the assemblages of Cendres, Or Cave and Font del Ros do not allow reliable conclusions on this issue. The materials could have become mixed after their processing or even postdepositionally. Besides, the presence of

Polygonum convolvulus and *Chenopodium album* in the record of Font del Ros was considered as typical of spring-sown fields (Pallarès, Bordas & Mora 1997). Unfortunately, the evidences were too scarce to defend any of these statements and all of them must be considered as hypotheses.

The use of silos for the storage of grain is potentially documented in the underground silo-type structures from Font del Ros, Caserna de Sant Pau, El Cavet and Carrer d'en Xamman (the potential primary function of the features was defined by the archaeologists on a morphological basis). No particular analysis of the capacity of these features is yet available. Large concentrations of charred grain in sector B of La Draga (in the earliest phase of occupation) indicate other types of (short-term?) domestic storage techniques, using baskets or bags to keep the grain. The paved floors from sector A in La Draga (Bosch, Chinchilla & Tarrús 2000), 75-78) which were interpreted as storages, could have been used, under the available (and few) evidences of their primary function, for a variety of purposes. Future research on this second phase of occupation at the site might help into a better comprehension of storage practices.

Concerning animal husbandry, available information is reduced for some sites for different reasons. On the one hand, in Font del Ros, preservation was quite deficient; while, on the other hand, the number of faunal remains in early Neolithic contexts of Caserna de Sant Pau was not published per chronological phase and the materials that were recovered inside dated structures were extremely reduced in numbers (Colominas et al. 2008). Goat and sheep are the best represented taxa for this site, even though they were not present in closed contexts and their chronological ascription is not yet clear. A thorough revision of the ascription of these materials is currently on-going (O. Vicente, pers. com.). Interestingly enough, the deposits of pits 9 and 1 seem to have been produced in one single action (Colominas et al. 2008). This could be interpreted as a possible refuse deposit of a feasting event. Better results have recently been obtained from Layers 17 and 18 in Can Sadurní cave (Saña et al. in press). The record is dominated by the presence of goat and sheep and they seem to be exploited as a resource of meat and milk. Milk residues and other ruminant fats were identified in some of the potsherds (Spiteri, 2012; Saña et al. in press). Some of these remains are part of a funerary context in layer 18 (Blasco et al. 2005). Cattle are present but their relative importance seems low. Pigs are equally exploited as a source of meat (Saña et al. in press). The most significant record has been recovered, without a doubt, at La Draga (Saña 2000, Saña 2011). At this site, all domestic taxa seem to be well represented, though ovicaprines make the largest group, considering the number of remains and the minimum number of individuals (*c.* 40%). Herding practices were oriented towards obtaining meat but other products were probably also exploited. The identification of pathologies produced due to the use of cattle for traction indicates the use of their labour force for several activities that could include transport or even ploughing. Like in Can Sadurní, mortality patterns of goats indicate milk production strategies, which have not yet been confirmed by lipid residue analysis of potsherds. An impressive assemblage of 4 bucrania was recovered in sector B of the excavation in La Draga. Their interpretation is not clear, since their exact location in the original huts (if they were ever hanging from the walls, as suggested in Bosch et al. 2008 is unknown. In other Neolithic sites from the Mediterranean region, like in Çatal Hoyuk (Turkey), these bucrania have been interpreted as symbols of feasting and sharing episodes (Bogaard et al. 2009). The presence of these bucrania at La Draga and other (much later) lakeshore sites in central Europe, like in Arbon Bleiche (Deschler-Erb, Marti-Grädel & Schibler 2002, Jacomet, Leutzinger & Schibler 2004), opens the possibility to the formulation of similar interpretations, but further investigations are needed. Finally, and concerning hunting practices, it has been proposed that they could have more of a social than a real economic value (hunted game make up less than 5% of the faunal assemblage of the site)

(Palomo et al. 2005). In all sites, in fact, game represents a rather small percentage of the total income of meat products.

Little is known about social structure during this period, but some interesting hypotheses can be formulated from the only collective burial documented in the area, which was found in Layer 18 of Can Sadurní Cave (Blasco et al. 2005, Edo, Blasco & Villalba 2011, Antolín et al. 2011, Antolín & Buxó 2011c). Ancient DNA analyses identified the buried people as a group (at least 7 individuals) of colonists, in which two of them were siblings (Gamba et al. 2011, Gamba, Fernández & Arroyo-Pardo 2011). These human remains were surrounded by a significant apparel consisting of personal ornaments (shell plaques), several tools (a hand stone of granite and several sand stones), complete legs of lambs and several pots full of charred grains (part of which were dehusked grains of glume wheats, which required a large investment of labour). The fact that domesticates form part of the apparel is equally interesting, since it gives the whole Neolithic "package" a profound symbolism for this community. Such an investment of labour at an early date in the Neolithic period seems to show that farming practices were already well established and these could have been organized at a household level. Further research is needed in order to confirm these postulates.

2.5.1.3. 5000- 4500 cal BC. "Herders of the mountains and farmers of the plain".

This phase would roughly correspond to what is known in the literature as the **Early Epicardial Neolithic**, due to the fact that the Epicardial pottery tradition seems to characterize most of the ceramic assemblages. Instead, the terms **Late Early Neolithic**, which are somewhat less restrictive, will be used in this work. Despite the name of the style, "epi-Cardial", which might suggest that it was some sort of subphase within the Cardial tradition, it has recently been recognized as a style on its own right which is present from Southern France to Andalucía (Manen 2002, Guilaine & Manen 2007) and available C14 dates demonstrate that it can be located within a rather particular time span in our region, after the development of the Cardial ware style (Barceló 2008). For some authors the Epicardial would correspond to the "local" development of pottery by populations who were acculturated by the arriving farmers during the first phase of the Neolithic (Bosch et al. 1998, van Willigen 1999, Bosch & Tarrús 2003, Bosch 2008). This theory has been rejected by C. Manen after the thorough analysis of huge collections of potsherds from the Gulf of Lyon and the NE of the Iberian Peninsula, demonstrating that the Epicardial originates from the Cardial tradition and must be interpreted in terms of continuity instead of rupture (Manen 2002).

It is certainly difficult to analyse this phase by itself. Most studies present the first 1000 years of the Neolithic as one single phase, which makes it impossible to understand the evolution of the first farming communities. But, as will be shown, and as noticed by other authors, this phase is characterized by the spread of farming communities across the territory (Guilaine & Manen 2007; Martín et al. 2010).

The number of well-studied sites increases significantly in this phase (Fig. 2.9). In the Pyrenees and pre-Pyrenees, the first clear signs of occupation at Sardo Cave (Boí, Alta Ribagorça) (Gassiot et al. 2012b) and Colomera Cave (Sant Esteve de la Sarga, Pallars Jussà) (Oms et al. 2008, Oms 2008) have been discovered in the past decade. Scientific and rescue excavations were undertaken in several areas of the NE of our region and up to four open-air sites were (at least partly) excavated: La Dou and Codella (Sant Esteve d'en Bas, La Garrotxa) (Alcalde et al. 2008, Alcalde et al. 2012), Plansallosa (Tortellà, la

Garrotxa) (Bosch et al. 1998) and Serra del Mas Bonet (Vilafant, Alt Empordà) (Rosillo et al. 2012). Some cave sites were also investigated, like Avellaner Cave (Les Planes d'Hostoles, La Garrotxa) (Bosch & Tarrús 1990). At the centre of Barcelona city, an open air site was uncovered in C/Reina Amàlia[1], 31-33 (González, Harzbecher & Molist 2011), which is, in fact, very close to Caserna de Sant Pau and could be interpreted as a continuation of the settlement. More towards the interior lands, a cave site, Frare Cave (Sant Llorenç de Munt, Vallès Occidental), was occupied (Martín, Biosca & Albareda 1986), while several short episodes of human presence were documented in Can Sadurní Cave (layers 12-15) (Blasco et al. 1999, Edo, Blasco & Villalba 2011). Some storage pits attributed to this phase were documented at CIM-El Camp (Reus, Baix Camp) (Bravo, Roig & Solà 2012). At southern Catalonia, another open air site, Barranc d'en Fabra (Tortosa, Baix Ebre) was partially excavated (Bosch, Forcadell & Villalbí 1996).

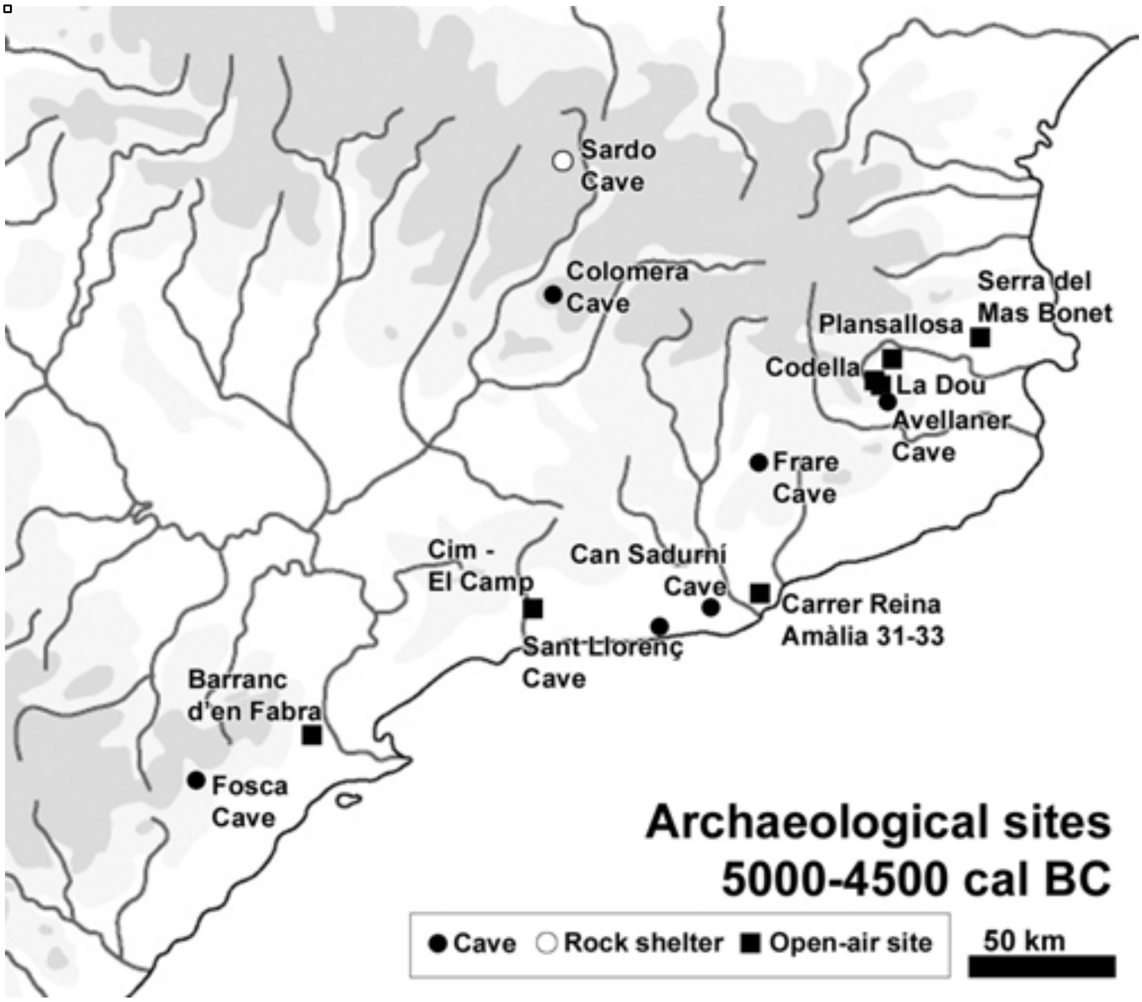


Fig. 2.9. Map of sites dated to 5000-4500 cal BC and mentioned in the text.

Some authors have seen the occupation of mountain contexts as an evidence of the increased exploitation of woodland resources (for human consumption or within a more complex practice of pastoralism) in times of crisis (Martín et al. 2010). This theory was sustained with the archaeological evidences of Frare Cave. This site is located at 960 m a.s.l., in a rocky area. The faunal assemblage of the earliest occupations of this site is of mixed composition, as usual for the Neolithic, with a particular dominance of goats and sheep, and with a minor role of hunting (Martín 2000). Several sickle blades

[1] C/ is the abbreviation in Catalan for "carrer", which means "street".

were identified (Ibáñez et al. 2008) and large pottery containers are reported, as well as other structures such as hearths (Martín, Biosca & Albareda 1986). The authors also report the important number of foetus and newborn animals that have been found (Martín 2000). Given present-day breeding season, it is very likely, then, that the cave was inhabited during late winter and early spring (Halstead 1999), which is not typical for transhumance practices. All of these evidences point towards a more sedentary model than that proposed by the authors. In fact, the statement proposed by Martín concerning mountain occupations is rather inconsistent, given that the plains were as wooded as the mountains, that there are no proofs for mountain pastoralism practices (in the sense in which it was discussed it in chapter 2.2.1.2.) for these periods, and that evidences of a much more complex farming economy (including agriculture) is documented in most of these sites. These data show the expansion of farmers to new ecosystems as part of a solid risk-buffering strategy. Mountain sites would not respond to short-term pastoralist practices but long-term strategies of exploitation of these ecosystems. Recent synthesis of the available record for the Holocene in the Eastern Pyrenees show how the occupation of the higher territories becomes more common and permanent within farming economies (Rodríguez-Antón 2011). P. Díaz-del-Río also criticized the assumption that sites located at a high altitude belong to marginal farmers or pastoralists, or the use of the concept of transhumance for the IIIrd and IInd millennium cal BC in the Iberian plateau (Díaz-del-Río 1995). According to this author, such practices are only observed when extensive farming practices are present in vast territories (therefore, more appropriate for Medieval times).

As for the previous phase, it is very difficult to deal with settlement size and organization for these contexts. Some data have been obtained from Barranc d'en Fabra and Plansallosa.

Barranc d'en Fabra was only partially excavated but it was reconstructed through aerial photographs. The village extended on a surface of around 1000 m^2, with an elongated or elliptic shape. Nine large constructions of 4-6 x 3-5 m (less than 25 m^2) with stone walls seem to be observed. There seem to be remnants of an outer stone wall, which would act as a limit for the village (it is not interpreted as a defensive structure). The archaeologists consider that the site could actually be much larger. Following previous equivalences, probably more than 40-50 individuals lived in the site. It is considered to be relatively permanent, especially because of the investment of labour in the construction of dwellings with stone material and communal structures like the outer wall of the village (Bosch, Forcadell & Villalbí 1996; Bosch & Santacana 2009, 56-63).

Plansallosa site is thought to be of around 2000 m^2 and two settlement phases were identified. The first phase of occupation was only documented in one sector and it could have been smaller than the second one. One single possible hut was identified. Its walls were built with stones, like in Barranc d'en Fabra. It is reported to measure *c.* 6 m^2 (Bosch et al. 1999) but if one considers that the walls might have collapsed inwards and takes the outer perimeter as a reference, a space of *c.* 12 m^2 can be calculated. During the second phase of occupation, the size and type of dwellings remains unclear, since both post holes and paved floors have been documented. The size of the paved floor is also *c.* 12 m^2 and its function is unknown.

Both sites, Barranc d'en Fabra and Plansallosa, are characterized by the use of stone for construction material. This could be interpreted as a sign of a larger will of permanence among their inhabitants. Nevertheless, these huts were very small (in comparison with other examples from previous or younger phases) and one could imagine that most of the productive activities would take place outside the house.

This is an important fact because it means that certain activities like cooking took place in public spaces and it opens the possibility to the existence of food sharing and hospitality (*sensu* (Wright 2000).

Other relatively large sites have been partially excavated, like Codella and la Dou. Codella could have been a medium-sized site of *c.* 550 m^2. Only one paved floor of a circular hut was excavated (*c.* 40 m^2). It was described as a dispersed settlement. La Dou seems to be a similar type of site. Several hearths and pits were identified. Both sites were located close to the lakeshore of a palaeolake that no longer exists in the area (Alcalde et al. 2008). These sites are in the process of being completely published and are part of the study that I will present in chapter 4.

Crop husbandry during this period has been understood in similar terms to the previous one. In fact, the data of both phases are usually discussed together. The available information is extremely scarce and they primarily comes from Plansallosa. Here, naked wheat seems to be the best-represented taxon, together with hulled and naked barley (Buxó 2007a). A total number of 35 grains of naked barley were found inside a jar corresponding to the second phase of occupation of Plansallosa. Naked wheat was better represented in the first phase. One seed of lentil was identified and barely any potential weeds were recovered (Bosch et al. 1998). More recently, some preliminary data from Colomera Cave (n: 44 items) have been published (Oms et al. 2008). A mixture of grain (at least the presence of naked wheat is mentioned), chaff and wild plants is reported. It should be noted that this material was retrieved from layers of charred dung, hence this would correspond to what the animals were being fed with.

Concerning animal husbandry, the data are equally scarce, but some results were obtained from Plansallosa site (n: 927 remains). Both phases show a similar strategy of livestock management: a mixed farming model with goats, sheep, cattle and pigs. Cattle and ovicaprines seem to dominate the assemblages in both phases and the production strategies seem to be oriented to meat exploitation (Bosch et al. 1998). It has already been mentioned that ovicaprines dominated the record in Frare Cave, although cattle and pigs were well represented (Martín, Biosca & Albareda 1986). Similar patterns might be applicable to Colomera Cave (Oms et al. 2008, Oms 2008), even though the quantified results have not been published. The recent studies carried out in Can Sadurní allowed the presentation of the mixed farming strategy (where ovicaprines prevailed) that was practiced at the site. Sheep, goats but also pigs were slaughtered at their meat optimum age (Saña et al. in press). A different pattern is observed in Serra del Mas Bonet, where bovines are well represented, followed by ovicaprines. Intentional deposition of pigs and dogs that were not consumed are interpreted as symbolic practices (Rosillo et al. 2012). In all cases, hunted game represents a small percentage of the overall faunal remains.

Burials are also sparse during this chronological phase, and the available data on social structure are meagre. An important collective burial was uncovered in Avellaner Cave. Recent aDNA analyses (Lacan et al. 2011) demonstrated, on the one hand, that the male individuals buried in this cave were genetically connected with the migrating populations who spread farming along the Mediterranean. Women, on the other hand, seemed to have different lineages, and some of them belonged to the haplogroup U5, which was also documented in Can Sadurní (layer 18). This haplogroup could belong to local Mesolithic populations (Malyarchuk et al. 2010, Gamba et al. 2011) (although no Mesolithic individuals from the region were studied) and it would prove that women with “local” genetic groups were incorporated into Neolithic communities at some point. Further interesting conclusions were drawn by this study. Five of the six males that were analysed seemed to belong to the same paternal lineage. This would reinforce the idea that collective burials act as symbolic references to ancestry and lineage. The social implications of the incorporation of women (who were probably in charge of most of the food production) into groups of farmers are very significant and require a more thorough debate. In any case, these interesting, yet preliminary, results are clear evidences that the Epicardial pottery was not a product of purely "local" communities.

2.5.1.4. 4500- 4000 cal BC. Regionalization. Explaining the difference.

This period is equally difficult to analyse as a single unit, since most approaches either group it with all the sites from the early Neolithic, making no chronological distinctions (Bosch, Miró & Molist 1991), or focus on the whole Vth millennium cal BC period, mixing sites with very different chronologies and cultural attribution (Molist, Ribé & Saña 1996, Hernando 1999, 172-175). In fact, a large debate on the nature of this chronological phase has been on-going for years and is out of the scope of this project to develop on it, since the debate has mainly focused on pottery decoration styles (these would be the Postcardial styles, i.e. Montboló, Molinot and Amposta). One thing must be highlighted, which is that a strong regionalization of styles is observed during this phase all over Europe. Once more, the work of J.A. Barceló, demonstrates that there are statistical reasons to consider this period as a consistent unit of analysis (Barceló 2008). He, in fact, proposes the period from 4400 to 3800 cal BC. I have shortened it because it would overlap with the next phase, which is better represented in our study.

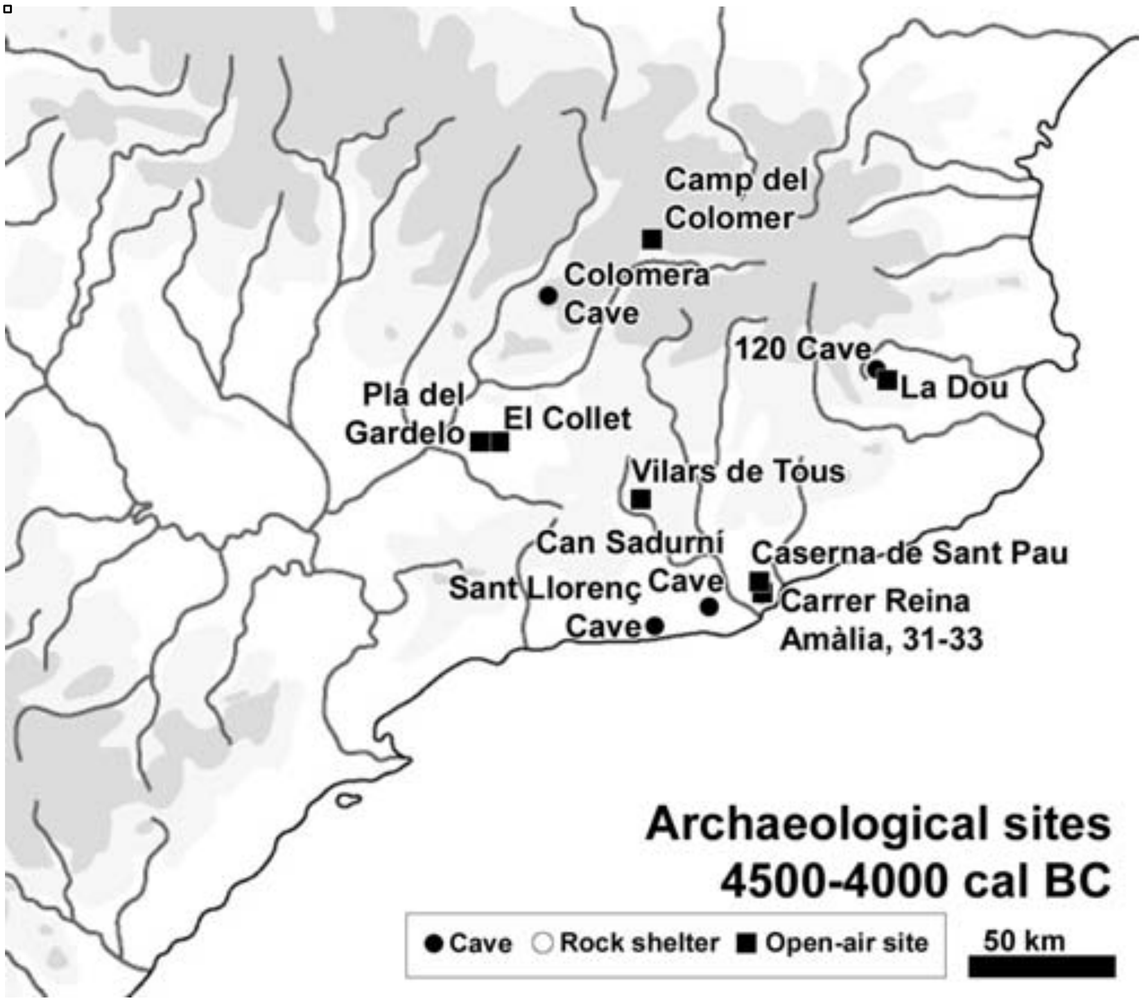


Fig. 2.10. Map of sites dated to 4500-4000 cal BC and mentioned in the text.

A number of sites that first appeared in the previous phase continue during this one (Fig. 2.10), such as La Dou (Alcalde et al. 2012), or C/Reina Amàlia 31-33 (González, Harzbecher & Molist 2011), as well as Can Sadurní Cave (layers 10 and 11, primarily) (Edo, Blasco & Villalba 2011, Blasco et al. 1999) and Colomera Cave (Oms et al. 2008). This continuity supports a local evolution during this phase, rather than a sudden cultural change. One site which was excavated during the eighties of the XXth century, 120 Cave (Agustí et al. 1987) has recently been ascribed to this phase (X.Terradas, pers.com.) after obtaining a C14 date on one of the grains that were analysed in this work. Some new sites of major interest were excavated in recent times. One of these is the open-air site of Camp del Colomer (Sant Julià de Lòria, Andorra) (Martínez, Vidal & Maese 2011). Only part of the original settlement (of an unknown total surface) was excavated. Another example is El Collet (Puiggròs, La Garriga), the first clear evidence of a farming settlement in the western plain of Catalonia (Piera et al. 2008). Many sites in the Penedès plain are reported for this period, such as Pou Nou-2 (Nadal, Socias & Senabre 1994), Pujolet de Moja (Mestres i Mercadé et al. 1997) or Hort d'en Grimau (Mestres 1989). There is an important lack of C14 dates for this area and problems have been encountered when some of structures that were initially attributed to this phase have been dated (see, for instance, E-3 in Pou Nou-2, which was finally dated to the Early Bronze Age; or E-13 in Pujolet de Moja, which was dated to the second half of the IVth millennium cal BC). For this reason, and the fact that they are only partially published, I think it is not yet the time to take these sites into consideration (despite them being potentially very important) at the level we are interested in for this text.

Given that some of the sites that have recently been excavated are not published, the only clear habitat contexts for this phase are Can Sadurní Cave, El Collet (Piera et al. 2008), C/Reina Amàlia, 31-33 (González, Harzbecher & Molist 2011) and Camp del Colomer (Martínez, Vidal & Maese 2011). The case of Can Sadurní cave is rather notorious (Edo, Blasco & Villalba 2011), although this site is repeatedly referred to as a cave used for particular purposes like storage in some of the literature (Molist, Ribé & Saña 1996, Bosch & Santacana 2009). Three episodes of occupation were distinguished at this site, but all evidences point towards a relatively permanent occupation. These would not only take place within the area inside the cave but also over the large terrace that is found outside, especially during the last phase, when several silos were dug in order to store cereal (Edo, Blasco & Villalba 2011). The archaeologists of the site have roughly calculated that, hypothetically, a production of 6000 kg of grain would have been possible. This would amount for the grain that is reported as necessary to sustain 5-6 nuclear families (c. 20-30 people) for one year (according to the reference data presented in chapter 2.1.1.1.1.). At the site of El Collet, a small rescue excavation documented the presence of five structures, four of which were extraordinarily well-preserved silos. The real extension of this site is unknown but it is possible that it corresponds to another small community. Unfortunately, no dwelling areas have been detected in Can Sadurní Cave and El Collet sites. In C/Reina Amàlia, 31-33, an interesting dwelling pit of *c.*50 m^2 associated with several hearths and storage pits was identified (González, Harzbecher & Molist 2011). The excavations at Camp del Colomer uncovered two possible huts of *c.* 15 m^2 and at least 7 silos were identified (Martínez, Vidal & Maese 2011).

The site of 120 Cave deserves particular attention. Eleven pits (some of which contained large intact jars) were found in this small cave of difficult access (Agustí et al. 1987). It is an interesting phenomenon that should be further explored. Was this cave only used for storage? What reasons made it necessary to store the harvest at such a place? Is it a communal storage? It is not possible to give a satisfactory answer to these questions at this stage of research.

Barely any evaluations concerning crop husbandry are available for this phase, although the meagre available data were included in more general approaches to agriculture in the region (Buxó 2007a, Molist, Saña & Buxó 2003). Naked wheat is the best-represented taxon in 120 Cave (Agustí et al. 1987). The scanty results from Caserna de Sant Pau document the presence of hulled and naked barley, as well as naked wheat and emmer (Buxó & Canal 2008). In Colomera Cave, no identified cereal macroremains are reported but one pea was recovered, along with several other taxa (Oms et al. 2008). Concerning plant food consumption, it is interesting to note that the production of beer (or some alcoholic beverage produced with germinated and fermented barley grains) was identified in Can Sadurní (layer 11) through the identification of several types of microresidues on a saddle quern, a hand stone and a potsherd (Blasco, Edo & Villalba 2008). Plants were probably very important in the diet. The intense dental wear of both of the individuals from El Collet indicate a diet predominantly based on plants (Piera et al. 2008).

Some data are available concerning animal husbandry. The data for El Collet are very scarce. A mixed farming system including ovicaprines, cattle and pig is documented and it seems to be oriented to the exploitation of meat products (Piera et al. 2008). Similar observations can be made for Caserna de Sant Pau (Colominas et al. 2008). More interesting data were obtained from Can Sadurní Cave. Here, archaeozoological and soil micromorphology analyses concluded that the area under the roof of the cave was used as a byre for ovicaprines (mainly). Mortality patterns seem to show a permanent occupation of the site. The many layers of burned dung that were observed through soil micromorphology analysis confirm that this was a constant situation along the formation of the several layers of this chronological phase. It is also interesting to note that sheep were kept until older ages (compared to previous phases of occupation), probably to obtain wool (Saña et al. in press).

A large part of the work from this period concerns funerary contexts and all specialists highlight the large diversity of burials that can be observed, usually under a regionalized pattern. This diversity is interpreted as evidence of cultural regionalization. The first megaliths are built in the Montboló region, primarily, which is north of the Llobregat River. These are stone cists where usually one or two individuals were buried. The social significance that megalithic monuments can entitle has long been acknowledged: as modifications of the landscape, symbols of territorialities and cult to the ancestries (see, for instance, Criado 1989). This phenomenon is rather different to what is observed in the central coast of Catalonia (Molinot region) and the Western plain, where individuals are buried within the settlement, inside pits or silos, like in Caserna de Sant Pau or El Collet (Piera et al. 2008). It must be highlighted that three trepanated skulls were recovered in Sant Pau. The authors consider that such practices did not have medical purposes. Instead, they would be embedded in some magical or ritual context or behaviour (Estebaranz et al. 2008). J. Robb considers that trepanation could have been a "public, multiperson social intervention" that would take place in all villages at some point (2-4% of Neolithic Italian skulls were trepanned) (Robb 2007, 39). Human bones are identified in some of the layers of Can Sadurní Cave but the funerary practices are not well understood yet (Edo, Blasco & Villalba 2011): 70). Cist-type burials are found in the Amposta region, although some authors consider that their chronological attribution remains unsolved (Chambon 2008).

2.5.1.5. 4000- 3200 cal BC. Mining, burials, salt and exchange... and farming?

This period, commonly known as the **Middle Neolithic** is rather well known and has been targeted in several dissertations and monographs (Muñoz 1965, Gibaja 2002a, Castany 2008). It is characterized by the existence of the phenomenon of the "pit burials" or "pit graves" (both expressions have been used in the literature to translate the Catalan expression "Sepulcres de fossa") in Central Catalonia. Two different subgroups were defined in the seventies by M. Cura: the Solsonià (central inland area) and the Sabadellià (central coastal area). The communities of the Solsonià were supposed to be mainly herders, while the ones of the Sabadellià would be mainly agriculturalists (Bosch & Santacana 2009, 92). At that time, no bioarchaeological evidence was available to support or refuse such theory. Megaliths were still the main funerary tradition at the north-eastern territories (which are called Empordanès group). This model of regionalization was long ago critized by M. Molist (Molist 1992), but it has been maintained in the literature. I will only refer to it with a geographic (not a cultural) sense. More significantly, the phenomenon of the pit burials is intrinsically associated with the personal ornaments that have been recovered inside. Variscite beads were found in a large number of them and these beads came from the mines located in Gavà. The Mines of Gavà are the first mining complex dedicated to a non-utilitary raw material that is known in the Iberian Peninsula (Villalba et al. 1986). This is a new situation with important social implications, not only for what prestige goods imply in the context of early farming communities but also to explain how mining and subsistence were both organized in Gavà.

As reported by other archaeologists, the interpretative potential of the many sites that have been excavated so far for this phase is huge. Unfortunately, scientific research has not been accordingly funded and the knowledge that we dispose of is minimal in comparison to the rich archaeological record that is available (Bosch & Santacana 2009, 92).

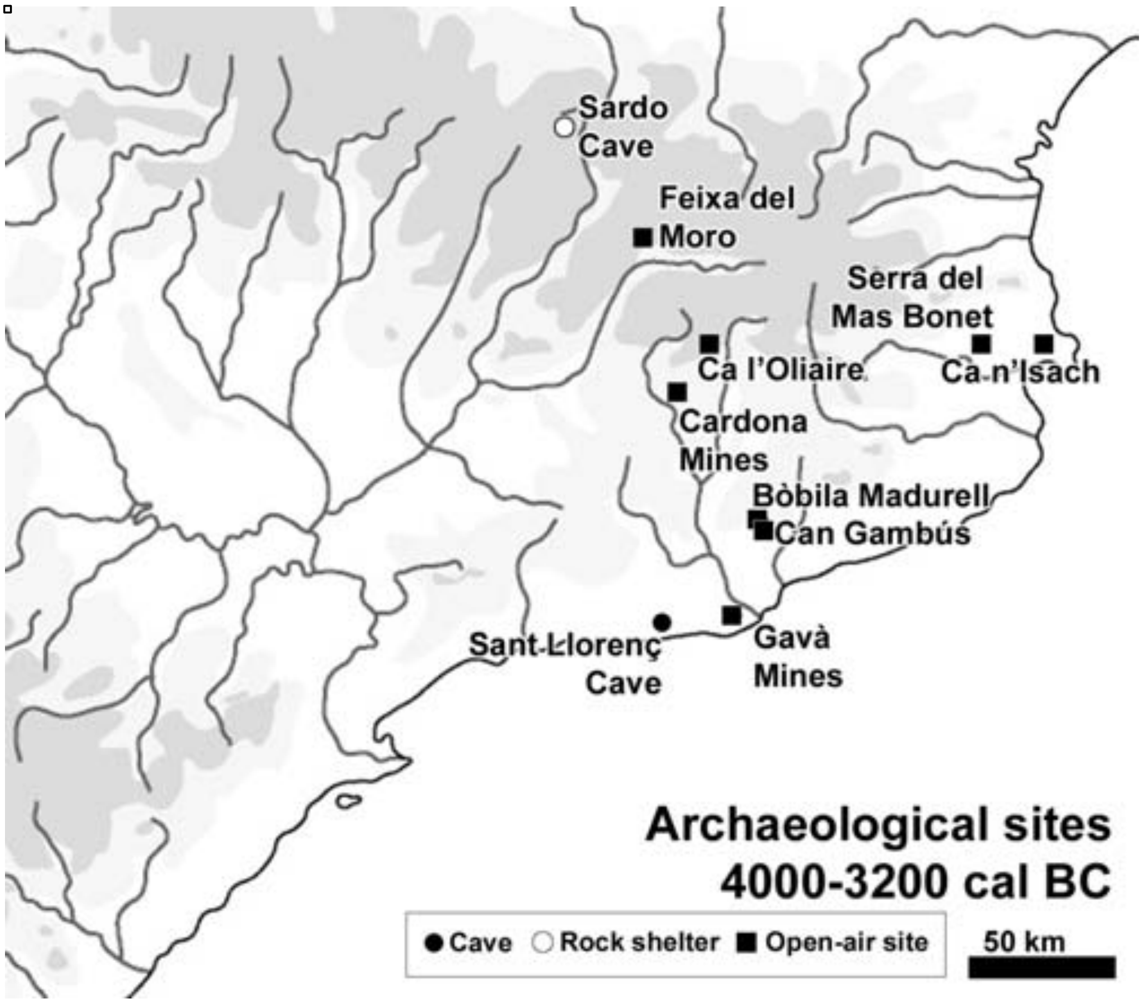


Fig. 2.11. Map of sites dated to 4000-3200 cal BC and mentioned in the text.

It becomes unfeasible to list a number of sites for this phase, since there are dozens of funerary contexts. However, open-air dwelling sites are very scanty. Three main sites are known (Fig. 2.11): Ca n'Isach (Palau-Saverdera, Alt Empordà) (Tarrús et al. 1990-1991, Tarrús et al. 1992, Tarrús et al. 1996), Bòbila Madurell (Sant Quirze del Vallès, Vallès Occidental) (Llongueras, Marcet & Petit 1986, Martín et al. 1988, Bordas et al. 1994, Martín, Bordas & Martí 1996) and Feixa del Moro (Juberri, Andorra) (Llovera 1985-1986, Llovera & Bertran 1991). Each one falls within the area of distribution of each of the mentioned groups: Empordanès, Sabadellià and Solsonià, respectively. Apart from these, Serra del Mas Bonet (Vilafant, Alt Empordà) was recently excavated. At a different level, the most impressive site of this period is the Mines of Gavà (Gavà, Baix Llobregat).

Bòbila Madurell is the largest settlement, without a doubt. 80 pits and silos and over 170 graves (Martín 2006) spread through 28 ha of land but it could have been much larger in the past, since several construction projects affected the surrounding areas during the XXth century without much archaeological control (or none at all). It is considered that it was a permanent settlement, occupied during at least 400 years (Martín, Bordas & Martí 1996). The number of published C14 dates for this site is rather low, bearing in mind its importance and its large time span, but it must be noted that the occupation could have been considerably longer. Even only taking into account short-lived samples, the site could well expand from c. 4200 until 3200 cal BC. Unfortunately, no dwelling features were identified for this period of occupation. A major dating project is needed for this site.

The open-air site of Feixa del Moro was only partially excavated and several post holes, hearths and burials were uncovered in a small area. It was interpreted as a primarily herding community (Llovera & Bertran 1991), which has recently been discussed under the light of new excavations in Camp del Colomer (Remolins, Antolín & Fortó 2011).

Ca n'Isach was excavated in an area of *c*. 600 m^2, although it could have spread over *c*. 800 m^2 of land in the past (Tarrús et al. 1990-1991, Tarrús et al. 1992, Tarrús et al. 1996). Here, the walls of four huts were built with stones. Three of the huts were large (*c*. 40 m^2) and one covered even a larger space of *c*. 80 m^2. Hearths, pits and querns were identified inside some of the houses. It seems, then, that at least part of the domestic activities could take place inside the household and that storage (at least short-term storage) would also happen inside the dwelling space. One could relate the larger size of the households with the wider diversity of activities that would have taken place indoors, in private. According to the reported data, Ca n'Isach seems to belong to a small community of c. 25 individuals. It must be mentioned that not more than 12 people between 15 and 50 years old are to be expected in an average community of 25 people during the Neolithic (see Robb 2007, 41). It has been proposed that this community was responsible for the construction of several megalithic tombs: Barraca d'en Rabert, Mas Bovill and Devesa (Bosch & Tarrús 2003). If Ca n'Isach was not larger than what we are thinking under the present state of research, two possible explanations could be put forward: either such massive projects would have required of episodes of aggregation with neighbouring communities and, consequently, they would be the result of a communal effort that would reinforce local lineages and ancestry; or maybe the building of megaliths was the result of an increasing process of household competition, through which each household or village would demonstrate their capacity to build large tombs that become part of a new landscape. Unfortunately, no conclusions can be reached on this issue given the insufficient archaeological data.

The works in Serra del Mas Bonet only affected a part of the original settlement, since it was a rescue excavation. Several silo-type structures and two post-holes from this chronological phase were uncovered (Rosillo et al. 2010). The size and duration of the occupation is unknown. Of particular interest is one of the ceramic dishes that were recovered. It was profusely decorated and it might be related to the sharing of foodstuffs. Of course, the evidences supporting this interpretation are limited, but it is interesting to note the presence of this dish, especially considering the unusual significance of the site during the Late Neolithic occupation (see below). The archaeologists consider that there are several connections (based on the observation of common pottery decoration techniques) between both phases of occupation (Rosillo et al. 2010).

Other cases of ceramic vessels potentially related with feasting episodes are known for this period. The most extraordinary example of a decorated potsherd comes from the variscite Mines of Gavà. At this site, one vessel with a feminine decoration was recovered (Bosch & Estrada 1994b, Bosch 2010).

It is not possible to go into detail with the description of the site of the Mines of Gavà. I refer, thus, to the extensive literature on the subject (Villalba et al. 1986, Bosch & Estrada 1994a, Bosch & Borrell 2010, Villalba, Edo & Blasco 2011); and see chapter 3.1.10). Around 100 mines have been located in an area of *c*. 250 ha. The period of exploitation of the mines seems to span from the second half of the Vth millennium cal BC until the first half of the IVth. The dwelling area, though, has not been found. The different teams who worked at the site assume that it was just next to the mines and rather permanent (Bosch & Estrada 1994a, 173, Bosch & Borrell 2010, 266, Villalba, Edo & Blasco 2011). M.J. Villalba highlights that this is hardly ever (or never) the case in Neolithic mines in Europe (Villalba, Edo & Blasco 2011, 313-316).

There is some evidence which indicates that this was not a fully specialized community, dedicating all of their labour force to the production of variscite beads, but several small self-sufficient groups who would live in the proximities of the site and would probably exploit the mines in generational episodes or on a seasonal basis. Firstly, sickle blades were identified in several of the mines (Gibaja 2010), which indicates that the population participated in activities other than mining. The presence of cereal pollen (Riera 2010) and cereal macroremains (charred grains and imprints on daub) (Villalba et al. 1986, Buxó, Català & Villalba 1991) would reinforce this theory. The possibility that other groups were farming to feed the specialized populations of Gavà is highly unlikely within an intensive farming model. It must be said, though, that there are some arguments against this theory. Some of the miners were buried inside the mines and there were distinct pathological signs that may distinguish these individuals from other known populations in the region, like the important muscular development of the upper extremities in comparison to the lower ones (Casas & Majó 2010, Villar, Ruiz & Subirà 2011)(). In contrast, studies from other populations like in Can Gambús-1 (Roig et al. 2010) show an equal development of all extremities and a different set of indicators. If the miners from Gavà were also farmers, such differences should not be expected. It might be possible that some individuals were specialized miners, and only those ended up buried inside the mine shafts. In fact, these studies are still preliminary and based on a small number of individuals. Further research is needed.

The settlement pattern of this period is considered to be completely different from the one in previous phases, since caves seem to be abandoned and only open-air occupations are documented. If this is true (and not a problem of lack of research), this is indicative of a different economic model, too. Groups no longer decide to support their subsistence through the exploitation of different ecosystems by different communities within the same lineage or network, but through the exploitation of prestige goods, which can be traded further away, expanding their networks horizontally rather than in an altitudinal sense. The long-term success of this strategy might be seen on the length of what is known as Middle Neolithic and the resulting settlement pattern and production strategies of the subsequent phase, known as the Late Neolithic (see chapter 2.4.2.6).

It has recently been proposed that two main focus would act as attracting forces for the distribution of sites: the variscite mines of Gavà (within the Sabadellià group) (Edo, Blasco & Villalba 2011)(Edo, Antolín & Barrio 2012) and the salt mines of Cardona (which belongs to the Solsonià group) (Weller 2002, Weller & Fíguls 2007, Weller, Fíguls 2010). Unfortunately, the exploitation of the salt mines is nearly impossible to document either at the point of extraction or as a product (since salt is hardly ever preserved in archaeological contexts). O. Weller and A. Fíguls propose, on the basis of the typology and macrospatial distribution of the macrolithic tools found around Cardona mines, that the extraction would be done at the open air, which would make it available for anyone, and that the production of salt (by grinding or pounding) would take place in the settlements. These tools probably came from Collserola mountains and were obtained through trade (Weller & Fíguls 2007, Fíguls et al. 2010). In this framework, the finding of salt residues in one of the pottery vases of Ca l'Oliaire (Berga, Bergadà) is extremely significant (Martín et al. 2003).

The Middle Neolithic is considered by authors like J. Vaquer as the real context where a constant long-distance network of exchange of prestige goods is established (Vaquer & Lea 2011). These long-distance networks were already in use in former times, but it is in this period when prestige goods circulate all along the north-west region of the Mediterranean and on a European scale (e.g. large alpine stone axes). As the author points out, there is a clear example of these prestige goods in the variscite beads that are produced in the Mines of Gavà, with the single purpose of personal ornamentation. Blond silex is yet another example of it, since it is found in dwelling sites in the region around (300 km) the valley of the Rhone River, where it was obtained, but the perception of it changes with distance, since it is mostly present in funerary contexts in the North-East of the Iberian Peninsula (Terradas & Gibaja 2002, Vaquer & Lea 2011). This is set as an example of how objects are introduced into a new social context where a need of prestige or exotic goods has appeared (Vaquer & Lea 2011).

Some authors have highlighted the social complexity that would be necessary in order to develop these networks. According to A. Martín, this phenomenon would correspond to complex and advanced groups who were capable of planning their surplus in order to exchange it for prestige goods. This author reports that there is an intensification of production and that there is a high degree of technological production. Bòbila Madurell is considered by A. Martín as a sort of central place or primary site of the region. Bòbila would have the higher status and it would be the centre of control and distribution of prestige goods (Martín, Bordas & Martí 1996). At this point I want to refer back to the work of Meillassoux (1980) (and chapter 2.3.1 of this work) to emphasize that this process might be part of the world of early farming communities and that, as observed in ethnographic examples, the exchange of prestige goods does not require large surpluses but people who are capable of acquiring prestige and power within the same social organization that existed before.

Palaeoeconomic data are barely included in any of the literature. Different assumptions are made on a regional scale. Castany, partly following the scheme drawn by M. Cura, describes the communities of the Solsonià group as organized sedentary families or groups who would practice a rudimentary agriculture and would have a controlled management of herds more or less in stalled conditions and who would produce enough surplus to allow a demographic increase, as detected through the study of burial practices (Castany 2008, 799). J. Tarrús partly rejects this position, by stating that the meagre available data seem to confirm that these populations lived in permanent settlements and practiced both agriculture and herding (Tarrús 2003). The relatively high number of querns that have been recovered in the Cardona region also lead to Fíguls and other to defend that agriculture was much more important than previously stated for these regions (Fíguls et al. 2010).

This period is considered as the golden age of the Neolithic for the Sabadellià group, with a well-established and successful agriculture, with herding practices centred on cattle and pigs (which are linked to more sedentary settlement habits), and the existence of large settlements in the lowlands, all of which would indicate the lack of violence in the society (Martín 1992; although see Martín, Bordas & Martí 1996)). Even though archaeobotanical data are barely non-existent, it is said that agriculture would intensify and that it would produce surplus (Bosch & Santacana 2009, 107). First of all, it should be noted that evidence of violence was documented in Bobila Madurell (Campillo, Mercadal & Blanch 1993). Secondly, no systematic research has been carried out on storage techniques during the Neolithic, for which any affirmation on this topic remains tentative. The change could concern habitat nucleation, which would have interesting social implications. Could this relate to an increasing power of local authorities (*sensu* Kent 1989)? The building of long-lasting networks of prestige goods would precisely support this theory. Of course, more data are needed in order to defend that habitat nucleation would be driven by the will of local authorities (it was probably a multiple-cause phenomenon).

The published archaeobotanical data come from the Mines of Gavà. Hulled and naked barley, naked wheat, emmer and einkorn were identified in low numbers. Both barleys and einkorn were also identified in daub imprints (Villalba et al. 1986). The use of cereal processing by-products as temper could only indicate local agriculture. The archaeobotanical finds that were recovered in the burial context of Mine 28 were of particular interest. Apart from some charred cereal grains, a large number of seeds of the Liliaceae family and wild olive stones were recovered in direct association with the single inhumation. This was interpreted as part of the funerary ritual (Buxó, Català & Villalba 1991). Nevertheless, most of the charcoal remains from this deposit belonged to *Olea* sp. (Piqué 2010), therefore it might respond to the burning of one or several branches of this tree which still had some fruits. Traces of opioids were detected on the bones of two male individuals buried in the mines and traces of the capsule of opium poppy were identified in the dental calculus of one of them (Juan-Tresserras & Villalba 1999).

Chemical analyses on a sample of 10 individuals from Bòbila Madurell led anthropologists to conclude that there were gender differences on the diet: women had a higher vegetal input in their diet in comparison to men (Subirà & Malgosa 1996). These studies should be continued and systematically applied. Similar differences were observed in other sites like in Mas d'en Boixos, where the higher percentages of masculine individuals with dental calculus was interpreted as indicative of an animal-protein-rich diet (Alfonso, Malgosa & Subirà 2004).

Herding practices are also poorly known due to preservation issues and lack of habitat contexts. Nevertheless, the theoretical assumption of M. Cura that we mentioned above, concerning the economic traditions of the Sabadellià and the Empordanià groups, are uncritically maintained (Bosch & Tarrús 2003, Martín 2006). Acidic soils of Ca n'Isach did not allow a good preservation of faunal remains, but ovicaprines and cattle were identified (Tarrús et al. 1996). At Bòbila Madurell, a mixed farming model is once again documented, primarily based on ovicaprines, but with important numbers of cattle and pigs. Exploitations seem to be oriented to the obtention of milk and meat, as well as the use of cattle as labour force (Martín, Bordas & Martí 1996). The implications of a systematic exploitation of the salt mines of Cardona (for which the evidences are still not completely conclusive) could have been very important for the consumption of meat. The preservation of meat for consumption requires large amounts of salt (1 kg of salt to 10 kg of meat for salted pork is recommended) and this would open the possibility for a delayed consumption of meat (Halstead 2007). The identification of such practices on the archaeozoological record would be of great interest.

Funerary traditions of this period have focused most of the studies. According to some researchers (Hernando 1999, 176), the pit burial phenomenon seems to be the generalization of some practices that were already observed before (like in Caserna de Sant Pau). These connections are not so clear to other specialists (Chambon 2008). It is significant to notice that the supposedly preceding practices are no longer observed during this phase (Bosch & Santacana 2009, 94). The pit burial tradition is characterized by individual or double burials with a characteristic apparel consisting on pottery vessels, lithic tools (usually these have not been used) and several prestige goods such as variscite beads (necklaces and bracelets primarily) (see, for instance, Martín 2006, Bosch & Santacana 2009, 94-97), for some recent synthesis). Stone cists with similar apparels are found in the Solsonià group area (see Castany 2008) for a complete evaluation).

The distribution of variscite is not homogeneous in the record. About 20% of the graves in Bòbila Madurell, for instance, have beads of variscite, and this percentage is slightly lower in the burials of the Solsonià group (Villalba, Edo & Blasco 2011). There are differences in grave apparel richness within one single site and there are young individuals with significant goods. This has been interpreted as the onset of social inequality (Blasco, Edo & Villalba 2005, Villalba, Edo & Blasco 2011). Such evidences agree with the proposed theory of the existence of local authorities who would achieve a social status. This status could even be inherited (which would explain rich graves of young individuals) in a similar way as A. Testart proposed considering ethnographic examples (Testart 2005, 44). It was people with a social status who claimed these objects when the opportunities appeared (e.g. marriages or other significant events) and traded with them.

One final approach to social complexity was recently done by J. F. Gibaja, through the study of use-wear traces on lithic tools and other grave goods that were present in burials from this chronological phase (Gibaja 2002a, Gibaja 2004). This author highlights the fact that some men and a few women and children have more remarkable apparels in Bòbila Madurell. This phenomenon does not occur in all necropolises, which would indicate that some social process of hierarchization was going on in certain areas. In general, men are more systematically linked with querns, cores, polished axes, geometric microliths and arrowheads (many of which were used to hunt or to work wood). Females were more frequently associated with bone tools and tools that have been used to prepare skin. Sickle blades are associated with all age and sex groups. As noticed by other authors (Piqué & Escoriza 2011, Alonso in press), this distribution is partly surprising, since the association of querns with men is not what could be assumed considering ethnographic references. Less unexpectedly, the frequent appearance of sickle blades indicates that harvesting was practiced by all the family, since this activity had to be done as fast as possible and all available labour force was needed. R. Piqué and T. Escoriza interpret these results in terms of domination and exploitation, considering the real economic role of each activity as observed in the archaeological record (female work) and what is eventually represented in rock art (male work) (Piqué & Escoriza 2011).

2.5.1.6. 3200-2300 cal BC. Stelae, metals and social coalescence. The end of an era?

The end of the Middle Neolithic and the onset of the so-called **Late Neolithic** is rather blurred on archaeological terms (Mestres & Martín 1996), but I follow the intervals of probability drawn by J. A. Barceló (Barceló 2008). It is obviously necessary to do more research in order to understand this long period in more detail, as noticed by other authors (Martín 2003). A mixture of several influences, especially from Southern France, is detected in the archaeological record. Local approaches to funerary practices during this period seem to support the establishment of some subphases that should be confirmed in future research (Edo & Martínez 2011). Bell beaker contexts have been avoided, even though they are frequently included within this "never-ending" Late Neolithic phase, because they are linked with metallurgy and such groups fall outside of the objectives of this work. Certainly, more research is needed in this region in order to distinguish a proper Chalcolithic horizon.

This period is considered to be a rupture with the previous situation. Some authors report that sites that were occupied during the Middle Neolithic are abandoned; instead smaller sites appear and a larger occupation of the mountains is detected, with a corresponding increase of the proportion of ovicaprines in the record (Martín 1992, Mestres & Martín 1996). This is interpreted by A. Martín (1992, 222) as a clear evidence of an intensification of the herding economy, and the recession of the development towards an agricultural society. According to this author, this could have originated from the climatic aridification or the overexploitation of the ecosystems, as well as social and economic crises.

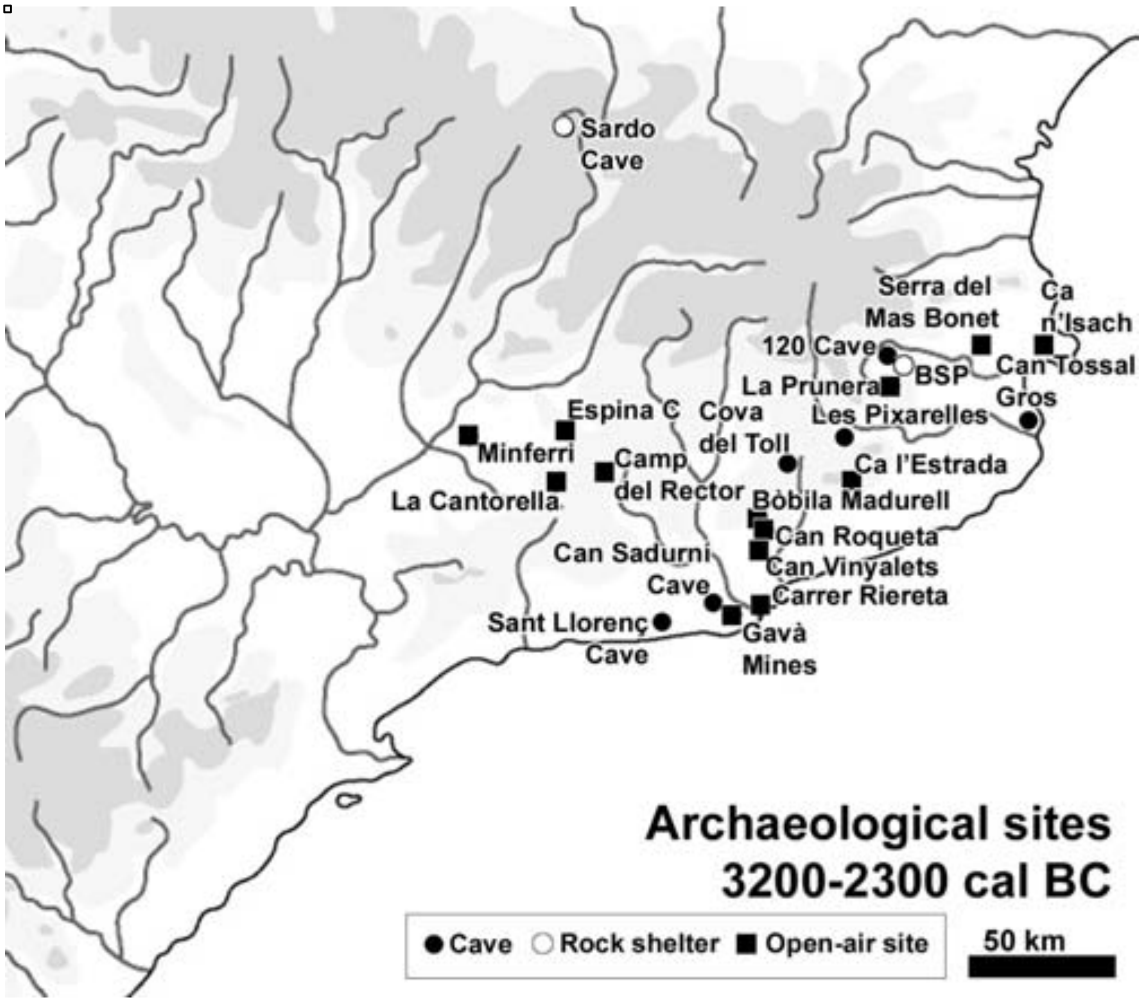


Fig. 2.12. Map of sites dated to 3200-2300 cal BC and mentioned in the text (BSP: Bauma del Serrat del Pont).

This is contradicted by the archaeological evidence, since there are a number of sites that remained occupied during the IVth and the IIIrd millennium cal BC, like Bòbila Madurell (Llongueras, Marcet & Petit 1986, Martín et al. 1988, Bordas et al. 1994), Gavà Mines (Villalba et al. 1986, Blasco, Edo & Villalba et al. 1986), the plain of Barcelona (Carlús & González 2008), Serra del Mas Bonet (Rosillo et al. 2012), Ca n'Isach (Tarrús et al. 1996), etc. There is, in that sense, a general continuation of the distribution of settlements. But dwelling sites are better documented for this phase, which could produce the illusion of a radical change. Some new open-air sites are documented (Fig. 2.12) in Camp del Rector (Jorba, Anoia) (Font 2005), La Prunera (Sant Joan les Fonts, La Garrotxa) (Alcalde et al. 2005), Ca l'Estrada (Canovelles, Vallès Oriental) (Fortó, Martínez & Muñoz 2008), Espina C (Tàrrega, l'Urgell) (Piera et al. 2009), or Can Roqueta (Sabadell, Vallès Occidental) (Oliva et al. 2008). And recent excavations are uncovering important sites with several storage pits like La Cantorella (A. Moya, oral com.) and Minferri (Juneda, Les Garrigues) (Alonso et al. in press b), in the Western Plain of Catalonia. Both sites are occupied until the Bronze Age, which seems to support some continuation between both phases in this area. The number of sites is actually large and I will only focus on the best cases for our purposes.

Bòbila Madurell yielded two elliptic huts of 40-50 m^2. They seem to have had several episodes of occupation and other negative structures are connected with them. In both structures, hearths, pits and other structures were identified and a spatial organization of the materials was observed (Bordas et al. 1994).

A complex set of structures was recovered in Camp del Rector (Font 2005). A single dwelling structure was identified, with two phases of occupation. During the first phase, it might have had and extension of 10 m^2. During the second phase it was larger, and covered around 25 m^2. Several small pits were identified inside the hut, some of which could have been used as hearths. Two other hut-type structures were identified at the site, but the archaeologists consider that these are un-walled working areas.

Serra del Mas Bonet had at least one large eight-shaped dwelling of *c.* 50 m^2 with one hearth inside and two very distinct areas, which could have been the result of a clear organization of the space inside the hut. Another hut that is not described is also mentioned in publications (Rosillo et al. 2012).

Another relatively large dwelling was found in Espina C (Piera et al. 2009). Here, the concentration of postholes, some of which are clearly aligned, could be interpreted as a large hut of over 60 m^2, possibly related to some silos, which were found both inside and outside the hypothetical limits of this hut. The use level of this hut was not found, but a large number of fragments of burned clay were found inside the nearby silos and postholes, which could correspond to the base of a hearth. It must be said, though, that is difficult to decide which postholes belonged to the same structure and alternative interpretations have also been proposed by M. Piera (Piera 2007). Likewise, the stratigraphic relationship between the storage pits and the hut is not clear.

In Bauma del Serrat del Pont, several short occupations seem to have taken place during this period. A small shelter of *c.* 10 m^2 would have been built against the wall of the rock shelter. Several hearths were identified, all of them outside the limits of the hut (Alcalde, Molist & Saña 2002). Archaeological data could support a different interpretation of the site (see below), with longer occupations and a local practice of farming activities.

La Prunera has been interpreted as a singular site, where episodes of coalescence would have taken place periodically, maybe related to animal husbandry (to promote exogamous reproduction) (Alcalde et al. 2005). The evidences are scanty, but one argument to support such interpretation is that palynological and soil micromorphological analyses concluded that the area where the site is located was frequently flooded. This is not suitable for a permanent site, unless we are dealing with pile dwellings, which seems not to be the case. No habitat contexts have been identified either, although several postholes, hearths and pits were present.

Most of these evidences point towards an increase of house (and maybe household?) size during this phase and, consequently, an increase in the diversity of productive activities that could be carried out in the privacy of the house. Of course, these are only tentative interpretations of a very scanty record.

Several sites with silos were identified for this phase, like Camp del Rector, Espina C, Minferri or La Cantorella. The specific study of the silos of most of them is currently on-going (G. Prats, PhD in progress, Universitat de Lleida).

The use of high mountain areas in the Pyrenees seems to intensify during the Late Neolithic (from *c.* 3000 cal BC onwards). Frequent fires have been recorded and there seems to be good evidence of not only the opening of woodland formations but also of their maintenance (Cunill 2010, Cunill et al. 2012, Miras et al. 2010). These observations are of huge interest for the understanding of the evolution of the household mode of production (in terms of Sahlins 1977) during the IIIrd millennium cal BC. Recent work at Sardo Cave indicates that as long as the mixed farming model is practiced, occupations at high mountain areas stay close to valley bottoms, and only during and after the Late Neolithic these occupations are abandoned in favour of the higher pasture lands above 2000 m a.s.l. (Gassiot et al. 2012b). In my eyes, the exploitation of high mountain pastures could only indicate a larger importance of cattle herding, which would explain the need for fresh and extensive pastures. This need of high mountain pastures might be increased by the progressive aridification of the lowlands (which is observed in all the archaeobotanical proxies available, see chapter 2.4.2), for which grasslands might have become too scarce. Goat and sheep could still be kept in settlements to help maintaining an intensive agriculture system. The evidence of the extensification of herding practices is not yet proved (see below).

Metals are used for the first time to produce jewellery. Gold and copper are found for the first time during this period (Martín 2003, Soriano, Soler & Soler 2012). Soriano considers that they would not have a high social impact. This is inferred from the fact that they are recovered inside collective burials where no specific apparel would be deposited, but just the ordinary goods of each individual. A change is observed in Bell Beaker contexts, where individualized graves contain much more elaborated golden beads, which would have a much higher social value (Soriano, Soler & Soler 2012).

Data on crop husbandry are very scanty for this phase, as well. The largest concentration of grain was identified in Toll Cave (Moià, Bages). It consisted on *c.* 9600 grains of hulled barley, and just some grains of emmer and naked wheat (Hopf 1971). A few cereal grains were identified in Bauma del Serrat del Pont. Naked wheat, emmer, naked barley, hulled barley and einkorn are represented. Acorns, hazelnuts and wild grapes could have been gathered as well. One possible storage pit, sickle blades and pollen grains of Cerealia were identified at the site, so the possibility of a local cultivation of cereals is realistic even though the site is interpreted as a seasonal occupation (Alcalde, Molist & Saña 2002).

Data on animal husbandry are very scarce. A more important role of ovicaprines is assumed (Martín 1992, Bosch & Santacana 2009), partially linked to the idea that mountain sites are reoccupied for herding purposes. In Bòbila Madurell, important concentrations of *Bos taurus* were recorded in some contexts. One complete animal in anatomical connection was documented in one of the huts (Bordas et al. 1994). In Serra del Mas Bonet, ovicaprines and bovines are well represented (Rosillo et al. 2012). Faunal remains were poorly preserved in Camp del Rector, but cattle, ovicaprines and pigs were identified (Font 2005). Similar results were obtained in Can Vinyalets (Santa Perpètua de la Mogoda, Vallès Occidental), but here the number of identifiable remains was higher (n: 83) and cattle constituted 65% of it (Font 2006). In Les Pixarelles Cave, a mixed farming model of ovicaprines, bovines and pigs is documented. Ovicaprines dominate the record, but bovines constitute 24,4% of the identified remains (Álvarez & Rauret 1996). In Espina C, only bovines and ovicaprines are represented, as well as domestic dog, but the number of remains is very low (Piera et al. 2008). The first evidences of the presence of horse in our region might be documented in the recently excavated open-air site of La Cantorella (A. Moya, oral com.). In general, wild animals are badly represented in the record, but a different pattern is documented at the rock-shelter of Bauma del Serrat del Pont. Apparently, domestic animals would only be occasionally consumed at this site and hunting would be more important (Alcalde, Molist & Saña 2002).

A large diversity of funerary practices is documented during this phase. There is a generalized use of caves for collective burials, like in Can Sadurní Cave (Edo, Blasco & Villalba 2011), 120 Cave (Agustí et al. 1987) or Frare Cave (Martín, Biosca & Albareda 1986). The construction of megaliths during this phase is well attested. The megaliths that are built during this period will be repeatedly reused during subsequent phases. For this reason it has been considered that megalithic tombs would act as signs of landscape appropriation and acknowledgment of the ancestries (for a clear example in the Empordà region see Baulenas & Heras 2007).

Several (politico-ideological) manifestations have been recently discovered for this period, which constitute a novelty in the Prehistory of the region (Tarrús 2011). This tradition, in fact, is considered to be a continuation of the first evidences found during the Middle Neolithic (Moya, Martínez & López 2010). The statue menhirs that have been recovered in the Vallès region and the stelae from the northern part of the Western plain of Catalonia have clear stylistic connections with Southern France, more specifically, the Roergue group. The anthropomorphic statue from Ca l'Estrada is the most interesting because of its archaeological context, where three large hearths (of 2-6 x 1,2-1,9 m) and ditches were identified (Fortó, Martínez & Muñoz 2008, Martínez, Fortó & Muñoz 2010). This site has been interpreted as a ceremonial place, probably with religious connotations (Moya, Martínez & López 2010, Martínez, Fortó & Muñoz 2010). It is an appropriate context for the celebration of feasts and a clear evidence for the need of group coalescence during this period. Similar hearths have been found in other sites like Can Roqueta (Oliva et al. 2008) or C/ de la Riereta (Barcelona) (Carlús & González 2008). These episodes of coalescence could be embedded in a more sophisticated abstract purpose, but what is of major interest for us is that social groups invest a lot of time and labour in order to create spaces for interaction and sharing as part of their productive and reproductive strategies.

Another extremely interesting set of stelae was recovered in Serra del Mas Bonet. Two nearly complete stelae with horns and one fragment were found inside pits, while three more fragments were found inside two huts. These sculptures were interpreted as symbols of masculinity and fertility, associated with the bull cult. One of the pits (E-17, see the location in Fig.3.4), where the better preserved stela was found, also contained a small menhir (120 cm long) and a large number of potsherds and faunal remains (cattle, ovicaprines and suidines) (Rosillo et al. 2010). Considering the archaeological context, these stelae might commemorate the celebration of feasts rather than some religious beliefs. Whatever the case may be, further research is needed.

2.5.1.7. Summary. Limitations and possibilities for the application of a socioeconomic model for the interpretation of the Neolithic record of the NE of the Iberian Peninsula. The potential contribution of the archaeobotanical data

Any critical reader will have noticed that the socioeconomic interpretation of the available archaeological data for the Neolithic of the NE of the Iberian Peninsula is a difficult task. The existing record is sparse for most periods and the published information is frequently partial. Nevertheless, the attempt resulted in the observation of some trends that could be worth noticing as hypotheses for future research.

Communities of around 100 inhabitants could have existed already in the earliest phases of the Neolithic (e.g. at La Draga), but somewhat smaller groups seem most likely for the majority of sites, at least until the

Middle Neolithic (e.g. in Bòbila Madurell). Continuity is observed in an important number of sites between several periods. Considering the available radiocarbon dates, many villages/dispersed groups of farms could have been rather permanent and would end up constructing long-lasting strong lineages in particular territories towards the late Vth and IVth millennium cal BC. Towards the end of the Vth millennium cal BC, networks of exchange of prestige goods developed into permanent relations and the social relevance of some individuals could have been such that it would be inherited by their offspring (which is evidenced in funerary apparels of young individuals). Their rising authorities or other factors, which are unknown to us, could result in a process of habitat nucleation during the IVth millennium cal BC. In the IIIrd millennium cal BC this phenomenon became generalized for the northern half of the territory under study and politico-ideological manifestations and evidences of social coalescence turned widespread. The third millennium might constitute a transitional period, where households became slightly larger and economic practices slightly more extensive (with exploitation of mountain pastures).

It seems clear that we are dealing, from the very first stages of the Neolithic, with small communities who practice a mixed farming economy. No archaeological evidences support shifting agriculture (e.g. lack of permanent sites, lack of large domestic animals or an important role of hunting), floodplain agriculture (deforestation of riverine areas, absence of evidences of use of cattle for traction) or extensive ox-drawn agriculture (large deforestations, systematic use of cattle traction, low diversity of cereal crops and livestock, practice of transhumance or the use of the threshing sledge). The use of mountain pastures is not documented until the latest stages of the Neolithic, when major social change seems to be occurring. Archaeozoological data, though insufficient, does support a mixed herding husbandry with dominance of sheep and goats during the first millennia and, only towards the IIIrd millennium, cattle might become numerically more significant (the data are not conclusive on this aspect). A polyvalent exploitation of animal resources seems evident since the first phases of the Neolithic and no specialized productive strategies are detected.

And what could archaeobotanical data bring to the knowledge of social and economic evolution of Neolithic communities in this region? Of course, a lot, and it is the **aim of this work** to provide data which can contribute to this discussion. Archaeobotanical analyses are indispensable in order to confirm crop husbandry practices and the intensity of farming. The intensity of agricultural practices might be identified in a variety of ways, such as the identification of crop rotation practices or weed assemblages which denote eutrophic environments and intensive management of the plots. This is one of the key aspects of the model and it certainly needs further (and specifically oriented) research. Further on, the definition of crop processing techniques and areas could complement the first mentioned issue and also bring up interesting information concerning household autonomy, local traditions and social organization of labour. For this, it would be necessary to identify single refuse deposits, which can potentially represent single actions. The study of the crop processing techniques applied to these assemblages might contribute to elucidate whether these practices were of intensive or extensive type (according to what was presented in chapter 2.2.1). The location of these activities within the settlement might shed some light on the scale in which they were practiced. A more precise knowledge of wild plant management could equally add further arguments to the mentioned topics and also contribute to our knowledge on the diversity of resources that were exploited by these populations and the frequency with which they were exploited. It would be of great interest to discern whether we are facing occasional wild plant use or a systematic management of these resources. For this, it is hoped that assemblages which can respond to single actions, are also identified and that the processing of these fruits can be approached in detail. It is through their repeated appearance that it will be possible to state the degree of frequency with which they could have been consumed in the past. Finally, the identification of consumed products (through the identification of elements like bread, bulgur, etc.) can shed light on the investment of labour on these products and their potential social significance and role in the diet.

All these methodological aspects will be presented in greater detail in the next chapter.

3. Materials and methods

3.1. Materials: sites under analysis

Materials from 17 archaeological sites were analysed in this work. The location of the sites is presented in Fig. 3.1. In the next pages, a short general presentation concerning location, chronology, settlement structure, palaeoecological and palaeoeconomic data and bibliography of each site is offered. The quantity and type of information given per site highly depends on the state of research and the available information from publications. Pit functionality (especially for dwelling and storage pits) was inferred by archaeologists from the shape and the archaeological context of the features (for a recent review of the criteria used by most archaeologists in the region see Terrats 2010). In this text, the same nomenclatures defined by the archaeologists of each site were used.

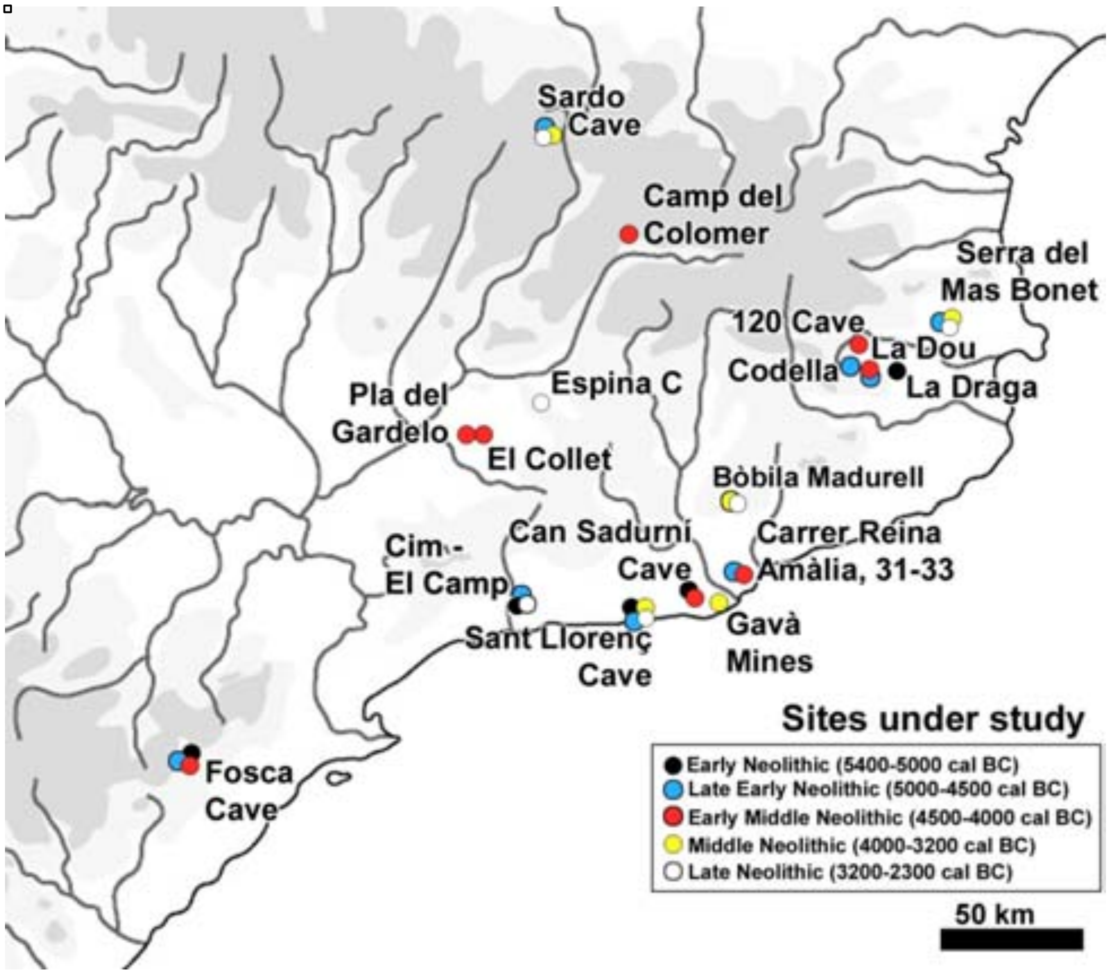


Fig. 3.1. Map of the sites under study.

3.1.1. Sardo Cave

3.1.1.1. Location and history of investigations

Sardo Cave is a small rock shelter located in Boí (Central Pyrenees). It is next to Sant Nicolau River, on a suntrap at 1790 m a.s.l. and just 60 m above the river valley. High mountains of over 2000 m a.s.l. surround the valley. Sant Nicolau valley is one of the wettest valleys in Catalonia at present, with an average annual rainfall of more than (Gassiot et al. 2012a) 1100 mm. It is very close (1 km) to the Llebreta pond, where a wider plant biodiversity is documented and small surfaces of arable land might be available (Fig. 3.2a). The cavity is 9 m wide and 3 m deep (20 m^2, approximately) (Gassiot et al. 2012a). The geology of the surrounding area is of granitic nature (Celma et al. 2008).

The site was discovered in 2004. The area under the shelter and the adjacent slope of 60 m^2 were excavated between 2006 and 2008.

Fig. 3.2a. View of the valley from Sardo Cave (Author: Sardo Team).

3.1.1.2. Chronology and phases

A wide chronological sequence was uncovered. Each phase was radiocarbon dated. Several occupations took place in historical times (during the IIIrd, IXth, XVIth and the XVIIIth centuries AD). In addition, five Prehistoric phases of occupation were also identified: phase 5 (2900-2500 cal BC); phase 6 (3300-3100 cal BC); phase 7 (3900-3500 cal BC); phase 8 (4800-4400 cal BC); and phase 9 (5600-5400 cal BC) (Gassiot et al. 2012b, Gassiot et al. 2012a).

3.1.1.3. Settlement structure

Most of the occupations of the site took place in the area under the rock shelter (Fig. 3.2b), although in phase 6 a wooden roof was attached to its entrance. In each phase, fireplaces acted as a centre for productive activities. Different types of hearths were found in different phases. Small hearths in pits were found in phases 9 and 7, circles of stones were used as delimitation structures in phase 8, and in phase 5 hearths were located against large blocks of stone (Gassiot et al. 2012b). Phase 9 merely consisted on a single hearth and some pieces of lithic industry. Phase 8 shows more evidences of occupation both inside and outside the cave, but the archaeological material is sparse. In phase 7 an intense occupation of the area under the shelter is observed, evidenced through the construction of several hearths. Numerous findings of highly fragmented burnt bone fragments seem to show the repeated consumption of animal products in the site. In phase 6, most of the evidences of human activity concentrate in front of the shelter, where a wooden roof or hut was probably built. All the prehistoric occupations are considered to be of short duration (Gassiot et al. 2012a).

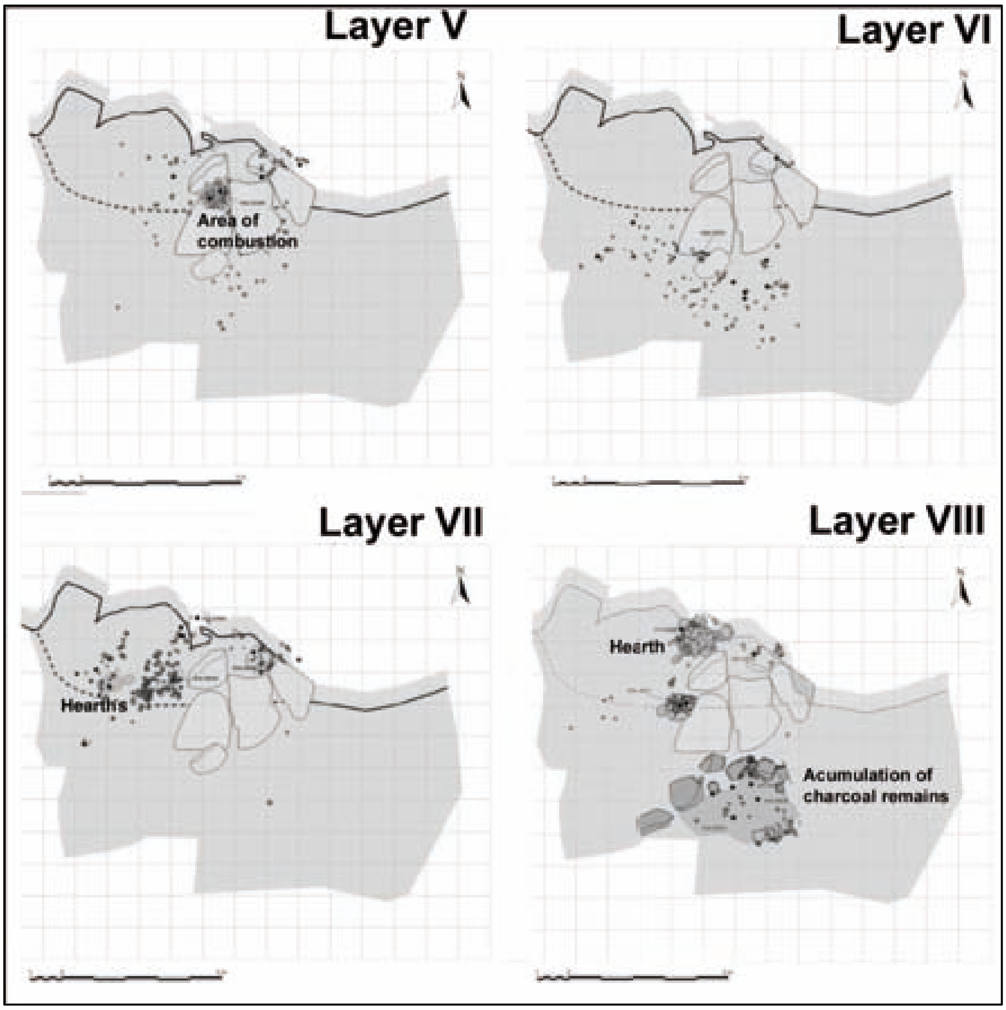


Fig.3.2b. Site plan of Sardo Cave (adapted from an image provided by E. Gassiot).

3.1.1.4. Palaeoecological and palaeoeconomic information

Pollen analyses (A.Ballesteros & F. Burjachs) show, for phase 9, a dense woodland cover of pine and birch with evergreen and deciduous oaks at lower altitudes. Ferns are abundant and riverside forests would be found in the river valley. Pastures/grasslands, together with pine woods, are better represented in the diagram in phase 8. It is considered that human modification of the landscape becomes more intense in this phase and, especially towards the end of the phase, birch, hazel and heather expand significantly. Between phases 7 and 5 the occupations seem more intermittent (consequently pine woods become more widespread). No cereal-type pollen has been identified (Gassiot et al. 2012b).

Only charred plant macroremains were preserved. The preliminary anthracological results show a wide predominance of pine wood (*Pinus sylvestris/nigra*), some riparian taxa and a small presence of other deciduous trees. From the fourth millennium onwards, pine decreases and juniper is equally well represented in the record (Obea et al. 2011).

Barely any identifiable faunal remain has been recovered at the site, which could be due to taphonomic issues. This remains to be evaluated. Despite this fact, it is considered that most occupations respond to the needs for shelter during the practice of herding. Use-wear analyses of flint tools seem to indicate that the most common activity at the cave would be the processing of animal skins and flesh. Hunting could equally be practiced by the inhabitants of the site, especially considering the finding of several arrowheads (Celma et al. 2008).

3.1.2. Camp del Colomer

3.1.2.1. Location and history of investigations

The open-air site of Camp del Colomer is located in Juberri, Andorra (Eastern Pyrenees), at 1280 m a.s.l., in a mountainous area (Fig. 3.3a). It is located in an area of *c*. 10º of steepness. Arable land, water (the Valira River) and lithic resources are located at less than 30 minutes from the settlement (Remolins, Antolín & Fortó 2011).

Camp del Colomer was discovered during the realization of some construction works close to the well-known Middle Neolithic site of Feixa del Moro. The excavation took place in 2009 (Martínez, Vidal & Maese 2011).

Fig.3.3a. Foto of part of the excavated area of Camp del Colomer and the views from the site over the landscape (Author: Patrimoni Cultural d'Andorra).

3.1.2.2. Chronology and phases

The site is radiocarbon dated around 4500-4200 cal BC (A. Vidal, pers.com.). The typological stile of the potsherds recovered, though, was classified as belonging to Late Epicardial Culture, which is believed to develop between 4750-4500 cal BC (Martínez, Vidal & Maese 2011, Martínez & Vaquer in press). All archaeological structures seem to belong to the same phase of occupation, although it was not possible to demonstrate the contemporaneity between all of them.

3.1.2.3. Settlement structure

Two trenches of *c.* 12 x 60 m and separated by *c.* 35 m (which were not affected by the construction works) were excavated. 40 structures were identified: two large dwelling-type pits; 7 silo-type pits and 31 negative structures of unknown function (Martínez, Vidal & Maese 2011) (Fig. 3.3b).

3.1.2.4. Palaeoecological and palaeoeconomic information

Large vessels (storage/cooking vessels?) were identified, as well as grinding stones and axes (Martínez, Vidal & Maese 2011).

Only charred plant macroremains were preserved. The anthracological analysis shows that the record is dominated by pine (*Pinus sylvestris/nigra*), deciduous oak (*Quercus* sp. deciduous) and yew (*Taxus baccata*). Oak is the more frequently encountered taxon. The important presence of yew is considered to be rare within the Pyrenean and pre-Pyrenean region (Piqué 2011).

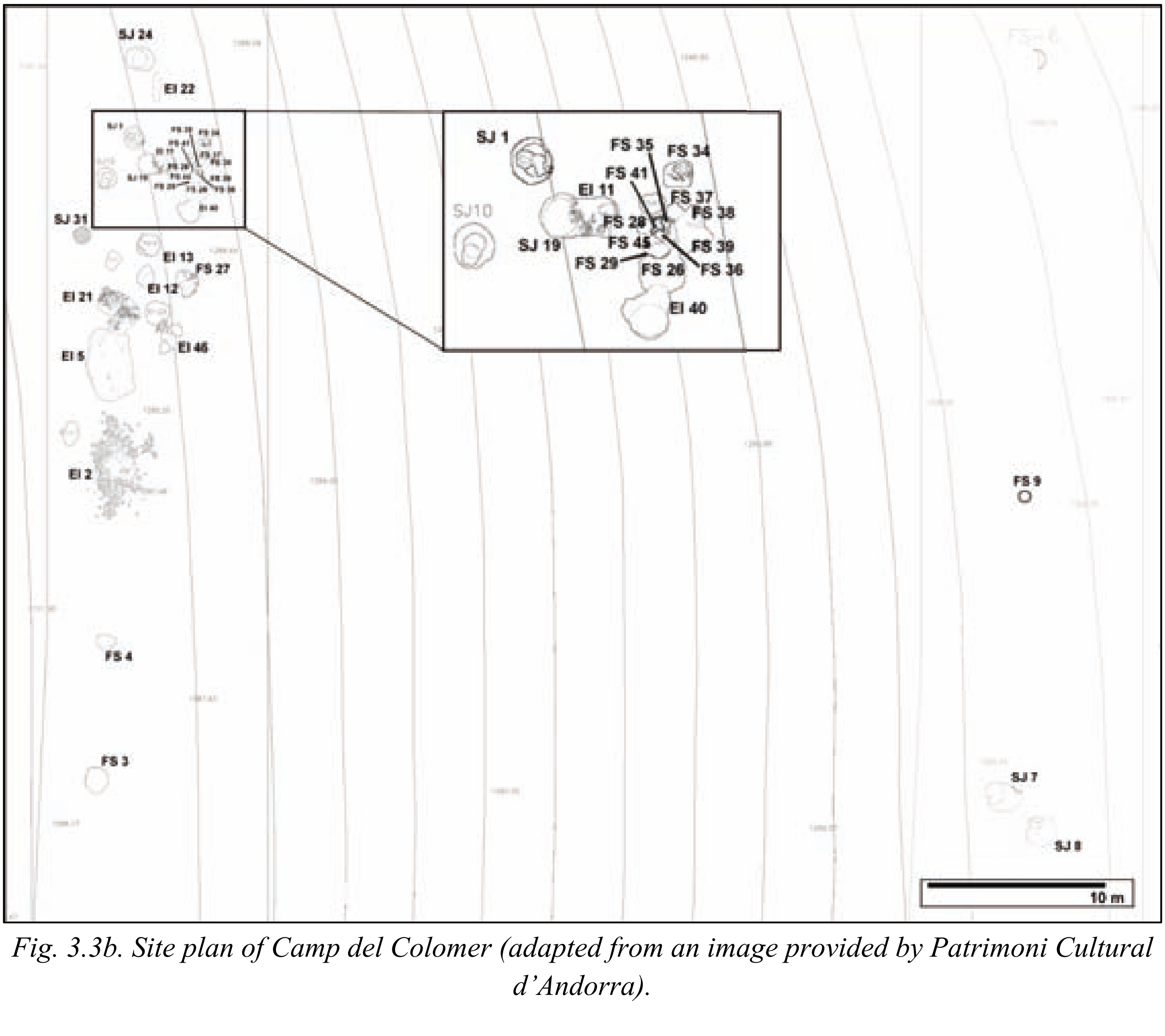


Fig. 3.3b. Site plan of Camp del Colomer (adapted from an image provided by Patrimoni Cultural d'Andorra).

3.1.3. Serra del Mas Bonet

3.1.3.1. Location and history of investigations

The open-air site of Serra del Mas Bonet is located in Vilafant (Alt Empordà), on the northern and western slopes of a little hill at 75 m a.s.l. The Manol River is at 500 m of distance. It is located on arable land.

It was discovered in 2008 while conducting some construction works under archaeological supervision. Negative structures were documented along an area of 2,5 ha. 112 structures were excavated (Fig. 3.4 and 3.5) (Rosillo et al. 2012, Rosillo et al. 2010)(Rosillo et al. 2012).

3.1.3.2. Chronology and phases

There are several occupations during the Late Early Neolithic (Epicardial, 4900-4600 cal BC), Middle Neolithic (4100-3400 cal BC), Late Neolithic (3400-2700 cal BC) and Early Bronze Age (2200-1500 cal BC) (Rosillo et al. 2012, Rosillo et al. 2012). Radiocarbon dates were obtained for some of the features, while the rest were ascribed to each phase considering the presence of characteristic archaeological artefacts.

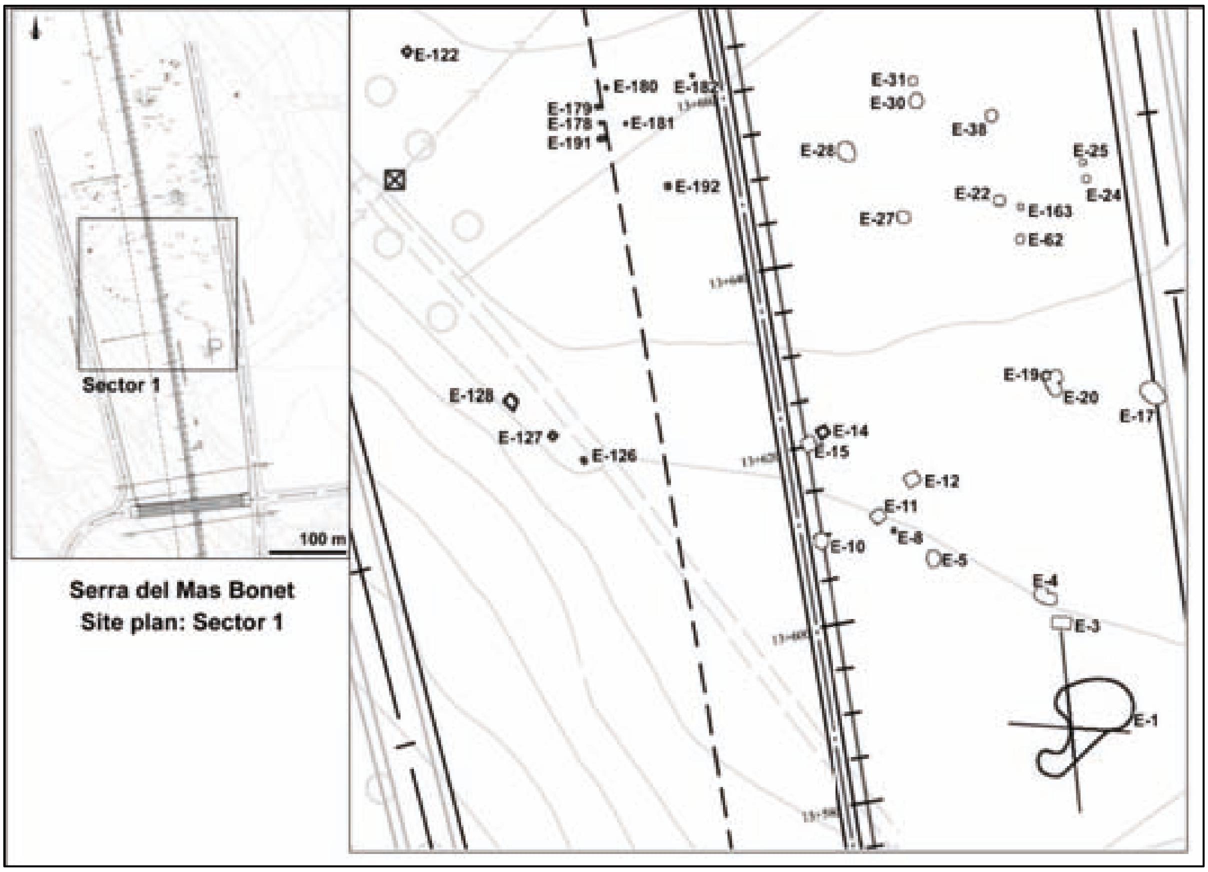


Fig. 3.4. Site plan of Serra del Mas Bonet, Sector 1 (adapted from an image provided by R. Rossillo and A. Palomo; the sectors shown in the figure were defined for practical reasons in this work, they do not respond to those defined during archaeological work).

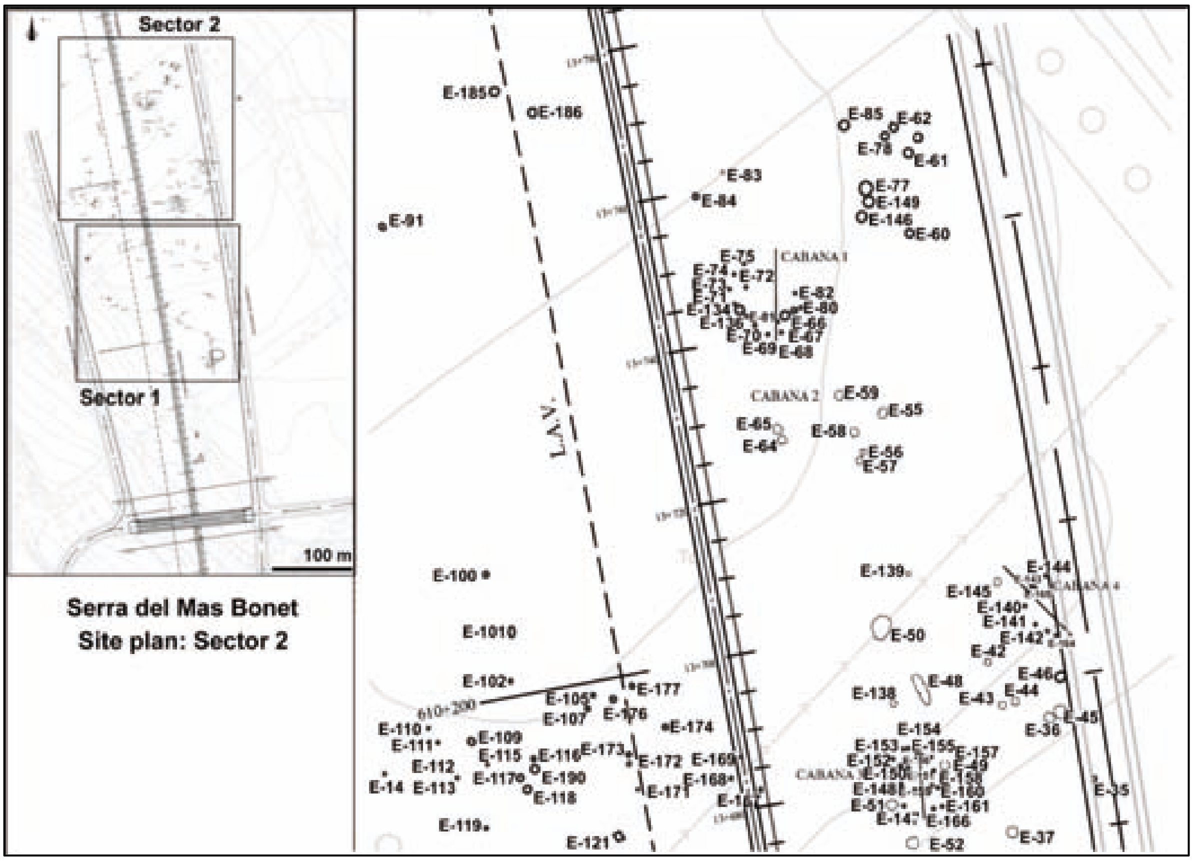


Fig. 3.5. Site plan of Serra del Mas Bonet, Sector 2 (adapted from an image provided by R. Rossillo and A. Palomo).

3.1.3.3. Settlement structure

A large number of features were uncovered (Fig. 3.4 and 3.5). Four structures were ascribed to the Epicardial phase. No dwelling constructions were identified for this period, but two silo-type pits were found. Eight structures are considered to belong to the Middle Neolithic: six silo-type pits and two post holes. The Late Neolithic phase is represented by 15 structures: one large and complex dwelling structure (which includes one hearth, pits and post holes) (E-1), another dwelling structure, silo-type pits, a hearth and several pits of unknown functionality. A menhir and several stelae were retrieved from the site. The stelae seem to have the shape of bull horns (see chapter 2.4.2.6. for a discussion on this topic) (Rosillo et al. 2010; Rosillo et al. 2012).

3.1.3.4. Palaeoecological and palaeoeconomic information

During the Epicardial phase, bovine, ovicaprine and suidine remains were identified. It is of particular interest to note that there seems to be an intentional deposition of unconsumed remains of pigs and dogs in one structure, which is interpreted as a ritual practice. A similar spectrum is documented in the Middle and Late Neolithic phases, though suidines are badly represented (Rosillo et al. 2012).

Archaeobotanical data (only preserved in charred state) are only significant for the Late Neolithic phase. Evergreen oak (*Quercus* sp. evergreen) (the best-represented taxon), strawberry tree (*Arbutus unedo*), heather (*Erica* sp.), mastic (*Pistacia lentiscus*) and other Mediterranean taxa were identified (Rosillo et al. 2012).

Use-wear analyses on lithic tools recently demonstrated that cereal harvesting was practiced at the site in all the Neolithic occupations. These blades show clear traces of intense and repeated use (Gibaja in press).

3.1.4. La Dou

3.1.4.1. Location and history of investigations

The open-air settlement of La Dou is located in Bas Valley (Vall d'en Bas; Fig. 3.6a), in the town called Sant Esteve d'en Bas (La Garrotxa), at around 500 m a.s.l. and close to the Fluvià River. La Garrotxa is a region that is well-known in Catalonia for being the only volcanic area in this territory, for which very fertile soils are available in the immediate surroundings of the site (Alcalde et al. 2008).

Fig.3.6a. Aerial view of the Bas Valley.

The site was discovered in 2005 during the construction of a road and a first preventive excavation was carried out. Subsequently, a scientific project was developed in order to continue with the investigations. A geophysical prospection of the area was carried out and the targeted areas were those for which clear indication of the presence excavated features had been obtained. In total, 630 m^2 were excavated (Fig. 3.6b).

3.1.4.2. Chronology and phases

Several radiocarbon dates were carried out, some of them on charred grains. They expand from *c.* 4900 until 4300 cal BC. G. Alcalde and others consider that this could be explained as the result of several short occupations during 350-400 years (Alcalde et al. 2012). The possibility that this is, in fact, the outcome of the uninterrupted occupation of this area between 4900 and 4300 cal BC (or a somewhat shorter period) should not be discarded. There are some spatial differences between dates from the earliest period (sectors F and J, towards the south west side of the excavated area), while dates from the later period are found in sectors A, 0, B and G, in the northern and south-western sectors). Some sectors lack of any dates, partly due to the lack of findings (e.g. sectors D, E, H and I).

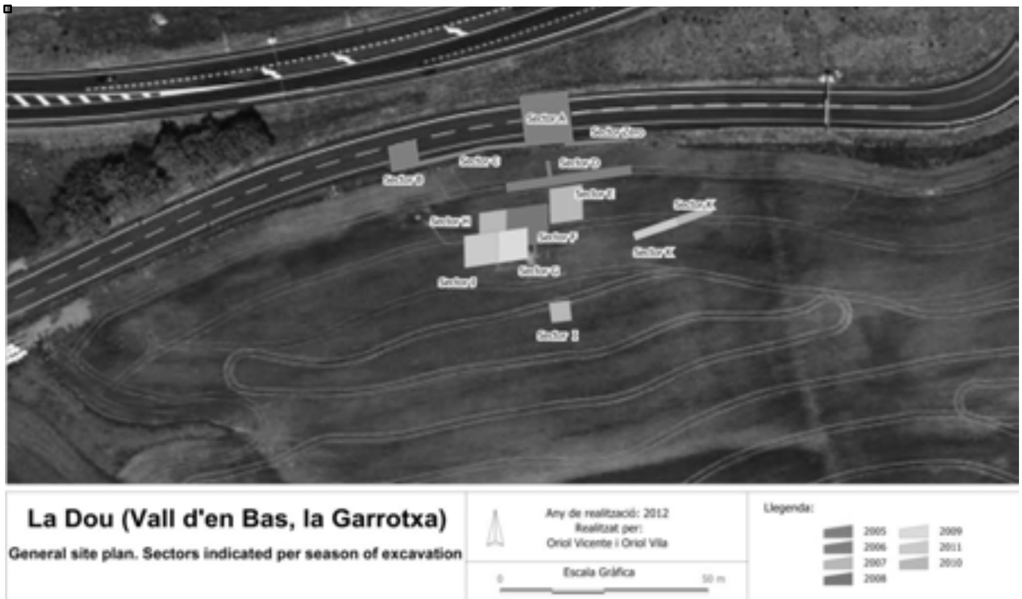


Fig. 3.6b. General site plan of the excavated area from La Dou site (Authors: O. Vicente and O. Vila).

3.1.4.3. Settlement structure

The settlement structure is complex and spatially dispersed (Fig. 3.6b). In sector A, two hearths were excavated in the south-eastern corner. Towards the northern limit of sector 0, two more hearths were uncovered. One possible dwelling structure was partly excavated in sector B. Most of the faunal remains from the site come from the filling of this structure. Another hearth was identified between sectors F and G. In sector G several possible post holes and two pits full of residues of fuel combustion were uncovered. Very recently, the archaeologists of the site published that 4 dwelling areas had been identified and that they were *c.* 40 m apart from each other (Alcalde et al. 2012). It is not known, though, to what extent these could belong to four contemporary households or just the result of the subsequent rebuilding of a house in an area over a period of time.

3.1.4.4. Palaeoecological and palaeoeconomic information

Deciduous oaks (*Quercus* sp. deciduous), the Rosaceae/Maloideae group and common box (*Buxus sempervirens*) are the best represented taxa in the charcoal record (Mensua, Piqué 2007a, Mensua, Piqué 2007b), while a large number (n: 216) of fruit stones of hawthorn (*Crataegus monogyna*) were identified in one single feature (Buxó 2007b). Only charred plant macroremains were recovered. It is important to note that the archaeologists of the site consider that La Dou would be located on the edges of a palaeolake that would have originated after a volcanic eruption during the early Holocene, which would have affected the natural course of the Fluvià River.

Domestic animals were identified in the archaeozoological record: primarily bovines, ovicaprines and suidines. Cattle bones seem to be well represented at the site (Alcalde et al. 2012).

3.1.5. Codella

3.1.5.1. Location and history of investigations

Codella is an open-air site located in Les Preses (La Garrotxa). It is rather close to La Dou site and, therefore, it is also located within the volcanic area of La Garrotxa and on another side of the previously mentioned palaeolake. It is situated on a low elevation at 460 m a.s.l. Water and arable land would be available in the immediacies of the settlement.

Superficial findings of archaeological materials were known in the area at least from the 1980s. The first archaeological works took place in 2003, with the aim of testing the integrity of the site. Several diggings took place until 2006. The area was systematically prospected (Fig. 3.7.).

Fig.3.7. Codella. The excavated surface and the systematically prospected area are shown in squares (the North is at the top of the plan; image provided by M. Saña).

3.1.5.2. Archaeological data

It is considered to respond to a single occupation radiocarbon dated between 4780-4490 cal BC (Alcalde et al. 2008).

It is interpreted as a medium sized site of around 550 m^2. One circular dwelling structure of *c.* 45 m^2 was identified and it is thought that other similar structures would spread across the area. Unfortunately, it is likely that recent agricultural work in the area destroyed any other archaeological evidences from this site.

Remains of faunal bones are very scarce, but cattle and pigs are better represented than ovicaprines. Plant macroremains were only preserved in charred state.

3.1.6. 120 Cave

3.1.6.1. Location and history of investigations

120 Cave is located in Sales de Llierca (Alta Garrotxa), at 460 m a.s.l. It is situated on a cliff, with no easy access (Fig. 3.8a), but close to the valley of the Llierca River. This area is characterized by the presence of mountains of low to medium height (450-600 m a.s.l.). It was discovered in 1975. The first archaeological work took place in 1981 (Agustí et al. 1987). Eleven storage pits were identified in around 21 m^2 (Fig. 3.8b) and one of them (number 10) was extracted as a whole piece from the cave and taken to the Universitat Autònoma de Barcelona, in order to excavate it and perform several scientific analyses. This work took place in 2010. Some of the analyses are still on-going.

Fig. 3.8a. View of the location of 120 Cave (image provided by X. Terradas).

3.1.6.2. Chronology and phases

Several phases were identified at the site. Nevertheless, our studied material was obtained from a single layer. Layer III is thought to belong to one phase of occupation (Agustí et al. 1987). It has recently been radiocarbon dated towards 4500 cal BC (X. Terrades, pers.com), although it had always been considered to belong to the Early Epicardial Neolithic. The geological nature of the area is of calcareous type.

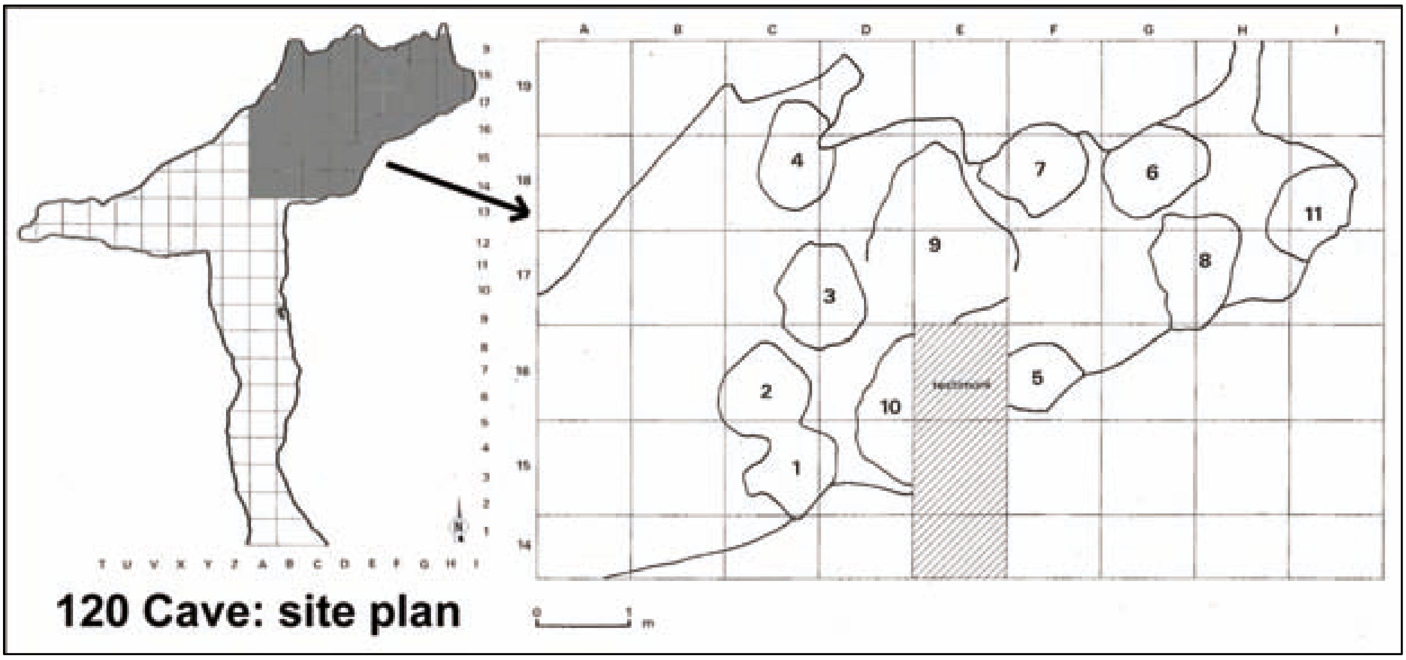


Fig. 3.8b. Site plan of 120 Cave. The entrance is on the southern end of the left image. 1-11: pits (image adapted from (Agustí et al. 1987).

3.1.6.3. Settlement structure

Eleven pits of 93-150 cm of diameter and a maximum depth of 48 cm were uncovered in an area of *c.* 58 m^2 (Fig. 3.8b). Some of them contained fragments of large vessels, one had an intact vessel and two of them (including pit number 10) could have either been plastered with clay/dung (A. Balbo, analysis is in progress) or they could have contained vessels made of dry clay. The vessels were rather large, of 25-35 litres of capacity (Agustí et al. 1987). The total capacity of the structures is of *c.* 325 litres (Alcalde & Buxó 1991).

3.1.6.4. Palaeoecological and palaeoeconomic information

The results of charcoal analyses (only charred archaeobotanical material was recovered) show a predominance of deciduous oaks (*Quercus* sp. deciduous) and other supramediterranean taxa, such as yew (*Taxus baccata*) or boxwood (*Buxus sempervirens*) (Ros 1996). Some sparse faunal remains of cattle and goat/sheep were identified. A small number of charred grains were also analysed in previous archaeobotanical investigations. Naked cereals (naked wheat (*Triticum aestivum/durum/turgidum*) and naked barley (*Hordeum vulgare* subsp. *vulgare*)) predominate in the assemblage. It is interpreted that the cave was used for grain storage (Agustí et al. 1987).

3.1.7. La Draga

3.1.7.1. Location and history of investigations

The open-air settlement of La Draga is located on the eastern side of the Lake of Banyoles (Banyoles, Pla de l'Estany), at 170 m. a.s.l. (Fig. 3.9a). The site is thought to be around 8000 m^2. It most probably stretched for over 100 m along the lake shoreline and around 80 m inland (Tarrús 2008). Fertile arable land was available at a close proximity to the site.

Fig. 3.9a. Aerial view of the lake Banyoles.

It was discovered in 1990 and excavations ran until 2005 (Bosch, Chinchilla & Tarrús 2000, Bosch, Chinchilla & Tarrús 2011, Tarrús 2008, Bosch, Chinchilla & Tarrús 1999, Bosch, Chinchilla & Tarrús 2006). Three main areas were excavated during this period (Fig. 3.9b): sector A, of approximately 284 m^2, sector B, of 126 m^2, and sector C, of 310 m^2. Sectors B and C remained under waterlogged conditions since the Neolithic period and a good preservation of uncharred plant material was possible. In contrast, sector A is on the southeastern part of the site, where the water table is around 70 cm below the archaeological layer. This means that waterlogged conditions did not prevail until the present and the waterlogged organic material of the archaeological layer has disappeared. Only those tips of the wooden posts which still were under the water table were recovered (Tarrús 2008).

A new field project started in 2008. The excavation took place in sector D, situated on the southern side of sector B, on a surface of *c.* 58 m^2, aiming to connect the excavated areas in sectors A and B (Fig. 3.9b) (Palomo et al. 2012). This project will continue, at least, until 2015. Most of the samples that have been analysed in this work come from this sector, though some samples from sectors B and C were also included.

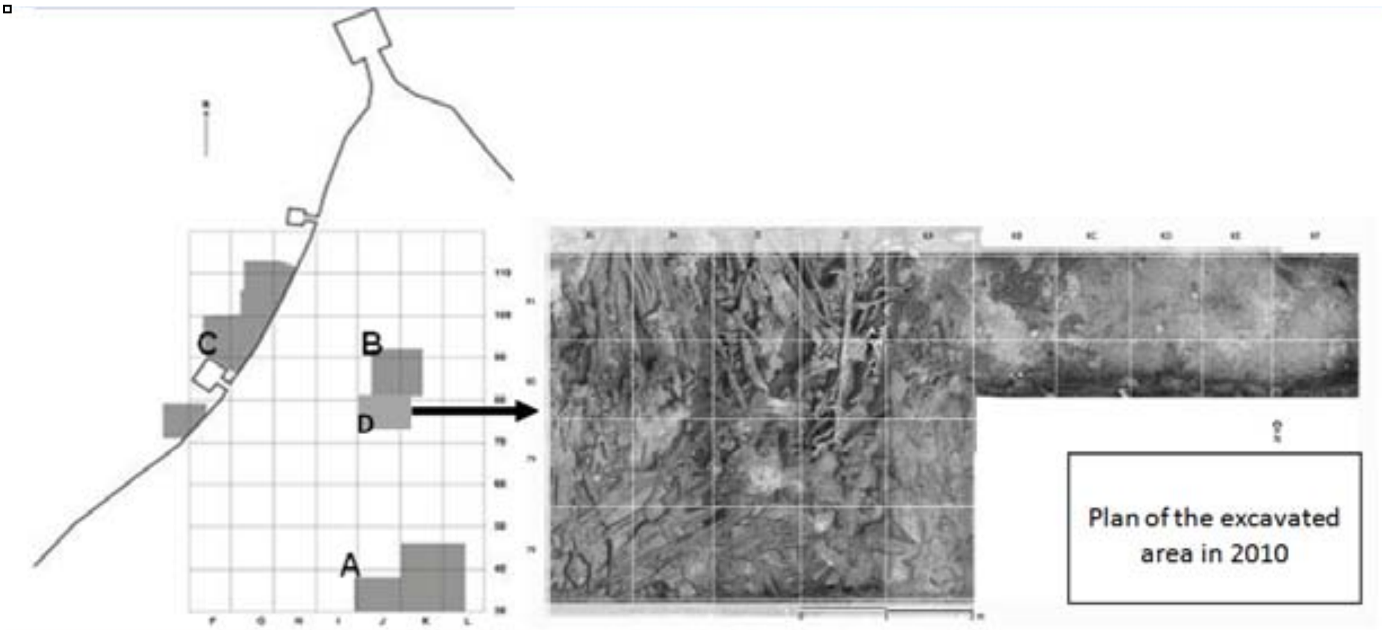


Fig. 3.9b. Site plan of La Draga (left) and indication of the location of sector D (excavated during 2010-2012). Plan of the excavated area in 2010 (right) (adapted from an image provided by Equip Draga).

3.1.7.2. Chronology and phases

After the recent excavations of sector D, it is considered that there are two main settlement phases, with no clear hiatus in between but very different settlement patterns. The earliest occupation is a real pile dwelling site. Wooden huts were built right on top of the lake marl. This phase could last from *c.* 5300 to 5200 cal BC, based on the available radiocarbon dates (Bogdanovic & Piqué 2012). Immediately after the collapse of the dwelling structures, a rather large accumulation of several layers of clay of terrigenous origin (Balbo & Antolín 2012) covered them and a new settlement was established, mostly using large travertine stones in order to produce an artificial floor. This second phase of occupation could have lasted until 5000 cal BC (see stratigraphy of sector D in Fig. 4.55).

It had long been argued that the site of La Draga responded to one single (and rather short) phase of occupation, though some diachrony seemed clear in certain areas (Bosch, Chinchilla & Tarrús 2000, Tarrús 2008). Despite the taphonomic differences between the three sectors, the archaeologists considered that they all reflected the same phase of occupation. This led to some problematic conclusions, like the ones concerning the relation between paved floors of sector A and the wooden posts that were found below, and the absence of such structures in sectors B and C. It was considered that sector A had to be interpreted as a functionally specialized area (Bosch, Chinchilla & Tarrús 2000). In relation to that, only 85 postholes were identified in sector A during the excavation of the archaeological layer, but a total number of 228 were identified after reaching the lake marl (where the tips of the posts were still in waterlogged conditions). The archaeologists considered that they missed these postholes during the excavation and that they belonged to the paved structures observed above (Bosch, Chinchilla & Tarrús 2000), 81). Most of these posts could belong to an earlier phase of occupation, which was not detected in this area because the water table was below it and waterlogged preservation only affected some of the tips of those posts. Thus, the two phases of occupation that have recently been identified in sector D are probably found in a much larger area of the site. A thorough revision of the initial work is in course and new radiocarbon dates on short-lived samples will be obtained.

3.1.7.3. Settlement structure

No house plans are yet available for the earliest settlement phase, since dendrochronological analyses have not been successful so far. This is due to the particular characteristics of Mediterranean woodlands and the limited amount of rings per post that have been obtained to date. Recent work in sector D allowed the recovery of large trunks and posts (P. Gassmann, in progress). It has been suggested, at a hypothetical level, that huts of around 40 m^2 existed during this phase and that they would be of rectangular shape (Tarrús 2008).

The second settlement phase is interpreted as a radical change, at least in terms of building techniques. Oval or ovoid huts with paved floors would have been constructed, without any evident spatial organization. The documentation of a large number of hearths led the archaeologists to conclude that these were open-air installations and that domestic activities would be much more public and prone to sharing (Bosch, Chinchilla & Tarrús 2011, Tarrús 2008, 9-14). As mentioned earlier, these interpretations need to be reviewed under the light of new evidences.

3.1.7.4. Palaeoecological and palaeoeconomic information

There is abundant information concerning palaeoecological and palaeoeconomic data from La Draga. I will only focus on the most relevant studies for this work.

Isotopic analyses carried out on oak wooden posts from La Draga recently confirmed that temperatures would be slightly lower during the early Neolithic and that there would be a higher precipitation (Aguilera et al. 2011).

Palynological data indicate that the area around the site would be densely wooded with oak, fir, pine and evergreen oak. Riparian forests would be important around the lake shore, where trees like hazel, ash, elm, alder and elder would grow (Burjachs 2000). The botanic diversity observed in charcoal analyses is rather similar. It confirms the generalized presence of oak in the immediacies of the site, but not pine or fir. These would grow in the nearest mountains located at about 15 km of distance (the Rocacorba mountains, of *c.* 970 m a.s.l.) (Piqué 1996, Piqué 2000, Burjachs 2000). Oak timber was used for building primarily. Oak, laurel and box were predominantly used as firewood. A wide botanical diversity of species is used to produce different wooden tools and handles, always taking into consideration the suitability of the properties of each wood.

Previous sampling strategies focused on large assemblages of charred cereal remains, which were particularly abundant in sector A, but also in sectors B and C. Previous work already showed that tetraploid naked wheat probably was the main cultivar at the site (Buxó 2007a, Buxó, Rovira & Sauch 2000, Antolín & Buxó 2011b). Nevertheless, the results obtained for other taxa (especially wild taxa) remained rather unreliable, as demonstrated in other archaeological cases where a similar treatment of the samples was carried out (Tolar et al. 2010). The importance of agriculture at the site is corroborated by use-wear analyses of sickle blades (Gibaja 2000). Furthermore experimental works recently demonstrated that low harvesting was not possible, considering the sort of sickle hafts that were used (Palomo et al. 2011).

A mixed herding strategy of ovicaprines, cattle and suidines provided most of the animal protein income to the human diet at the site. Sheep, goat, cattle and pigs were important resources. Mortality patterns seem to show that farming was oriented towards meat consumption, although a low number of bovines could have been exploited for traction (Tarrús et al. 2006, Bosch et al. 2008, Saña 2011) and there might be evidences of goat milk production (Saña 2011).

3.1.8. Bòbila Madurell

3.1.8.1. Location and history of investigations

Bòbila Madurell is an open-air settlement located in Sant Quirze del Vallès (Vallès Occidental), at around 180 m a.s.l., in a privileged area. It is located on fertile arable land, while at the same time it is close to the high mountains (over 1000 m a.s.l.) of Sant Llorenç del Munt and Serra de l'Obac, in the pre-Littoral chain, and at less than 4 km of distance from the Besós and the Llobregat Rivers. It is for this reason in control of the communication networks along the pre-Littoral depression, as well as those crossing the pre-Littoral mountains, towards the interior plains (Martín, Bordas & Martí 1996).

The site was discovered early in the XXth century and several researchers have performed investigations on the impressive archaeological materials that were uncovered. I will only deal with the features uncovered during the last field projects that started in 1987 and lasted until 1992 (Bordas et al. 1994).

3.1.8.2. Chronology and phases

Radiocarbon dates from Bòbila Madurell are rather scarce considering the large size and the importance of the site. Only 13 of them belong to the Neolithic period, mostly obtained from charcoal samples. Three of them fit in the Late Neolithic while the remaining ten dates stay within the Middle Neolithic. Most of the archaeological features were ascribed to one or another period on the basis of artefact typology. There is some slight hiatus in the available dates and there is no proof for continuity, but this possibility cannot be discarded considering the large size of the site, the parts that have been destroyed due to uncontrolled construction works during the XXth century, the low number of dated contexts and the fact that most of the dates were carried out on long-lived samples. It has been proposed that the site could have been occupied during 400 years, abandoned after a socioeconomic collapse, and then reoccupied during the Late Neolithic (Martín, Bordas & Martí 1996), but the available C14 dates show that the population could have settled there from *c.* 4200 until 3200 cal BC uninterruptedly.

3.1.8.3. Settlement structure

The known area of the site is around 28 ha. It is thought, though, that it could have been much larger (Martín, Bordas & Martí 1996). Eighty storage pits and other negative structures of unknown functionality have been excavated, along with 120 pit burials. Most of the pits measure less than 50 cm of depth (they were probably not fully preserved). The settlement structure is still not well understood, although it seems that burials would take place within the space of the living (Martín, Bordas & Martí 1996). Such statements should be supported by a large dating project, which is currently ongoing. It was also proposed that the fields would be located at the northern area, where there is a lower density of structures (Bordas et al. 1994).

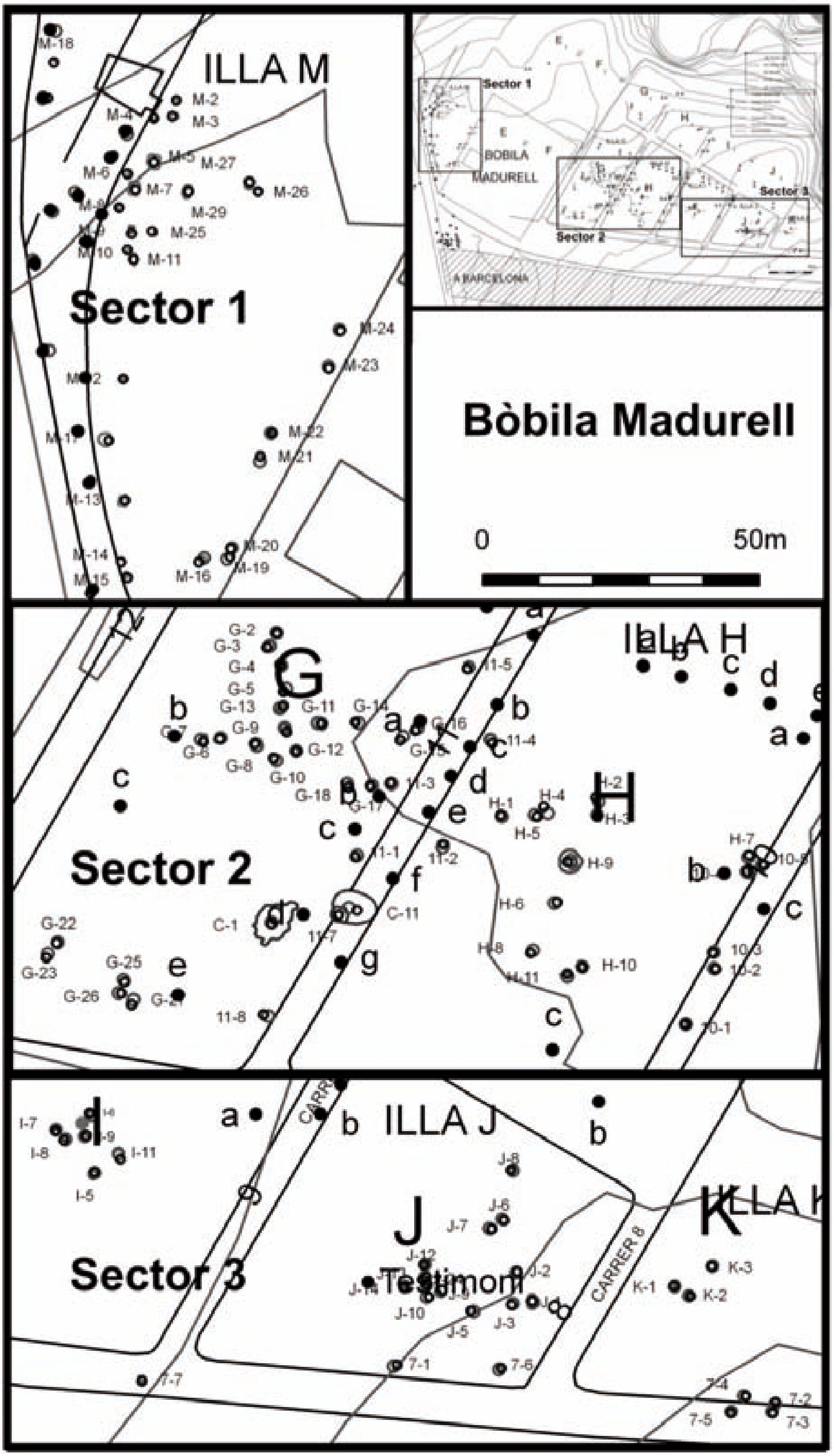


Fig. 3.10. Site plan of Bòbila Madurell (adapted from an image provided by X. Plasencia; the sectors shown in the figure were defined for practical reasons in this work, they do not respond to those defined during archaeological work).

A large number of structures were ascribed to the Late Neolithic period. They were found in the same area where the Middle Neolithic structures were situated (see Fig. 3.10; or Fig. II.9, p. 24 in Gibaja 2002a). Two large excavated features were interpreted as dwellings. They present some stratigraphy and spatial organization (hearths, pits, etc.). They were very close from one another, at the Eastern side of the known settlement. The feature C.11 was around 50 m^2 and of ovate shape. Two different layers with hearths were identified. Feature C.1 was of more irregular shape and measured around 40 m^2. Two subphases with a similar organization as the one observed in C.11 were identified (Bordas et al. 1994).

3.1.8.4. Palaeoecological and palaeoeconomic information

Few environmental data are available for the site at the moment. Plant macroremains were only preserved in charred state. Dense deciduous oak woodlands are reported for the Middle Neolithic period from an unpublished work of M.T. Ros (Martín, Bordas & Martí 1996).

A mixed herding economy was practiced at the site during the Middle Neolithic. Ovicaprines are the best represented group among faunal remains of domestic animals, closely followed by cattle and pigs. The consumption of secondary products (e.g. milk and animal traction) was also proposed for the Middle Neolithic (Martín, Bordas & Martí 1996). Towards the Late Neolithic, cattle became the best represented taxon, especially in dwelling contexts, though ovicaprines were equally well represented (Bordas et al. 1994).

The importance of agricultural practices at the site was well documented both through the identification of storage pits and the numerous findings of sickle blades associated both to male and female burials (Gibaja 2003; Gibaja 2004).

3.1.9. Carrer Reina Amàlia, 31-33

3.1.9.1. Location and history of investigations

The open-air site of Carrer Reina Amàlia, 31-33 is located in the Raval quarter of Barcelona (Barcelonès). It is situated in a fertile plane, close to the sea (<1 km), the mountains of Collserola (*c.* 300-500 m a.s.l.) and Montjuïc (*c.* 175 m a.s.l.), and to fresh water resources.

It was discovered in 2007 and rescue excavations took place during 2008 and 2009 (González, Harzbecher & Molist 2011).

3.1.9.2. Chronology and phases

It is considered as one permanent occupation which took place between 4700 and 4360 cal BC (based on the available radiocarbon dates). Three phases were identified on a stratigraphic basis. The foundation of the site (UE[2] 95 and feature XX), would be followed by a second phase (UE 59 and 46 and feature XV) and a final burial episode (feature XIV). No rupture is observed during these three episodes (González, Harzbecher & Molist 2011).

3.1.9.3. Settlement structure

The archaeological site measured *c.* 200 m^2 but it should be assumed that this is only one small part of what would have been a rather large village (of maybe *c.* 25 ha) located at the plain of Barcelona. The site is

[2] UE is the abbreviation, in Catalan language, for stratigraphic unit. Likewise, E is the abbreviation for archaeological feature or structure.

characterized by one large dwelling structure (E-III), five possible silos (E-IV, VIII, XII, XVIII), several hearths (E-II, V, VI, IX and XX), an oven (E-XI), pits without a clear functionality (E-XIII), a posthole (E-XVII) and three funerary features (E-XIV, XV and XVI) (Fig. 3.11). The hut consists of a large pit of *c.* 50 m^2 and it has a pseudo-ovate shape. There was one hearth and two child burials inside this structure. The silos were found around the dwelling, on its eastern side.

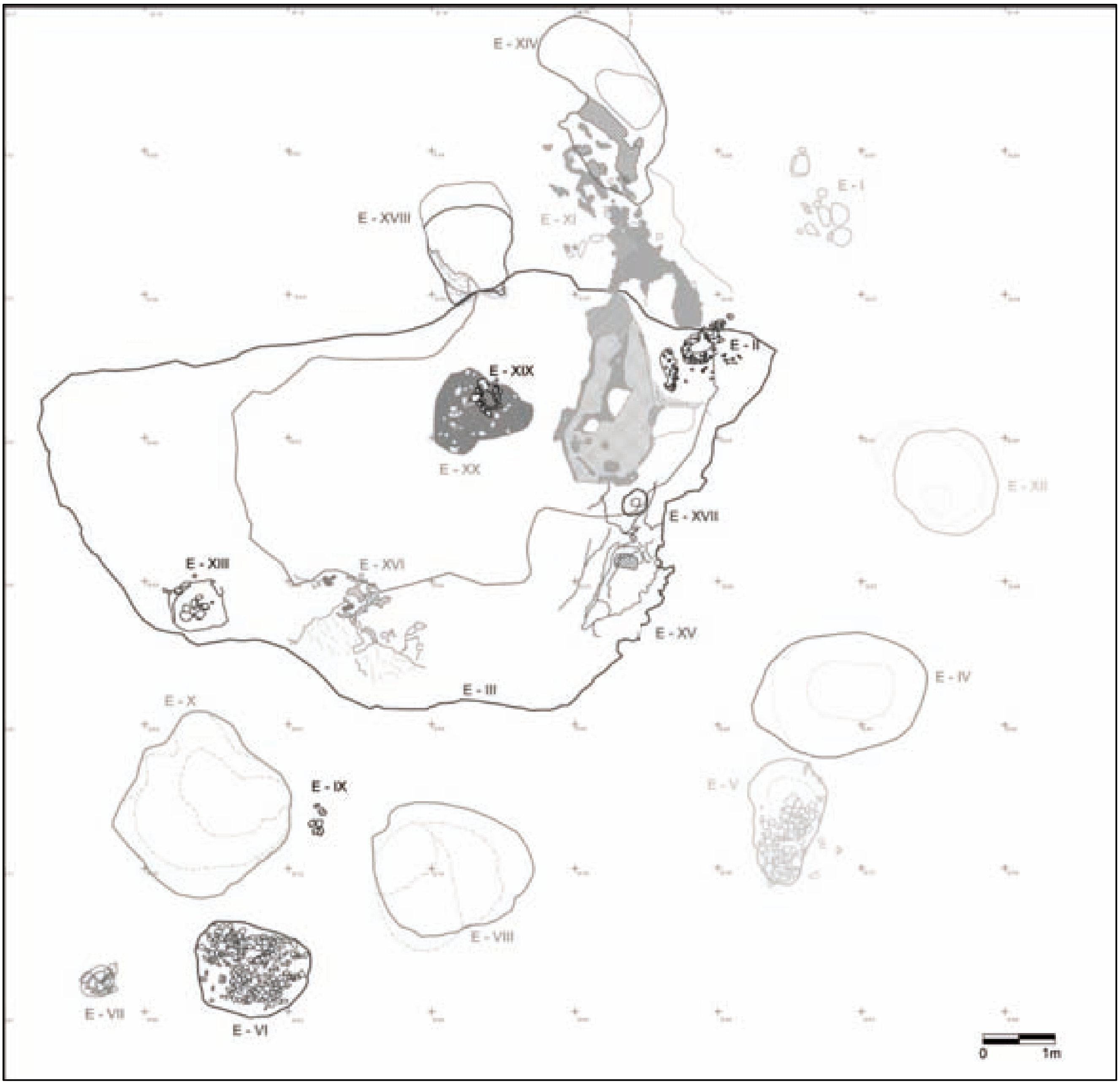


Fig. 3.11. Site plan of C/Reina Amàlia 31-33 (image provided by J. González).

3.1.9.4. Palaeoecological and palaeoeconomic information

Riparian forests and mixed oak forests would grow in the plain of Barcelona at the time when the settlement existed (Riera 1996). The results of the charcoal analyses carried out in the nearby site of Caserna de Sant Pau indicate that Mediterranean trees would already grow in the area, probably in mixed formations with more supramediterranean taxa. Deciduous oak (*Quercus* sp. deciduous) is the best-represented taxon at that site and riverside taxa are totally absent from the record (Mensua & Piqué 2008).

The results of the archaeozoological analyses are not available, but findings of bull antlers, ovicaprines, etc., are reported by the archaeologists of the site (J. González, pers.com.). A mixed herd of bovines, ovicaprines and suidines was probably found at the site.

3.1.10. Prehistoric Mines of Gavà

3.1.10.1. Location and history of investigations

The Prehistoric Mines of Gavà, also known as Mines of Can Tintorer, are located in Gavà (Baix Llobregat), between 40 and 260 m a.s.l., at a short distance (*c.* 2 km) from the Garraf Mountains (with maximum heights around 600 m a.s.l.) and the plain of Barcelona. It is thought that the seashore was at around 1 km from the site during Neolithic times (Gàmez et al. 2011). The mouth of the Llobregat River would be in the near vicinities. Therefore, a wide variety of ecosystems would be available at a very short distance. Arable land would be accessible in the immediacies of the site, although the sandy soils are not considered to be very fertile (Bosch, Estrada 1994a): 17).

The site expands along the Palaeozoic formations at the Eastern side of the Garraf mountains, and these include the Ferreres and Rocabruna mountains and the Can Tintorer hill (Fig. 3.12). These mines were produced to obtaine variscite. Other elements were also extracted in the process, such as ocres or quartz. Most of the research has focused on the sector of Can Tintorer, where the mines were discovered in 1978. Its total extension was established as *c.* 250 ha, and around 100 mine shafts were located (Villalba et al. 1986, Villalba, Edo & Blasco 1998). The first projects focused on the Can Tintorer sector (Villalba et al. 1986) while more recent works were carried out in Can Tintorer (Bosch, Estrada 1994a) and Les Ferreres sectors (Bosch, Borrell 2010).

3.1.10.2. Chronology and phases

The chronological span of the mining activities was soon established through radiocarbon dating (Villalba et al. 1986, Blasco, Edo & Villalba 1992) and it has recently been reviewed (Borrell, Bosch & Vicente 2010). Unfortunately, no settlement phases have been recognized to date. Consequently, this site will be treated as one settlement phase.

It seems that the onset of the mining activities was performed by populations living in sites located at a short distance (*c.* 8-10 km) from the mines, like Can Sadurní Cave, already around 4500-4200 cal BC. Evidences of the use of lithic raw material from the Palaeozoic basement of the Garraf mountains in Can Sadurní cave, is known, in fact, from the Epipaleolithic period onwards, and the intensity of the exploitation of such sources increases dramatically during the Vth millennium cal BC (for a recent evaluation see Edo, Antolín & Barrio 2012)). Eventually, these populations probably moved to the plain to exploit the mines more systematically.

The start of the subterranean mining activities would be at some point around 4200 cal BC (mines 8 and 83) (Borrell, Bosch & Vicente 2010). Most of the available dates, though, concentrate between 4000 and 3600/3400 cal BC, when the mining activities are thought to be more intensive (Villalba, Edo & Blasco 1998).

The last evidences of use of the mines are the funerary contexts of Mine 28, dated to the end of the IVth millennium cal BC (Villalba et al. 1986), and Mine 8, which is actually dated to the early IIIrd millennium cal BC but the populations that were buried were still miners (Villar, Ruiz & Subirà 2011).

3.1.10.3. Settlement structure

The situation, the extension and the permanence of the dwelling structures within the site are largely unknown. Fragments of daub prove the existence of above-ground constructions in the immediacies of the mines, but no archaeological features from such structures have been identified so far. In general, the available data seem to favour the interpretation of a rather permanent settlement (Villalba, Edo & Blasco 2011). Therefore, only mine shafts have been excavated. Several types of contexts were identified inside the shafts and galleries, namely funerary deposits, clayey layers with refuse from everyday activities outside the mines (animal bones, pottery, etc.) and, primarily, major accumulations of refuse derived from the mining activity themselves. Layers with refuse from everyday activities were mainly targeted when sampling.

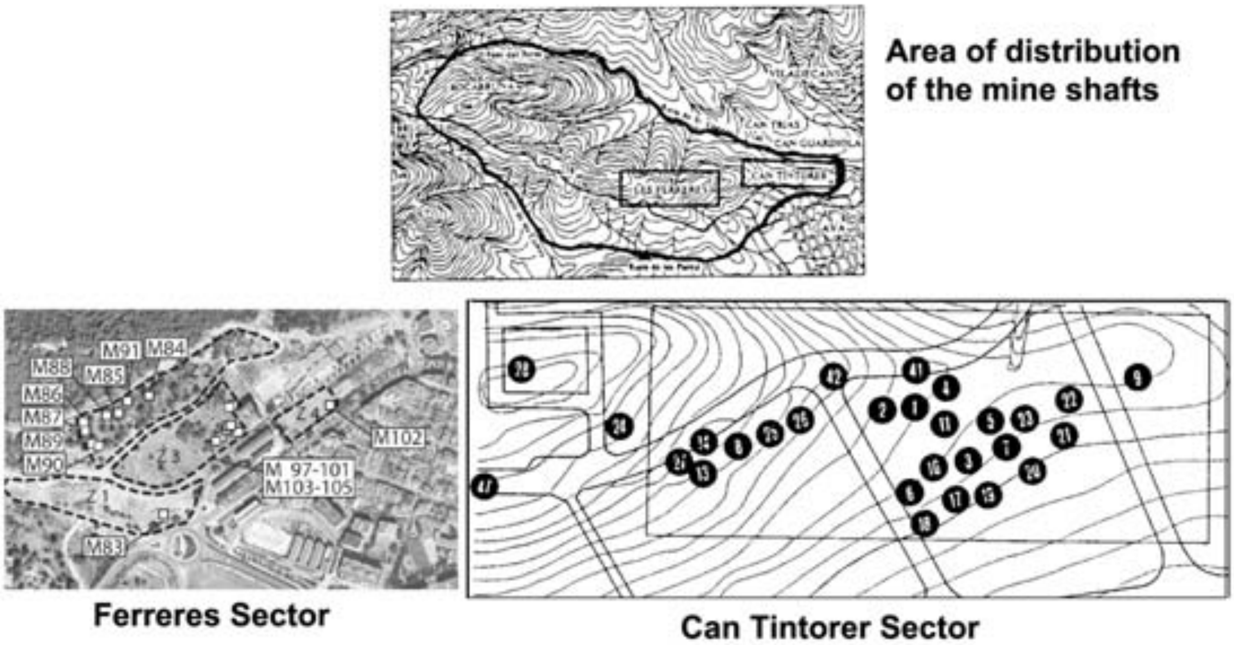


Fig. 3.12. Location of the Can Tintorer and Les Ferreres sectors of the Gavà Mines (adapted from (Villalba, Edo & Blasco 1998, Bordas, Borrell & Bosch 2010).

3.1.10.4. Palaeoecological and palaeoeconomic information

Bioarchaeological analyses were performed at this site from the very beginning of the excavations. I refer to the corresponding monographs for details.

Archaeozoological and archaeobotanical data support a local farming economy. G. Kraus-Kashani carried out the first cereal identification works. A wide diversity of cereal taxa were distinguished both as charred grain remains and daub imprints (Villalba et al. 1986). Later on, R. Buxó identified the materials coming from a funerary complex in Mine 28 (Buxó, Català & Villalba 1991) and one fragment of hulled barley (*Hordeum vulgare*) in layer 5 of mine 68 (Bosch & Estrada 1994a), 266). Unfortunately, a more thorough sampling and flotation strategy was not possible to apply until more recently. The importance of farming activities at the site was also confirmed through use-wear analysis of flint tools, in which several sickle blades were identified (Gibaja 2010).

Faunal remains are not well preserved in this site. Apparently, ovicaprines are better represented in the earlier contexts of the late Vth millennium cal BC, while cattle might become more important during the

IVth millennium cal BC. A mixed herding model seems to apply in both cases (Estévez 1986, Saña 1994, Saña 2010).

An open Mediterranean landscape seems to characterize the landscape around the site during the Neolithic according both to charcoal and pollen data (Ros 1994, Ros 1996, Piqué 2010, Riera 2010). Bush formations of mastic trees (*Pistacia lentiscus*), olive trees (*Olea europaea* subsp. *sylvestris*), evergreen oaks (*Quercus* sp. evergreen), strawberry trees (*Arbutus unedo*), along with some Aleppo pine (*Pinus halepensis*) forests, would grow in the area. It is particularly interesting to note that the charcoal record at the site is not dominated by a single taxon. The best represented taxon changes from one mine to the next (Piqué 2010). This would support a lack of planning of fuel gathering, though R. Piqué does not discard the possibility that this could be due to taphonomic reasons (*op.cit.*). On the other hand, cereal pollen was identified in mine 84, which would support the hypothesis of local cereal cultivation (Riera 2010).

3.1.11. Can Sadurní Cave

3.1.11.1. Location and history of investigations

The Cave of Can Sadurní is on the side of a small hill in the calcareous Garraf Massif, overlooking the plain of Begues (Baix Llobregat) (Fig. 3.13a), at 421 m a.s.l. Therefore, it is located in a privileged position, very close (<500 m) to fertile arable land, water resources and controlling two historical pathways which connect the plain of Barcelona with the southern coastal areas (see Blasco et al. 1983)). The cavity encompasses nearly 200 m^2 and a large terrace of around 325 m^2 is found in front of the entrance. They are both oriented to the south/south-east (Fig. 3.13b) (Edo, Blasco & Villalba 2011).

Fig. 3.13a. View of the plane of Begues from Can Sadurní cave (left) and entrance to the cave (right).

The archaeological work started in 1978 and continued until 1983. In 1993 the excavations were reinitiated and they have continued until the present (except during the years 1994 and 2000, when no archaeological fieldwork was done). A more detailed history of the investigations can be found elsewhere (e.g. Antolín 2008b, 69).

3.1.11.2. Chronology and phases

Twenty-seven different archaeological strata have been identified, dated between approximately 11000 cal BC and the last century (Fig. 3.14) (for a recent compilation see (Edo, Blasco & Villalba 2011).

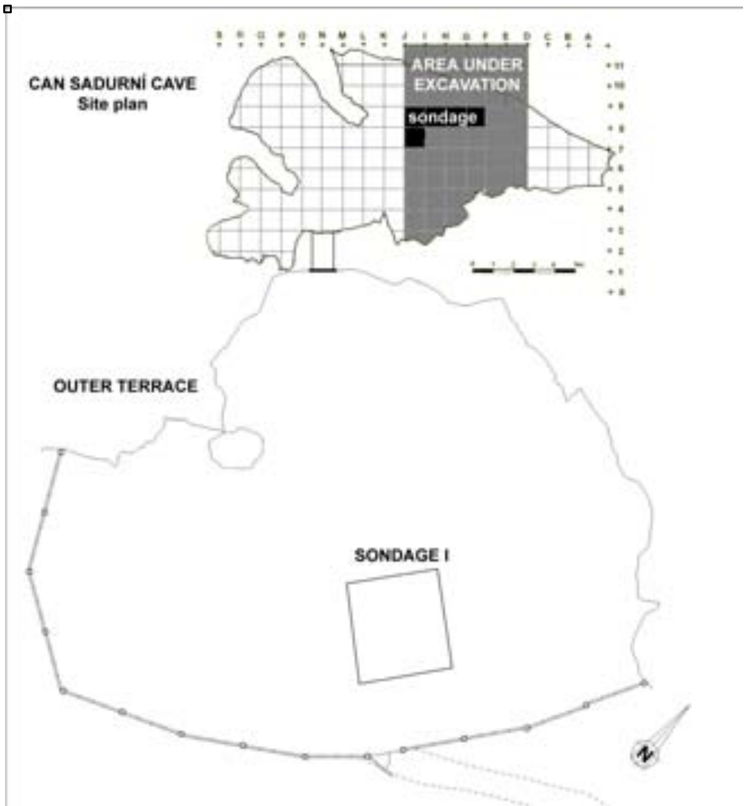


Fig. 3.13b. Site plan of Can Sadurní Cave and the outer terrace. Indication of the location of Sondage I, excavated between 1978 and 1983 (image provided by M. Edo).

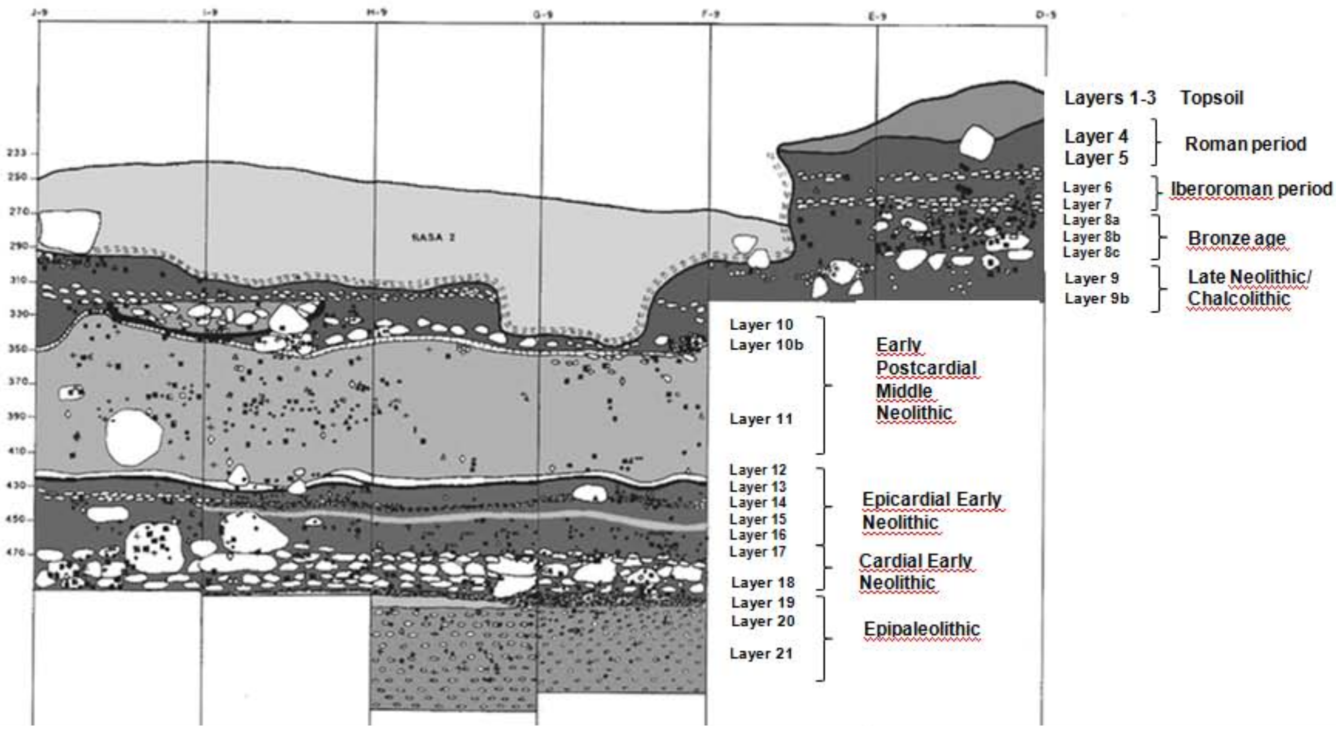


Fig. 3.14. Profile view of the stratigraphy of Can Sadurní Cave (Blasco et al. 2005).

Even though seed and fruit remains have been identified in Early, Middle and Late Neolithic layers (Antolín 2008b, Antolín et al. 2013), this study will only focus in three contexts or layers: layer 10 (dated to 4180-4037 cal BC ((Edo, Blasco & Villalba 2011))), layer 11 (dated to 4470-4340 cal BC (Edo, Blasco &

Villalba 2011)) and layer 18 (dated to 5392-5304 cal BC (Martín et al. 2010)). These are the best-studied contexts from the site and, consequently, a more complete archaeological evaluation of the data is possible.

3.1.11.3. Archaeological phases of occupation or use of the cave

The occupation of layer 18, dated to the Early Neolithic, is so far a unique case in the north-eastern Iberian Peninsula, as it corresponds to a collective funerary deposit. The remains of a minimum number of 7 individuals were recovered, according to the results of the aDNA analyses (Gamba et al. 2011). These remains were accompanied by rich offerings: several pottery vessels full of carbonised seeds, the intentional deposition of sheep extremities, plaques made of marine shells and other elements (Blasco et al. 2005). The pottery vessels were fragmented *in situ* (fragments of the same vessels were closely spatially related) and fire traces were found in nearly all the archaeological materials found around them (including large amounts of charcoal). It cannot be assumed at the moment that the fire took place at the same place where the assemblage was found, since the soil micromorphological analysis of one sample from the north-eastern profile of the trench seems to show no (or very low) evidences of burning and a lack of ashes (Antolín et al. 2011). The actual working hypothesis is that there might have been a fire, perhaps with ritual meaning, that affected the offertory vessels containing grain and part of the human remains (only cranial fragments were burnt) and grave goods (Antolín et al. 2011). The presence of a goat pellet in the soil micromorphology slide and other archaeological elements like a sickle blade or a hand stone, point towards a more diverse use of the surrounding area of the cave, which could have been inhabited by the same group that used it for funerary purposes.

The Early Middle Neolithic layer 11 shows a completely different settlement structure. It is a rather thick layer that was formed in around 400 years. Apparently, the interior of the cave was used as a byre during the first period of the formation of this layer. Archaeozoological and soil micromorphology data confirm an intense use of the cave, probably all-year-round (Bergadà & Cervelló 2011, Saña et al. in press). A similarly intensive exploitation of lithic resources of the surrounding environment of the site is equally observed in the archaeological record (Edo, Antolín & Barrio 2012). It seems that towards the more recent period of formation of this layer, the cave could have preferentially been used for funerary purposes (this is at the moment a working hypothesis). Within this context, several evidences of beer production have recently been documented (Blasco, Edo & Villalba 2008). A unique anthropomorphic figurine (popularly known as "The Enchanted") made on ceramic was recently recovered in this layer in the field campaign of 2012.

Still in the Early Middle Neolithic, layer 10 seems to be a continuation of the settlement pattern that is observed in layer 11. One of the most significant differences is found in the terrace outside the cave, where several storage pits were probably used for storing grain. Such storage practices would confirm the hypothesis of a permanent occupation of the area surrounding the site during this period (Edo, Blasco & Villalba 2011).

3.1.11.4. Palaeoecological and palaeoeconomic information

Palaeoenvironmental analyses at the site are very numerous and I refer to the large list of existing reports and publications for a thorough description of the results (Edo et al. 1986, Edo et al. 1991, Edo et al. 1995, Blasco et al. 2005, Blasco et al. 1999, Blasco, Edo & Villalba 2008, Blasco, Antolín 2008b, Antolín et al. 2011, Antolín & Buxó 2011a, Antolín & Buxó 2011c, Antolín et al. 2013, Saña et al. in press).

Soil micromorphology analyses recorded humid environmental conditions during in the Early Neolithic (layer 18), which do not extend towards the Middle Neolithic (Bergadà & Cervelló 2011).

Charcoal analyses show a clear shift in fuel gathering strategies between the Early (layer 18) and the Middle Neolithic (layers 11 and 10). While supramediterranean taxa are dominant during the earliest phase, Mediterranean shrub taxa become the main taxa towards the end of the Vth millennium cal BC (Antolín et al. 2013). Such change is very probably due to the Middle Holocene climatic change (see for instance (Pérez-Obiol et al. 2011)), which produced a progressive aridification of the landscape. This shift would become more visible in intensively exploited areas.

Changes are equally observed in the faunal record. A mixed herding model is observed in the three settlement phases, being ovicaprines the best-represented group along the stratigraphy. A diversified exploitation of goats and sheep (meat, milk, fats) is observed during the first phase of occupation. This pattern changes towards the Middle Neolithic, when most of the individuals are killed at their meat optimum stage. Besides, some sheep seem to be kept for a longer time, which was interpreted as a possible evidence of wool exploitation (Saña et al. in press).

The existence of charred cereal grains and imprints on daub were already identified by G. Kraus-Kashani for the Middle Neolithic layers (Edo et al. 1991). Lists of identified taxa were then presented by R. Buxó for the Early and Middle Neolithic layers (Blasco et al. 1999, Blasco et al. 2005, Buxó & Piqué 2008). A first quantified approach to the archaeobotanical record was presented shortly after (Antolín 2008b). All these data will be included in the analysis of the site. Harvesting and cereal processing tools were documented in several layers. Studies are currently on-going (for instance, use-wear analyses have only been partly carried out for layer 18). One sickle blade was identified in layer 18 (Gibaja et al. 2011b), while several grinding stones and hand stones were recovered in all of the three mentioned contexts (Ache 2011). In layer 11, microresidues of malting and brewing were identified in some of these elements and a potsherd (Blasco, Edo & Villalba 2008). These are, at present, the earliest evidences of beer production in Western Europe.

3.1.12. Sant Llorenç Cave

3.1.12.1. Location and history of investigations

The site is located on the southern slope of Sant Joan Mountain, at the southern end of the Garraf Massif. The cave is situated at 245 m a.s.l., overlooking the beach of Sitges and the natural corridor towards the pre-Littoral plain (Fig. 3.15a). The cave measures 8 x 13 m. It has two entrances, both oriented towards the south-west (Fig. 3.15b) (Borrell et al. 2011). Arable land and fresh water are available in the inmediacies of the cave, but there is at a relatively short distance (1 km). The excavations started in 2007 and the project is still on-going.

Fig. 3.15a. View over the town of Sitges from the entrance of Sant Llorenç Cave (image provided by C. Tornero).

3.1.12.2. Chronology and phases

Five different periods have been documented at the cave: Layer II (b), dated to *c.* 5200 cal BC; Layer III, dated to *c.* 4800 cal BC; Layer IV, dated to *c.* 3700 cal BC; Layer V, dated to *c.* 2550 cal BC; Layer VI, unknown (Chalcolithic or later periods) (O. Vicente, pers.com.).

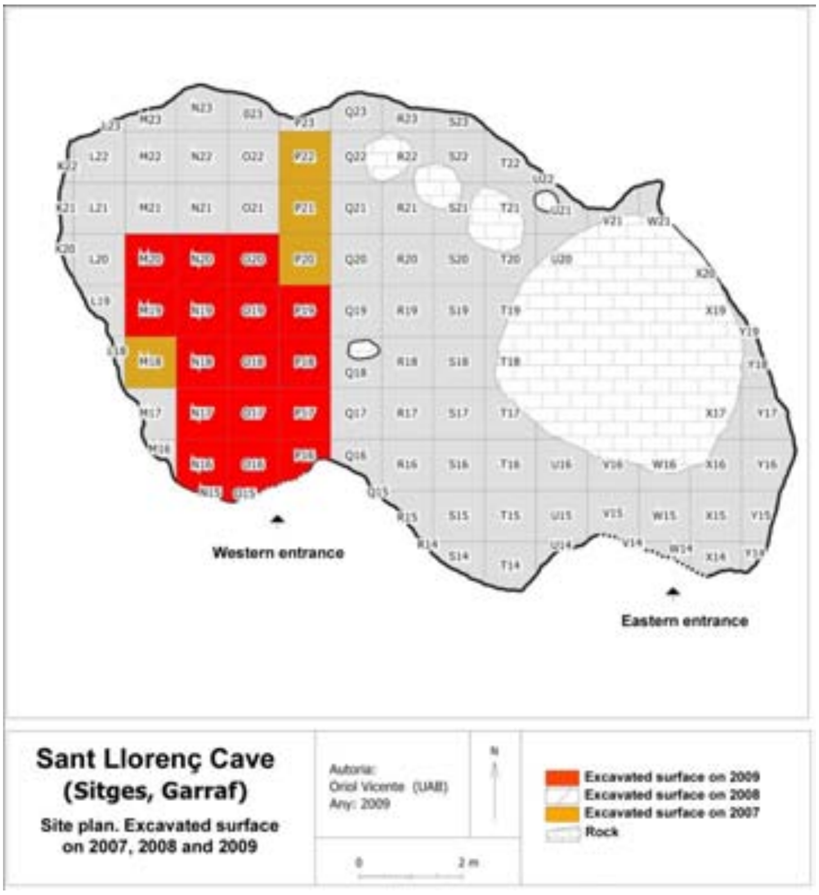


Fig. 3.15b. Site plan of Sant Llorenç Cave. Excavated surface on 2007, 2008 and 2009 (image provided by O. Vicente).

3.1.12.3. Archaeological data

The settlement structure is not well known for any of the phases, since the archaeological studies are in progress.

For the moment, no archaeobotanical analyses have been carried out at the site. The closest palynological records are located in Cubelles (at the coastal side of the Garraf Massif, at 10-12 km of distance) and Muntanyans (at the inland side of the Garraf Massif, in the pre-Littoral plain, at 14-16 km of distance) (see, for instance, Riera, Esteve & Nadal 2007, Antolín et al. 2011). In Muntanyans, one can observe the progressive development of olive and pine trees during the Vth and the IVth millennia cal BC, together with grasses that denote an anthropic factor on vegetation dynamics. In Cubelles, mastic tree, rather than olive tree, has a dominant role, along with pine woods. Towards the Late Neolithic, a reforestation process is observed in Muntanyans, while maquis formations become better developed in the coastal side of the Garraf Massif.

3.1.13. Espina C

3.1.13.1. Location and history of investigations

The site of Espina C is located in Tàrrega (l'Urgell), at 410 m a.s.l. It is situated on the Espina hill. Cercavins River is at less than 200 m from the settlement. It is located on arable land.

The site was excavated as a rescue excavation in 2006.

Fig.3.16a. View from the archaeological site of Espina C (image provided by M. Piera).

3.1.13.2. Chronology and phases

Most of the archaeological structures of the site seem to belong to the Late Neolithic phase (2870-2570 cal BC), although some pottery fragments of Epicardial tradition have recently been identified (M. Piera, pers. com.). The analysis that is presented in this work only refers to structures from the Late Neolithic phase.

3.1.13.3. Settlement structure

The total area of the settlement is unknown but M. Piera considers that it is probably larger than the excavated surface (*c.* 3500 m^2). Within this area, several storage pits, pits of unknown functionality and post holes were identified, which resulted in the identification of, at least, one dwelling associated with several storage pits (Fig. 3.16b).

3.1.13.4. Palaeoecological and palaeoeconomic information

There are no palaeoenvironmental data available from this site.

Herding practices are scarcely represented but it is possible to identify that they were primarily based on ovicaprines and cattle (Piera et al. 2009).

Cereal harvesting and processing tools were recovered. This, together with the identification of storage pits, seems to support that agriculture had a significant role in the economy of this population (Piera et al. 2009).

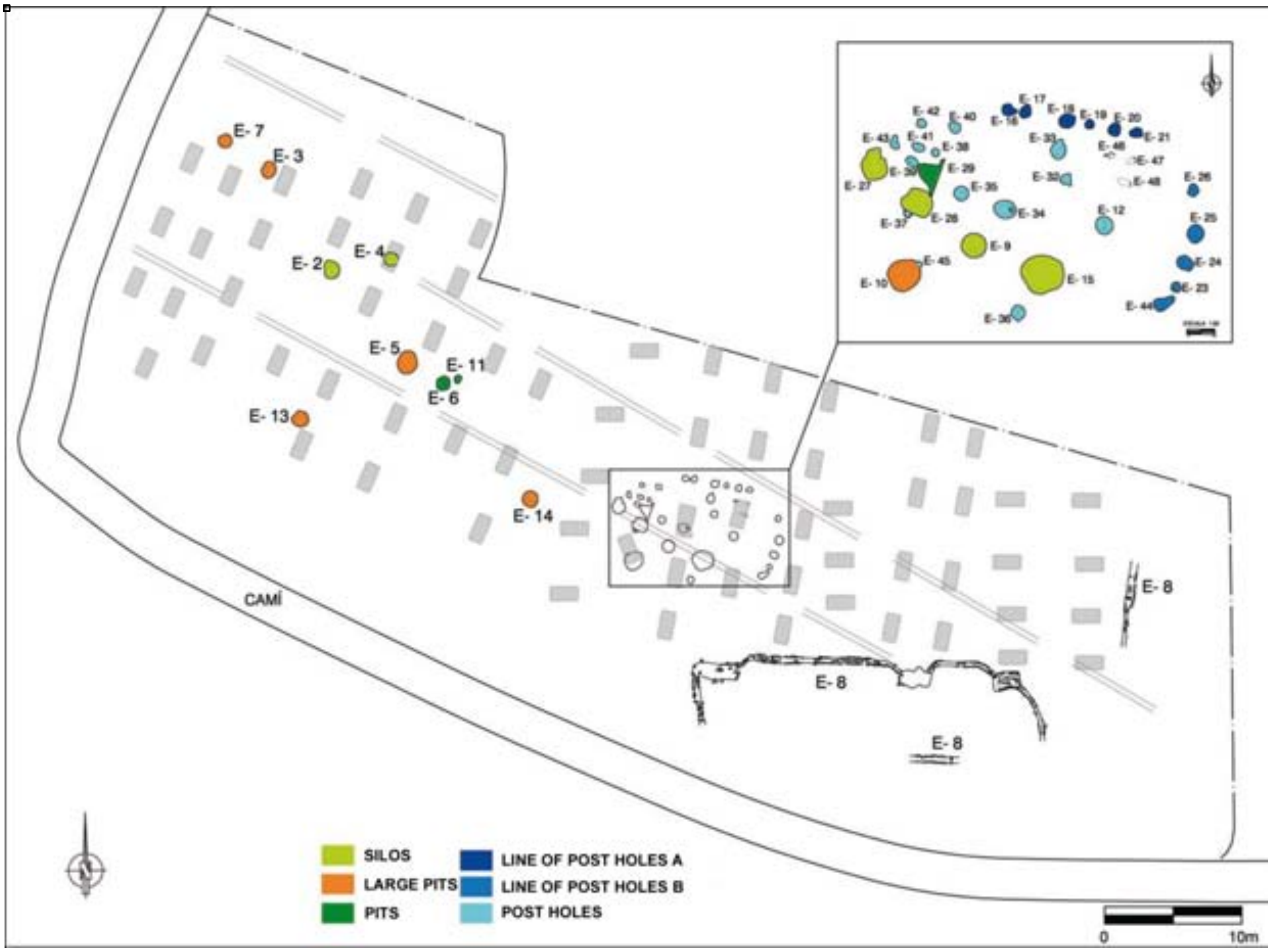


Fig. 3.16b. Site plan of Espina C site (image taken from Piera et al. 2009).

3.1.14. Pla del Gardelo

3.1.14.1. Location and history of investigations

Pla del Gardelo is located in Juneda (les Garrigues), on a rather large plain on the top of a hill, at *c.* 380 m a.s.l. Only small seasonal water courses are found in the vicinities of the site, while the closest river, La

Femosa, is found at several kilometres of distance. It is located on arable land. The site was excavated as a project of preventive archaeology in 2006.

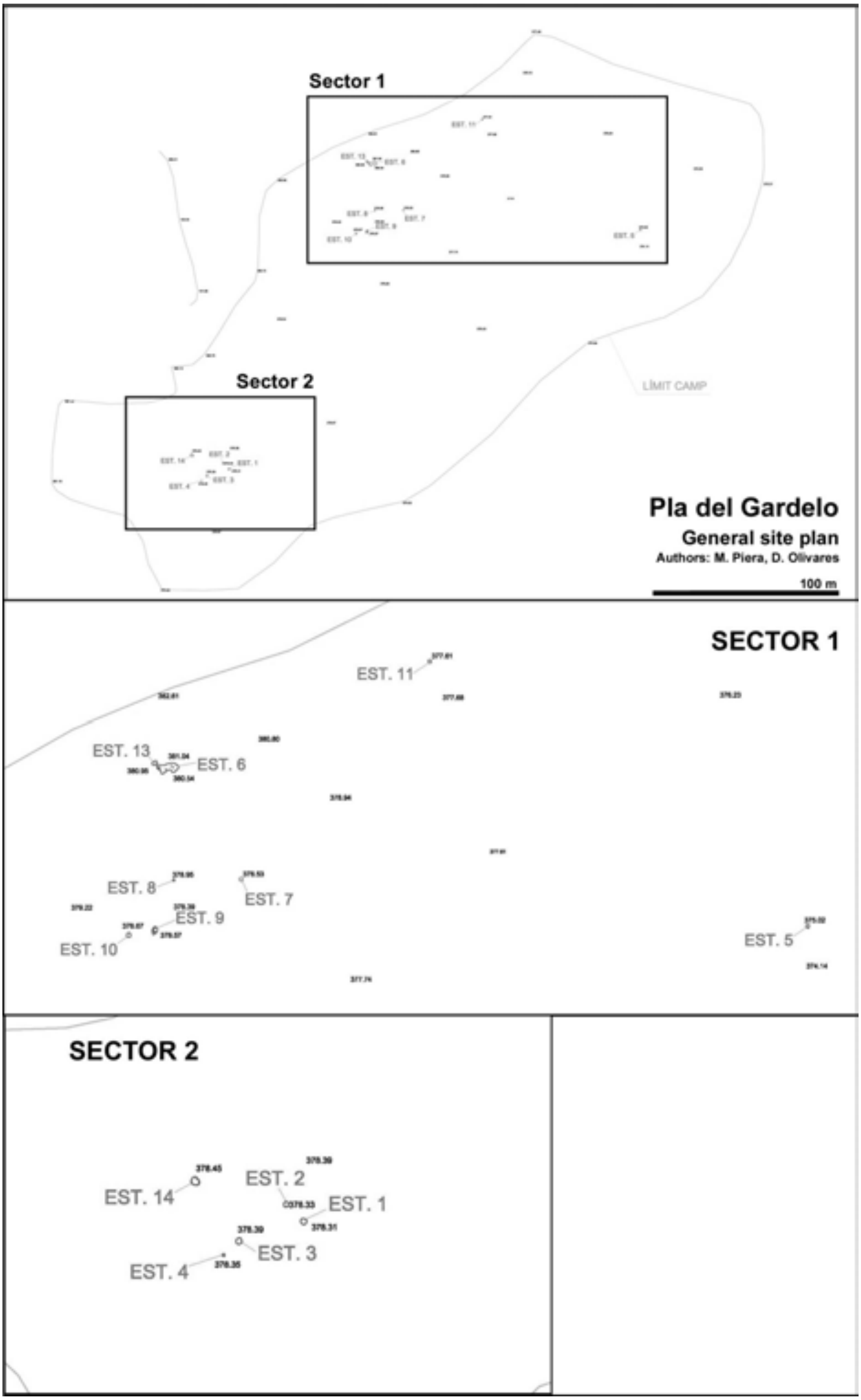


Fig. 3.17. Site plan of Pla del Gardelo (adapted from an image provided by M. Piera; the sectors shown in the figure were defined for practical reasons in this work, they do not respond to those defined during archaeological work).

3.1.14.2. Archaeological data

No radiocarbon dates are available from the site yet but, considering the type of pottery vessels that were recovered, it is thought to belong to the second half of the Vth millennium cal BC (Early Middle Neolithic).

Archaeological structures were badly preserved, due to the agricultural works that have been practiced in the area for centuries. Eight storage pits, two pits, one possible dwelling structure and another funerary pit were identified (Fig. 3.17).

Archaeobiological studies have been conducted at the site but their results are not yet available. Consequently, one can only draw the attention towards the relatively large number of storage pits and grinding stones that have been retrieved during the excavation. These could be interpreted as evidences of the importance of agricultural practices within the economy of this group.

3.1.15. Puig del Collet

3.1.15.1. Location and history of investigations

El Collet is situated in Puiggròs (Les Garrigues). It is located on the top of a low hill (Fig. 3.18a), at 317 m a.s.l., on arable land, and less than 1 km away from La Femosa River. The site was excavated in 2005 as a rescue excavation.

Fig.3.18a. View of the surroundings of the site of El Collet (image provided by M. Piera).

3.1.15.2. Chronology and phases

It is radiocarbon dated to the second half of the Vth millennium cal BC (*c.*4500-4200 cal BC). All structures are thought to belong to the same settlement phase but no contemporaneity can be demonstrated.

3.1.15.3. Settlement structure

Five storage pits were identified. Some of them were reused for funerary purposes, while others were filled with refuse. The site is likely to be larger than the excavated area (Fig. 3.18b).

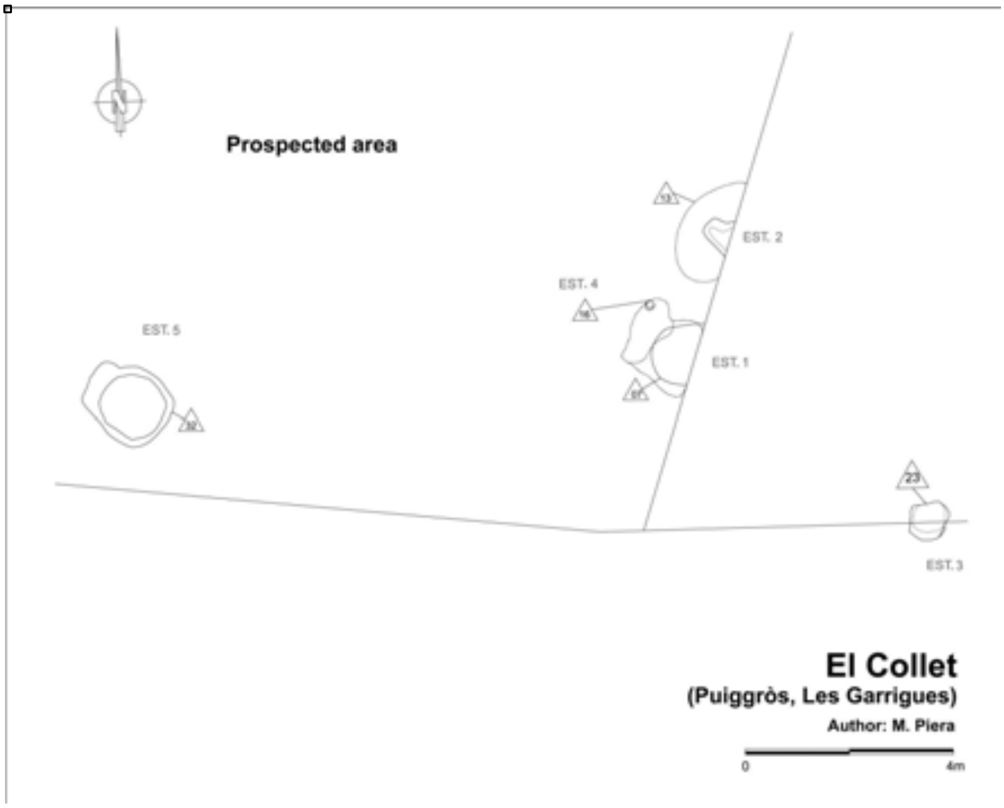


Fig. 3.18b. Site plan of El Collet (image provided by M. Piera).

3.1.15.4. Palaeoecological and palaeoeconomic information

Palaeoecological data from the site are not yet available. However, some palaeoeconomic information has already been published.

Concerning animal husbandry, a mixed farming model, oriented to the production of meat is observed at the site. Other resources of animal origin (e.g. game) were probably exploited at the site, but the scarce record does not allow further interpretations (Piera et al. 2008).

The results of use-wear analyses on lithic tools indicate that harvesting (and probably threshing) would take place at the site (Piera et al. 2008).

3.1.16. CIM "El Camp"

3.1.16.1. Location and history of investigations

The site is located in Reus (Baix Camp), at 45-50 m a.s.l., in a rather flat area, close (<500 m) to la Boella River. Two sectors or sites were excavated within this large area: Reus Airport and Coll blanc. The richness of this area in archaeological features of Prehistoric and Roman periods was already known. At present, it is a very adequate land for agricultural practices (Bravo, Roig & Solà 2012).

The site was excavated between 2007 and 2012 as a rescue excavation. The structures that yielded archaeobotanical material come from the Coll blanc sector.

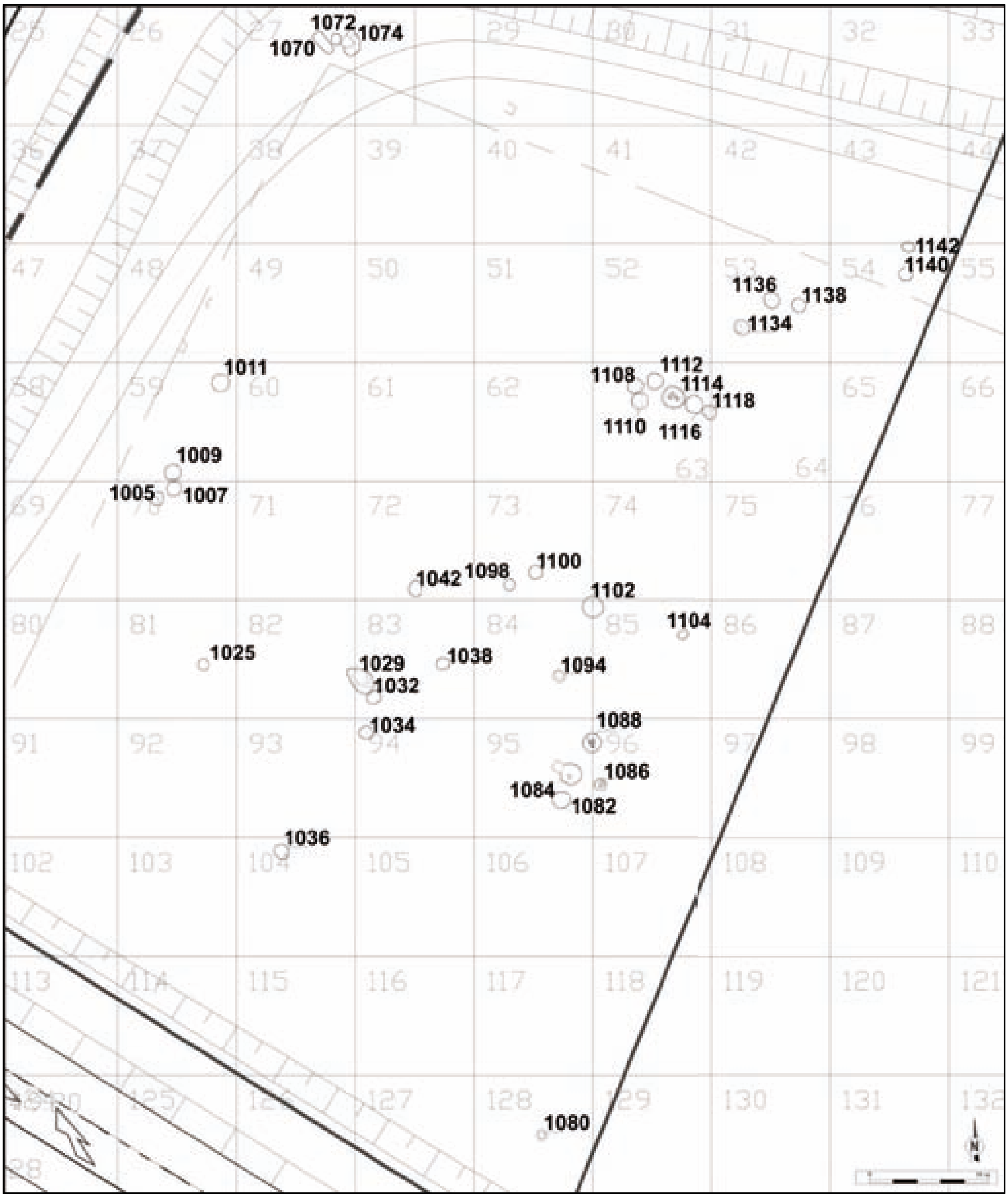


Fig. 3.19. Site plan of CIM "El Camp", sector Coll Blanc (adapted from an image provided by P. Bravo).

3.1.16.2. Archaeological data

Most of the studies from this site are currently on-going and the vast majority of structures are not yet dated. But it is clear (on the basis of artefact typology) that there are several features which belong to the Late Early, Middle and Late Neolithic, as well as to the Bronze Age. The structures that will be dealt with in this project were ascribed to the Early Middle Neolithic (no radiocarbon dates are yet available). The pottery fragments that have been recovered include both Epicardial and Postcardial decoration styles (Bravo, Roig & Solà 2012).

A large number of features, over 100, have been uncovered in the more than 400.000 m^2 that have been excavated (Fig. 3.19). Most of these are either pits of unknown functionality or storage pits. Some of them have been used for funerary purposes (Bravo, Roig & Solà 2012).

Palaeoecological and palaeoeconomic studies are currently in progress. It is significant to state that several saddle querns and hand stones were recovered at the site which, together with the identification of several storage pits, could be considered as an indicator of the importance of agriculture at the site (Bravo, Roig & Solà 2012).

The faunal record is extremely scarce. This could be due to taphonomic issues but other possibilities are not discarded by the archaeologists (Bravo, Roig & Solà 2012).

3.1.17. Fosca Cave

3.1.17.1. Location and history of investigations

Fosca Cave is located in Ares del Maestrat (Castelló), at 900 m a.s.l. in an area that is particularly rich in archaeological sites. The considerable altitudinal gradient of this spot allows the exploitation of rather different ecosystems in a relatively short distance (Fernández-López-de-Pablo 2006). The cave is *c*. 20x27 m (Fig. 3.20). It has been excavated for over 30 years by the Universitat Jaime I from Castelló.

Fig. 3.20. Site plan of Fosca Cave (image adapted from Olària 1988).

3.1.17.2. Chronology and phases

There is a very complete stratigraphic sequence at this site, from the Upper Palaeolithic to the Neolithic period. I will focus on the Neolithic levels (VIth and Vth millennium cal BC). Archaeobotanical data from the Palaeolithic and Mesolithic layers were already published elsewhere (Antolín et al. 2010).

3.1.17.3. Settlement structure

Most of the studies are on-going and little information is available concerning settlement structure. Palynological analyses (F. Burjachs) might indicate that the cave was used as a byre in some periods (Olària, Gusi 2008).

3.1.17.4. Palaeoecological and palaeoeconomic information

Anthracological analyses were carried out and over 1000 charcoal fragments were analysed. Scotts/Black pine (*Pinus sylvestris/nigra*) dominates the record during the Mesolithic. A significant decrease of this taxon is observed during the Neolithic, but only for a short period of time (Antolín et al. 2010).

The archaeozoological evidence seems to support the interpretation of a mixed farming model, with a clear dominance of ovicaprines, but with some cattle and suidines. It is particularly significant to note the importance of hunting activities at this site (*c*.12% of the total number of remains) (Olària & Gusi 2008).

3.2. Methods

The methods for obtaining archaeobotanical data have already been described and discussed by many authors. In the next chapters, I will focus on the methods that have been used in this text, especially on those aspects which are new proposals (otherwise, known methods were followed, like those described in (van der Veen & Fieller 1982, van der Veen 1985, Jacomet 1985, Jacomet, Brombacher & Dick 1989, Pearsall 1989, Buxó 1997, Alonso 1999, Buxó & Piqué 2003, Jacomet & Brombacher 2005, Wilkinson & Stevens 2008, Jacomet et al. 2009, Jacomet & Kühn 2012, Jacomet 2013). I will start with the sampling strategies, which determine the representativity of each of the studies and of the whole work that is being presented afterwards; then I will briefly comment on the soil processing techniques that have been used, which have been diverse; after that, I will specify what subsampling strategies have been applied and under which circumstances; next, some short comments on identification methods are described, followed by a relatively detailed presentation of the database that has been used to record the archaeobotanical material; finally a relatively accurate insight to the methods used for the numeric description of the data, as well as for the taphonomic and paleoeconomic analyses is offered.

3.2.1. Sampling: questions, general guidelines and data

In this work, each amount of sediment that has been purposely obtained from a defined structure and processed separately has been considered a **sample**. Only in particular cases, different "samples" have been amalgamated straight from the beginning. That is the case of cave sites where excavation took place in grid squares and 100% of the soil was recovered. This usually produced several "fake samples" that actually belonged to the same archaeological context and square (which is what is considered spatially significant). For this reason they were treated as one single sample. Thus, in general, it was preferred to distinguish samples from contexts. One context can be sampled several times considering several research questions and it is methodologically interesting to keep both concepts separated for a thorough evaluation of the applied sampling strategy. It should remain clear, then, that I do not use the word sample as a synonym of "amount of soil that most likely represents one single event in the past" (that would be determined by the **archaeological context/feature** from where the sample was taken). For palaeoeconomic evaluations, the **context** was the unit of analysis.

Sampling strategies can be designed at several scales, according to the scientific questions of the research project (Jones 1991). Our questions concern several aspects: plant economy at a site level, at a regional scale, and along a particular chronology. As a result, the applied sampling strategy must be evaluated at several scales:

- at a chronological level: do we have enough samples to offer a representative view of the whole Neolithic period and each of its subphases?;
- at a macro-spatial level: do we have enough samples to offer a representative view of the region under study as a unit, as well as its different subregions?;
- or at a site level: do our samples give a reliable picture of the total extension of the site, each of its settlement phases and each of its archaeological features or contexts.

This work was never aimed to have truly representative results (only the best results possible) for the first two categories (which is probably beyond the capacities of a single researcher), and it was only partially expected to offer representative results at a site level (not for complete sites, which are usually not fully excavated, but for at least the excavated area of such sites). At a context level, the sampling strategy usually aimed to evaluate the homogeneity or heterogeneity of the composition.

Whatever the case may be, it is necessary to evaluate the representativity of this work at all levels in order to proceed with a complete evaluation of the obtained results. For this reason, the number of samples, the volume of sediment, the number of sampled contexts, the number of contexts that yielded positive results, and the number of seed and fruit items obtained will be presented per site, chronological phase and region. The type of contexts that are sampled has significant implications on the final results and the sampling strategy will also be evaluated at this level. The sampling strategy applied in the 17 analysed sites has not been completely homogeneous and a detailed site-by-site description will be presented in Chapter 4.

3.2.1.1. General comments on sampling strategies at a site level

The sampling strategies that have been applied at each site are diverse (there is abundant literature on this topic, see e.g. Orton 2000, Jacomet et al. 2009) . Only part of the sites were sampled by or supervised by myself, while the rest were sampled either by the archaeologists themselves (without any advice) or in collaboration with other archaeobotanists. The sites in which I collaborated in some way in the formulation of the sampling strategy or the recovery of the samples are: La Draga, Can Sadurní Cave, Sant Llorenç Cave, Camp del Colomer, Espina C, Pla del Gardelo, El Collet, Serra del Mas Bonet, 120 Cave and La Dou. The sites that were sampled by other archaeobotanists are Bòbila Madurell and Sardo Cave. Codella, Gavà Mines, C/Reina Amàlia 31-33, CIM "El Camp" and Cova Fosca were sampled on the sole initiative of the archaeologists.

Firstly, it is necessary to briefly state the target population that one aims to sample. Ideally, this should be the total quantity of seed and fruit remains that were discarded in an archaeological site. Of course, reaching this target depends on what proportion of these remains have preserved in the archaeological sites/features that have been excavated (what other authors may call the "sampled population" (van der Veen 1985)). Usually, especially in dryland sites, this is a very small proportion and, as stated by other researchers, only a modest part of the assortment of plants used in these sites will be known through this analysis (e.g. (Jacomet, Brombacher & Dick 1989, Out 2009). In any case, all interpretations that will be elaborated from the archaeobotanical data presented in this work necessarily assume that there is, to a certain extent, some positive correlation between what is preserved and what was obtained, processed, consumed and discarded in the past. Otherwise, this work would be meaningless. Many works have targeted the chances of plant macroremains of getting charred, basically as refuse of the processing and consumption of cultivated plant foods (e.g. (Willerding 1971, Hillman 1981, van der Veen 2007), or by using dung as fuel (Miller 1984, Charles 1998, Valamoti & Charles 2005, Valamoti 2013). The process of carbonization allows their long-term preservation in dry mineral sites.

The desired number of plant macroremains that should be obtained in each sample is *c.* 400 items (after (van der Veen & Fieller 1982). If the sample was obtained in a representative way (from all the surface of the context, rather randomly taken), this population gives representative proportions of the better-represented taxa (= over 10% of the total) with an accuracy of 95% ± 5%. In the majority of occasions, such number of remains was impossible to obtain at a sample or context level. This is a frequent case for dryland sites (with the exception of burnt storages). In that case the target was aimed for each chronological phase of a site (partly following van der Veen 1985).

Previous works in sites with anaerobic preservation demonstrated that the botanical diversity is much larger than in dryland situations and that larger subsamples are needed in order to have a reliable proportion of the most significant taxa. The desired number of items per sample, then, was increased to around 800 items (400 per sieve fraction) (Hosch & Jacomet 2001). This number could rise even more when the recording of the whole botanical diversity of a rich sample is aimed (Vandorpe and Jacomet, unpublished). It must be noted that, ideally, these numbers should be obtained through a random sampling of the whole site. This was hardly viable in any of the sites that were included in this work, since excavations never affected complete settlements. Consequently, systematic samples were taken as far as possible in order to obtain data that can be considered as representative of the excavated area.

The different existing types of archaeobotanical samples were clearly described by M.K. Jones (Jones 1991):

- grab sampling: which includes the study of chance finds and data from past frameworks of research;
- judgement sampling: these samples are taken on the basis of assumptions concerning the “population” that is being sampled;
- interval sampling: taken with an even spacing across a “population” of material;
- and probabilistic sampling: through which the probability that the sample reflects the population from which it came can be statistically assessed.

Figure 3.21 shows the types of sampling strategies that have been used and the sites where they have been used.

SAMPLING STRATEGY	**SITES**
100% of the sediment	Sant Llorenç Cave, Can Sadurní Cave (Layers 18 and 11), 120 Cave
Interval sampling: fixed volume, systematically taken	La Draga, Can Sadurní Cave (Layer 10), Bòbila Madurell
Judgement sampling: variable, according to the type of context, the richness of organic content of the sediment, etc.	Serra del Mas Bonet, Camp del Colomer, C/Reina Amàlia 31-33, La Dou, Codella, El Collet, Espina C, Pla del Gardelo, CIM “El Camp”, Gavà Mines
Probabilistic sampling: 20% of the sediment of all contexts	Cova del Sardo
Grab sampling: manual collection and judgement samples	Cova Fosca

Fig. 3.21. Sampling strategies applied per site.

These sampling strategies resulted in very different quantities of volume of soil processed: from less than 15 litres in Fosca Cave to an unknown volume of over 1000 litres in Bòbila Madurell. Consequently, very different results were obtained: from 1 item up to 49322 remains. Some sites produced very large amounts of items even though a relatively low volume of sediment was sampled, like La Draga, while other sites yielded very few remains despite the large volumes of sediment that were processed (for instance, Sant Lorenç Cave, CIM "El Camp" or Sardo Cave).

Seventeen sites and thirty-four settlement phases have been analysed in this work (for an overview, see Fig. 3.22). The total number of samples that have been taken is close to 1200. Unfortunately, more than 400 were either not possible to ascribe to any chronological phase or belonged to other chronological periods (from the Upper Paleolithic to the Modern Ages). This affected quite dramatically the numbers presented for some particular sites like Sant Llorenç Cave or CIM "El Camp", where the chronological classification of the samples was particularly complicated. Only those samples that have been chronologically ascribed to the Neolithic period will be considered. Some other sites with structures or layers from the Neolithic period were sampled and processed but they either yielded no seed and fruit remains, or had very few remains and only identified to family level, or were not ascribed to any particular phase within the Neolithic period. That is the case of Pesseta Cave (Antolín 2008a), Camí dels Banys de la Mercè (Antolín 2007), Cingle del Mas Nou (Alonso and Antolín, unpublished) and Can Roqueta – Can Revella (Antolín 2008c), respectively. These sites were not included in the analysis.

The average number of samples per settlement phase is 22.4 (being 1 the minimum and 243 the maximum). The average volume of sediment is somewhat above 200 litres, 8 being the minimum and around 900 the maximum. All in all, 337 contexts were sampled, of which 213 gave positive results concerning plant remains (an average of 6.3 per settlement phase). A total number of 95148 seed and fruit remains were obtained within these samples, nearly 2800 per settlement phase (Fig. 3.22). Unfortunately, these results are not equally homogeneous and there are 26 settlement phases that did not reach the desired number of items per phase.

The volume of the samples should be in accordance with the target number of remains that one expects to recover. The size of the samples is also significant for other issues, since large items have less possibilities of being represented in small samples. Consequently, a systematic strategy based on small samples (probably below 10 litres in a dry site and below 3 litres in a wet site with waterlogged preservation) systematically neglects the representation of the larger fruits (see, for instance, Hosch & Jacomet 2001, Jacomet 2013). The optimal method is taking (and analysing) test-samples (Pearsall 1989, Buxó 1997, Alonso 1999), but this strategy was not possible, for which I relied on previous experiences. Consequently, most of the times the archaeologists were requested to sample *c.* 20 litres of sediment per sample at least (I never gave a maximum). But, as observed in Fig. 3.21, the strategies have been very diverse and they will be specified on a site-by-site basis in Chapter 4.

Site	Chronological phase	Nr. of samples	Volume of sediment	Nr. of contexts	Nr. of contexts with positive results	Nr. of seed and fruit remains
Bòbila Madurell	Middle Neolithic	239	>900 Kg	42	36	7847
Bòbila Madurell	Late Neolithic	55	>125 Kg	10	8	998
Camp del Colomer	Early Middle Neolithic	61	673,6	61	51	3447
Can Sadurní Cave	Early Neolithic	11	unknown (>100)	1	1	49322
Can Sadurní Cave	Early Middle Neolithic 1	13	unknown (>500)	1	1	1814
Can Sadurní Cave	Early Middle Neolithic 2	25	unknown (>250)	1	1	1814
Codella	Late Early Neolithic	7	unknown	1	1	27
CIM "El Camp"	Early Neolithic	4	37	2	1	1
CIM "El Camp"	Late Early Neolithic	1	10	1	1	1
CIM "El Camp"	Late Neolithic	1	8	1	0	0
120 Cave	Early Middle Neolithic	1	35	1	1	12
St. Llorenç Cave	Early Neolithic	4	35,5	1	1	6
St. Llorenç Cave	Late Early Neolithic	12	181	1	1	44
St. Llorenç Cave	Middle Neolithic	5	87,5	1	1	9
St. Llorenç Cave	Late Neolithic	2	17	1	1	4
Sardo Cave	Late Early Neolithic	6	195.5	4	4	33
Sardo Cave	Middle Neolithic 1	9	148,5	8	8	36
Sardo Cave	Middle Neolithic 2	6	124	5	5	20
Sardo Cave	Late Neolithic	5	68	4	4	47
Fosca Cave	Early Neolithic	15	12,8	13	9	10
Fosca Cave	Late Early Neolithic	2	0	2	2	14
Fosca Cave	Early Middle Neolithic	1	0	1	1	2
Draga	Early Neolithic	63	111,9	1	1	28478
El Collet	Early Middle Neolithic	4	179	4	4	114
Espina C	Late Neolithic	13	104	12	3	13
La Dou	Late Early Neolithic	30	431,5	15	6	53
La Dou	Early Middle Neolithic	13	183	13	10	121
Gavà Mines	Middle Neolithic	38	584	28	9	76
Pla Gardelo	Early Middle Neolithic	13	620	13	9	44
C/Reina Amàlia 31-33	Late Early Neolithic	14	253,5	8	7	142
C/Reina Amàlia 31-33	Early Middle Neolithic	16	218,5	11	9	451
Serra del Mas Bonet	Late Early Neolithic	6	89	4	2	4
Serra del Mas Bonet	Middle Neolithic	11	129,5	14	2	4
Serra del Mas Bonet	Late Neolithic	53	650,5	49	12	128
TOTAL	**34**	**762**	**>7000**	**337**	**213**	**95128**

Fig. 3.22. Number of samples, total volume of sediment, number of contexts, of contexts with positive results on archaeobotanical remains and total number of remains presented per settlement phase studied in this work (only those samples of which the archaeobotanical remains have been fully quantified are included in this table).Early Neolithic: 5400-5000 cal BC; Late Early Neolithic: 5000-4500 cal BC; Early Middle Neolithic: 4500-4000 cal BC; Middle Neolithic: 4000-3200 cal BC; Late Neolithic 3200-2300 cal BC.

3.2.1.2. The sampling strategy at a chronological level

The chronological span of the project and the different chronological phases that have been used have been presented in chapter 2.4.2.

Between 5 and 8 sites have been sampled for each of the chronological phases under study (see Fig. 3.23). Between 78 and 312 samples were obtained per phase. The number of samples increases towards the more recent phases, especially for the Middle Neolithic period. The volumes of sediment partly show the same picture. These are between 300 and 2750 l. Only for the Early Neolithic phase less than 500 litres of sediment were processed. The number of contexts is rather large from the Early Middle Neolithic onwards, but stays below 50 for the first two phases. Consequently, the number of structures that yielded positive results is higher (above 50) for the Early Middle and Middle Neolithic periods. A considerably different impression is obtained when comparing the number of seed and fruit items that have been recovered in each phase. The Early Neolithic period is, by far, the phase from which more remains have been recovered. Similar numbers, around 8000 items, were produced for the two Middle Neolithic phases, and slightly over 1000 items were obtained for the Late Neolithic period. With respect to this last phase, it must be noted that the Late Neolithic is the phase for which a larger number of contexts did not contain any seed and fruit remains. More than 400 items were obtained for all phases except for the Late Early Neolithic.

Period	Nr. of sites	Nr. of settlement phases	Nr. of samples	Volume of sediment	Nr. of contexts	Nr. of contexts with positive results	Nr. of seed and fruit remains
5400-5000 cal BC	5	5	97	>300	18	13	77817
5000-4500 cal BC	8	8	78	>1100	35	24	315
4500-4000 cal BC	8	9	147	>2750	106	87	7814
4000-3200 cal BC	5	6	308	>1900	98	61	7992
3200-2300 cal BC	6	6	130	>950	77	28	1191

Fig. 3.23. Number of sites, settlement phases, samples, total volume of sediment (l.), number of contexts, of contexts with positive results in archaeobotanical remains and total number of remains presented per chronological phase (only those samples of which the archaeobotanical remains have been fully quantified are included in this table).

These results show that more samples or a larger volume of sediment does not necessarily imply better archaeobotanical results. This is probably due to taphonomic reasons. Different types of contexts and types of preservation (one site with waterlogged preservation, La Draga, is dated to the Early Neolithic phase) were sampled in each phase and, consequently, the results show large differences. This could also have some relation to the crop processing techniques applied in each phase (whether roasting took place or not, for instance) and where the materials were being stored (inside houses or in underground storage pits). As a result, the data obtained for the Late Early Neolithic (5000-4500 cal BC) and the Late Neolithic (3200-2300 cal BC) are probably too scarce to provide a representative picture for the period under study.

3.2.1.3. The sampling strategy at a spatial level. Zones under analysis

The definition of the zones under analysis that were used for this study followed the major geomorphologic units that were presented in Chapter 2.4.1 (Fig. 2.2): the Pyrenees (including the pre-Pyrenees); the north-east (particularly the region at the Northern side of the Ter River); the central coast (corresponding to the Littoral and pre-Littoral mountains and plains at both sides of the Llobregat River); the Western Plain (or Central Depression); and the coastal area to the south of the Llobregat River.

The results per region are rather variable (see Fig. 3.24). The number of sites per region is between 2 and 5 while the number of settlement phases is between 3 and 12. Even larger differences are observed when considering the number of samples, which ranges from 24 to 438. Similar differences are observed when comparing the number of contexts or contexts with positive results in archaeobotanical macroremains. In general, the numbers are always lower for the Western Plain and the Southern regions. On the other hand, when one compares the volume of sediment that has been processed, it is around 1000 l (or 3000 for the

Central Coast) for all regions except for the Southern area, from where only a small number of small samples was obtained. It must be said, though, that these low numbers for the Southern area are largely affected by the impossibility to ascribe most of the samples from CIM "El Camp" to any chronological phase (398 litres of sediment were processed from this site). Finally, if one compares the number of plant macroremains (other than wood) that have been recovered in each region, these are well above 3000 items for the Pyrenees, the North Eastern and the Central Coast regions. The Southern area and the Western Plain do not reach 200 items all together. One further aspect must be highlighted, which is that a large number of contexts from the North East region did not contain any seed and fruit remains.

Region	Nr. of sites	Nr. of settlement phases	Nr. of samples	Volume of sediment	Nr. of contexts	Nr. of contexts with positive results	Nr. of seed and fruit remains
Central Coast	5	12	434	>3200	106	76	62527
North East	5	8	184	>1613	97	35	28819
Pyrenees	2	5	86	1209,6	82	72	3584
South	2	6	24	67,8	20	14	28
Western Plain	3	3	30	903	29	16	171

Fig. 3.24. Number of sites, settlement phases, samples, total volume of sediment (l.), number of contexts, of contexts with positive results in archaeobotanical remains and total number of remains presented per region (only those samples of which the archaeobotanical remains have been fully quantified are included in this table).

These results show that the number of sampled sites for the South and Western plain areas is insufficient and that the obtained results will not be representative. The low amounts of data recovered in the Western Plain are probably due to the type of contexts sampled (mostly underground pits from open-air sites located in large planes) and the chronology (from the younger phases of the Neolithic, when the density of remains per litre of sediment seems to decrease).

3.2.1.4. The sampling strategy according to type of context

The types of contexts that are studied in one settlement phase usually imply certain taphonomic histories that most certainly affect the final composition of the archaeobotanical record. It is for this reason of interest to get a general view of the type of contexts that were sampled in this work. These are, of course, archaeological contexts, which are determined in the field before any other analyses can help to produce more precise definitions. On the other hand, these contexts do not speak for themselves concerning the *in situ*-ness of the material. That must be evaluated on a sample by sample basis.

Half of the samples that have been taken come from occupational layers, these include all those stratigraphic units (primarily) from cave sites that most probably respond to a variety of activities and not just one single action like a refuse disposal. Around 30% of the samples come from pits, which can potentially be accumulations of refuse produced in a relatively short period of time or mixtures of refuse that were either accumulated after cleaning dwelling structures or naturally over a more or less long period of time. Dwelling structures (including post holes and hearths) are a small percentage of the total, around 10-12%. Finally, 4% of the samples were obtained from funerary contexts (Fig. 3.25).

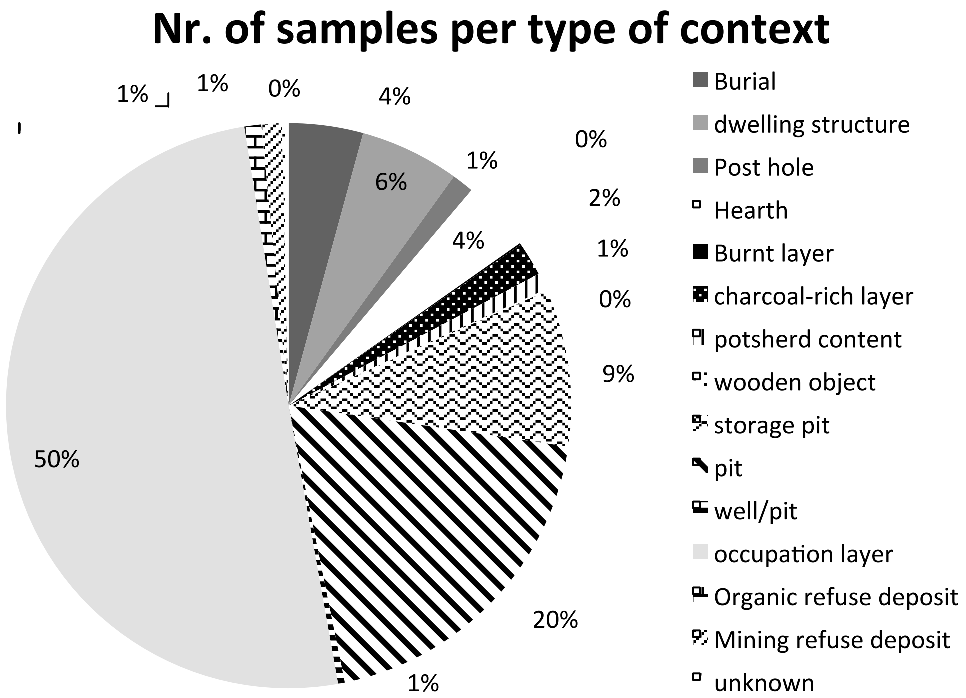


Fig. 3.25. Relative frequencies among the number of samples taken per type of context.

These results have clear implications for the interpretation of the data. The taphonomic origin of the samples has a major effect on the preservation of archaeobotanical materials. Contexts identified as settlement phases usually respond to multiple actions and the identification of short events becomes difficult (only if grid sampling is applied or trained archaeologists are able to identify particular concentrations). An uncritical comparison between different types of contexts, chronologies or areas might lead to erroneous conclusions and, in the future, one should aim to increase the database in order to be able to compare like-with-like (primary deposits with primary deposits, secondary deposits with secondary deposits, etc.). For the moment, such an approach is not possible.

3.2.2. Sediment processing techniques: flotation, wash-over and water screening

Different soil processing methods for the retrieval of archaeobotanical macroremains are known (see, for instance, Pearsall 1989) and they all have some advantages and disadvantages (e.g. Wagner 1988, Wright 2005, Antolín 2010a). In general, the use of the flotation machine with a sieve of 1 or 2 mm mesh size for the heavy fraction and two sieves (one of 2 mm and one of 0,5 mm of mesh size) for the light fraction or "flots" is considered enough for obtaining good results concerning the palaeoeconomy from dry mineral sites. Some authors, though, prefer to use a column of sieves and water-screen all the samples of less than 20 litres (Buxó 1997, Alonso 1999). Loamy sediment is often difficult to sieve. In such cases, drying and re-sieving the samples became necessary (Jacomet et al. 2009). On the other hand, samples from wet sites with waterlogged preservation require a much more gentle treatment in order not to break the fragile remains. Consequently, the use of the wash-over method has been considered as optimal (Hosch & Zibulski 2003, Jacomet 2013). For a description of this method, see e.g. (Kenward, Hall & Jones 1980, Tolar et al. 2010, Antolín, Buxó & Jacomet in press). In order to disaggregate compacted samples, the freeze-thaw system has been used, since it was proved to have the best results (Vandorpe & Jacomet 2007)

Some sites were totally processed by me (Sant Llorenç Cave, Espina C, Pla del Gardelo, El Collet, Fosca Cave, 120 Cave). I participated in the processing of part or most of the samples of La Draga, La Dou, Can Sadurní Cave, Sardo Cave, C/Reina Amàlia, 31-33), while the rest where processed by other people (Serra del Mas Bonet, Camp del Colomer, Codella, CIM "El Camp", Bòbila Madurell, Gavà Mines).

Sant Llorenç Cave, C/Reina Amàlia, 31-33, Serra del Mas Bonet, Camp del Colomer, Codella, La Dou and 120 Cave were treated with a flotation machine. Manual flotation was used in Bòbila Madurell. Water-screening was performed in Fosca Cave and CIM "El Camp", while a mixture of methods (mainly flotation and water-sieving, but also the wash-over technique) were used in Can Sadurní Cave, Sardo Cave, Espina C, Pla del Gardelo, El Collet and Gavà Mines. La Draga, the only wet site with anaerobic preservation was processed using the wash-over method, along with water-screening of very large samples. In all cases, the applied methodology can be considered adequate.

The combination of water-screening and flotation was used at some sites in order to test whether the methodology proposed by other authors suited our case studies. Usually, researchers who combine both methodologies use a sieve of 5 mm mesh size for the heavy fraction in the flotation machine. The column of sieves, thus, is considered a more accurate method where a lot more of the inorganic fraction is retained. From my experience, the use of a sieve with a mesh of 1-2 mm size for the heavy fraction inside the flotation machine is a better solution instead of water-screening the samples. The 0,5 mm fraction of the column of sieves usually gets stuck during sieving, which is rather time consuming. Besides, it needs to be re-floated manually before sorting (see Alonso 1999, 63-65). Some authors may consider that such a small mesh size inside the flotation tank equally multiplies the sorting time. This is true, but the recovery of charred plant macroremains in the heavy fraction of our samples is frequent enough to make it worth the time (Fig. 3.26). This is especially important when wild fruits are present in the samples. The case of Camp del Colomer is paradigmatic in this sense. More than half of the seed and fruit remains were recovered in the heavy fraction.

	Nr. of remains found in the heavy fraction after flotation
C/Reina Amàlia, 31-33	57 (9,61%)
Camp del Colomer	2065 (60%)
Sant Llorenç Cave	10 (15,87%)
Sardo Cave	22 (15,94%)
La Dou	64 (35%)
Serra del Mas Bonet	3 (2,2%)
Total general	**2221**

Fig. 3.26. Number of seed and fruit items recovered in the heavy fraction after flotation.

3.2.3. Sorting and subsampling the different sieve fractions

I have personally sorted the "flots" (flotation residues) of nearly all of the sites and the heavy fraction of a lot of them. Just as was observed by other authors during soil sieving, the reliance of sorting on unexperienced hands can produce very inaccurate results. Thus, training of these people and revision of the work was always enhanced. Some sites, though, were (at least partially) sorted by other people. Bòbila Madurell was majorly sorted by the late Vicente López (archaeobotanist) already in the early nineties (partly under the supervision of R. Buxó from the Museu d'Arqueologia de Catalunya, and S. Jacomet and collaborators from the University of Basel), and only a small part was sorted by me. Can Sadurní was also partially sorted by the archaeologists, since the contexts were excavated in the late nineties and early years of the twenty-first century. The samples from Gavà Mines were sorted by Natàlia Alonso and her collaborators.

The sorting of the flots was done with the help of a binocular. A magnifying lamp (x3) was used to sort the heavy fraction in some occasions, but this was sorted with the naked eye most of the time. Samples from La Draga were always sorted under the binocular.

Subsampling was carried out on a low number of sites, mainly when the amount of grain was far too large for the questions that were aimed to answer. In such cases, a riffle-box was used and a subsample of *c.* 400 items was usually aimed for (following van der Veen & Fieller 1982). In some occasions, this required the production of small subsamples (1/32 or 1/64). Subsamples beyond 1/8 are usually avoided by many authors (for instance, see Valamoti 2004, 26). Nevertheless, this was practiced on very homogeneous samples of more than 90% of one single taxon (for which the effect of subsampling will probably be minimal). Flots were never subsampled before sorting except in the case of Sardo Cave, where some 0,35 mm fractions were subsampled due to the poor number of remains that they contained. Only in one site, La Draga, subsampling was systematically carried out for the 0,35 mm fraction. Here, the grid method was used in order to obtain a subsample of *c.* 10 ml (following Hosch & Jacomet 2001).

3.2.4. Botanical identification

The identification of seeds and fruits was based on morphological features of the remains, namely shape, size and surface decoration or cell pattern. The reference collection of recent seeds and fruits of the IPAS (Institute for Prehistory and Archaeological Science) of the University of Basel and the Centre de Documentació de Biodiversitat Vegetal of the University of Barcelona were consulted, along with a relatively large number of atlas (e.g. Berggren 1981, Jacomet 1986, Anderberg 1994, Cappers, Bekker & Jans 2006, Bojnansky & Fargasova 2007, Knörzer 2007) and specialized literature (Aalto 1970, Renfrew 1973, Lange 1979, Bakels 1984, Jacomet & Schlichtherle 1984, Jacquat 1988, Buxó 1997, Alonso 1999, Jones, Valamoti & Charles 2000, Hillman 2001, Kreuz & Boenke 2002, Jacomet & Petrucci-Bavaud 2004, Jacomet et al. 2006, Rovira 2007, Martin 2010). The few subfossil pericarp remains of wild grasses that were retrieved were identified with (Körber-Grohne 1991). Charred cereal remains were identified according to (Jacomet et al. 2006), and the terminology follows the traditional nomenclature (for modern groupings see, (Zohary, Hopf & Weiss 2012). The taxon *Hordeum vulgare* is used in this text to refer to all hulled varieties of barley. The distinction between two- or multi-rowed barley was only performed when very clear materials were available (e.g. well-preserved chaff remains). The nomenclature for the rest of the taxa follows the *Flora Manual dels Països Catalans* (de Bolòs et al. 2005).

The full description of the identified taxa, along with some botanical and ecological information, pictures and drawings can be found in Annex I.

3.2.5. The database

The database (recorded with Excel) that has been used includes a relatively large number of variables that respond to particular scientific questions (Fig. 3.27), especially concerning the taphonomic history of the remains. The basis for their recording is the premise that formation processes leave characteristic traces on the archaeological record and that they can be approached when they are systematically evaluated on a seed-by-seed basis. These variables were defined following other authors (Boardman & Jones 1990, Hubbard & al Azm 1990, Valamoti 2002, Braadbaart et al. 2004, Bouby, Fages & Treffort 2005, Braadbaart 2008) and also a small number of experiments carried out by myself (see Annex II; Antolín 2012). A detailed presentation of the database is available from previous publications (Antolín 2010b, Antolín & Buxó 2011c, Antolín 2012,). Nonetheless, a complete list of variables is presented in Fig.3.27., together with some hints concerning the questions that are aimed to answer and the type of recording (whether it is a nominal or an ordinal variable).

CATEGORY	AIM	TYPE OF RECORDING
NUMBER	General information concerning the storage of each item (reference number + bag number) and the context from where it came (site, chronology, archaeological feature)	correlative number
SITE		text
YEAR		number
LOCATION		text
CHRONOLOGY		text
C14 DATES		number
FEATURE/LAYER		text
SPIT		text
STRATIGRAPHIC UNIT		text
SIEVE FRACTION		text
BAG NUMBER		number
TAXON		text (see chapter 3.2.4)
REPRESENTED PART	part of the plant identified	Text (Fig. 3.28)
NUMBER OF REMAINS		number
PRESERVATION TYPE	1: charred to 5: subfossil	ordinal ranking number
NUMBER OF PARTS		number
FRAGMENTED PART	for cereals, part of the grain that is preserved	text (Fig. 3.29)
DEGREE OF FRAGMENTATION	Several variables that are aimed to describe the postdepositional history of the remains (chapter 3.2.10.3)	ordinal ranking number (Fig. 3.30)
DEGREE OF EROSION OF THE SURFACE		ordinal ranking value
ROOTS		yes/no
TYPE OF FRACTURE		text
CONCRETIONS		yes/no
PS (popped seed)	Several variables that are aimed to describe the depositional history of the remains (charring conditions) (chapter 3.2.10.2)	yes/no (Fig. 3.38)
PROT (seed with protrusions)		yes/no (Fig. 3.38)
AG (aggregated seeds)		yes/no (Fig. 3.38)
PELL (glumes preserved)		yes/no
CC (concave flanks)		yes/no
CT (cracked testa - for legumes)		yes/no (Fig. 3.38)
Ocot (open cotyledons - for legumes)		yes/no (Fig. 3.38)
DEFP (deformation by pressure)		yes/no
DEF (deformation)		yes/no
AP (apical hairs)	Several variables that are partly related to charring conditions but also, and most importantly, to some pre-depositional factors that could help understanding crop processing methods or storage conditions (chapter 3.2.10.1)	yes/no
FI (insect holes)		yes/no
SHINY SURFACE		yes/no
EA (adhered embryo)		yes/no
ENA (absent embryo)		yes/no
EG (germinated embryo)		yes/no
l (length)		number
w (width)		number
h (height)		number
l/w		number
w/h		number
l/h		number
w/l*100		number
h/w		number
Observations	Other observations	text

Fig. 3.27. List of variables that are recorded in the database.

Maximum accuracy is always aimed in the description of the plant parts represented. The complete list is offered below (Fig. 3.28). However, the use of such a relatively precise vocabulary implied a lot of processing of the data before producing the final tables (which mainly reflect the conventional categories).

On the other hand, recording them allowed some intra-site evaluations of crop processing strategies that would not have been possible otherwise.

2-grain spikelet	fruit?
acorn	fungi
acorn base	glume
acorn base fragment	glume base
agg. FPostC	glume fragment
agg. FPreC	inflorescence fragment
agg. FpreC+ straw imprints	infructescence fragment
agg. grains	internode
agg. grains + FPreC	laterally perforated bead
amorphous object	leaf fragment
amorphous tissue	needle fragment
awn fragment	needle tip
bark	node
bead	node + 1 grain
bead fragment	node + 2 grains
bristle	peduncle
bud	peeled/cut grain
capsule fragment	pericarp
catkin	pericarp fragment
chaff	pericarp fragment with hilum
cone scale	pericarp with hilum
cone scale fragment	pod fragment
cotyledon	pod fragment?
cotyledon fragment	rachis fragment
cracked grain	rachis fragment (base)
cupule fragment	rachis fragment (top)
cut/peeled grain	rachis fragment + 1 grain
ear fragment	rachis internode fragment
embryo	sclerotia
endosperm	seed base
final spikelet	seed/fruit
FPostC	spikelet
FPreC	spikelet fork
fragment	spikelet fork + 1 grain
fragment with tip	spine
fruit	stalk fragment
fruit flesh and pericarp fragment	straw fragment
fruit flesh fragment	straw node
fruit flesh fragment?	twig fragment
fruit fragment	underdeveloped fruit
fruit stone	underdeveloped grain
fruit stone fragment	Varia
fruit stone fragment?	

Fig. 3.28. List of categories used to describe the represented part of each taxon (FPostC: fragment produced prior to charring; FPreC: fragment produced prior to charring).

The nomenclature of the fragmented part of cereal grains was presented elsewhere (Antolín 2008b, Antolín & Alonso 2009, Antolín 2010b, Antolín & Buxó 2011c) (Fig. 3.29).

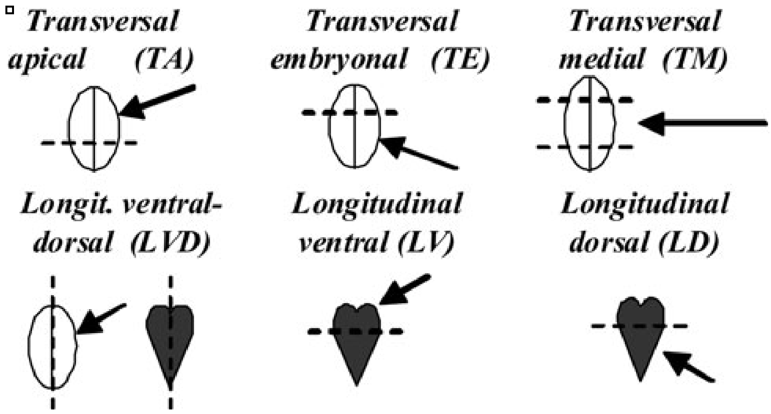


Fig. 3.29. Nomenclature for the fragmented part of cereal grains used for the calculation of the MNI (Antolín 2008b).

Finally, some further details concerning the scoring for the degree of fragmentation should be added. This has been specifically designed for some taxa (see Fig. 3.30).

Taxa	Scoring
Cereals (charred grain)	1= < 1 mm 2= 1-1,9 mm 3= 2-2,9 mm 4= > 3 mm
Acorn pericarp (waterlogged)	1= ≤25 mm^2 2= 26-50 mm^2 3= >50 mm^2
Acorn kernel (charred)	1=less than half a cotyledon and without distal or basal end 2= less than half a cotyledon but with distal or basal end 3= more than half a cotyledon
Hazelnut pericarp (waterlogged or charred)	1= ≤ 15 mm^2 2= 16-50 mm^2 3= > 50 mm^2
Rest of the taxa	1 = less than half of the grain/fruit 2 = half or more than half of the grain/fruit

Fig. 3.30. Scoring criteria for recording the degree of fragmentation for the different taxa.

3.2.6. Techniques of numerical description of seed and fruit remains: NR, CU, MNI and density

Archaeobotanical data can be described in a variety of ways, from semi-quantitative systems (presence/absence or scales of abundance) to fully quantitative descriptions. Each of them has advantages and disadvantages (see, for instance, Jones 1991). Semi-quantitative systems are especially useful when sites or particular chronological phases are very well known (through quantitative analyses) and the only interest is to record major trends and the taxonomic diversity. They are also valuable for preliminary evaluations previous to more thorough analyses, or for the rapid screening of large samples (Vandorpe 2010). Quantitative systems allow comparisons between sites/features in terms of concentration of items per litre of sediment, as well as with experimental or ethnographic reference materials. They are, for this reason, necessary in order to reach significant taphonomic and palaeoeconomic evaluations.

Both systems were used in this work, but in most occasions fully quantitative approaches were carried out. Some samples, mainly from La Draga site, were rapidly scanned, sorted and semi-quantified. These samples had been roughly water-screened at the site and they were mainly taken in order to recover large items that had few chances of being represented in the small systematic samples. This **semi-quantification** mainly consisted on a rough and fast counting of complete seeds just for getting a general idea of the composition of the samples.

Numerical descriptions are a way of presenting results in an objective way. But, how exact should they be? Is it enough to count the **number of remains (NR)**, should **counting units (CU)** be defined even if these do not represent a **minimum number of individuals (MNI)**? Why should one want to quantify 35 individuals instead of 18 CU, or 3000 remains instead of an MNI of 250? At some point, numbers become rather meaningless (Hubbard 1980) and small differences are not statistically significant. In our case, we expect to obtain results, which can be compared to those from other studies and to reference ethnographic or experimental work in order to reach a better understanding of taphonomic processes and the representativity of each assemblage. Besides, as will be commented more in detail in the following chapters, a lot of thresholds are used in archaeobotany: in order to choose suitable samples for palaeoeconomic analyses (>35, >50 or >100 crop items), in order to determine whether they are "pure" or mixed (90% of one single taxon), in order to consider a sample accurate concerning the relative frecuency (proportion) of the best represented taxa (>384 items). As long as we depend on those thresholds, which are actually useful (but somewhat arbitrary in some occasions), there is a need for exact **quantification**. The need of exact quantification is more evident in small assemblages, where the largest MNI possible is aimed. The results obtained for large assemblages might not change significantly using one method or another: an average "loss" of 20% was observed in previous works with heavily fragmented assemblages when only embryo ends were counted (Antolín & Buxó 2011c), a lower proportion would be expected in better preserved ones.

In cases where comparisons are necessary, one should aim to quantify the materials in the same way as they were quantified in previous archaeobotanical analyses, experimental or ethnographic work. But only as long as that is possible and as long as other factors are not affecting the quantification of the archaeobotanical remains. For instance, embryo ends of cereal grains were counted in order to present ethnographic reference data concerning the ratios between cereal grain, chaff and weeds in each of the processing stages of a harvested crop (Jones 1990). A resulting database was obtained which has been used by many archaeobotanists as a reference for interpreting their archaeological assemblages. Usually the same quantification methods are used, aiming for some methodological coherence. But a charred assemblage of grain has a rather different state of preservation than that of a freshly threshed crop. Therefore, counting embryo ends might not lead to the most accurate **MNI** possible as in the ethnographic material. For this reason, another method, which takes into consideration all recognizable grain fragments, was proposed (Antolín 2008b). A similar method to that proposed by myself was actually practiced by other archaeobotanists (e.g. Van der Veen 1992, Valamoti 2004). But reaching an MNI is not possible in all cases. The quantification of seed and fruit remains is complex, as already stated by other authors (Jones 1991), due to the frequent impossibility of counting a minimum number of plants (one can only aim to get a minimum number of seeds/fruits in many cases). And sometimes even reaching this goal is somewhat unfeasible. A good example for this would be subfossil pericarps of acorn. In these cases, a **counting unit** (CU) needs to be determined: for instance, a fragment above 25 mm^2 (Hosch & Jacomet 2004). Establishing a CU is a useful counting strategy in order to not over-represent a taxon but it is not an MNI, for which the problem of over-representation may still not be solved. In many other cases, including all rare taxa, presenting the number of remains does not affect any statistical approach to the record and calculating an MNI becomes unnecessary. Finally, there are some types of remains for which counting CU or MNI is not possible because the material has been intentionally fragmented due to some processing. That would be the case of the fragments of grain produced prior to charring. These are produced during threshing, dehusking or bulgur preparation. Their quantification should be carried out by counting **NR**, since any other approach would be too complex given the difficulty of recognizing anatomical features. Besides, these are relatively rare finds and their quantification as NR does not imply a large effort.

A fast look at the quantification techniques used by different researchers leads to the discouraging conclusion that quantification methods are not homogeneous. This lack of homogeneity can be observed in many studies. For instance, slightly different counting systems were used by M. Van der Veen (1992) and S.M. Valamoti (2004) concerning cereal chaff remains; while the quantification of wild fruits like hazelnuts has been attempted by using weight (e.g. McComb & Simpson 1999, Mithen et al. 2001), volume (e.g. Marinval 2008) and absolute counts of CU (Hosch & Jacomet 2004, Martin 2010) or the total NR (many studies, e.g. Zapata 2001, Antolín & Alonso 2009, Salavert 2011, Antolín et al. 2010, Antolín & Buxó 2011b) (for a more in depth discussion on hazelnut quantification see Berihuete & Antolín in press). For this reason, it has been considered necessary to develop suitable quantitative methods for a proper prosecution of our goals, especially concerning economically important taxa like cereals, acorns, hazelnuts and strawberry tree fruits. At the same time, these numeric descriptions have been done in enough detail so that these data can be quantified through other systems, so as to facilitate the comparison with other sites or regions. In order to make this possible, the final number of MNI was not introduced into the database, but only calculated and presented in the final tables of results.

The proposed methods usually imply some processing of the data, which should not be a problem when having adequate databases that can perform the desired calculations automatically. Unfortunately this is not yet available and extra time has been dedicated to the obtention of the MNI per taxon and per sample.

3.2.6.1. The calculation of the CU and the MNI

Several simple formulae were designed for the calculation of the CU and MNI of those taxa which were more frequent and which posed more problems for an exact quantification. A summary table is presented in Fig. 3.31. In nearly all cases, the **total number of items (NR)** has been recorded, since this is the most basic description. Then, an MNI is calculated.

3.2.6.1.1. Cereal grain and chaff

The quantification of charred cereal grain follows the method that we already presented elsewhere (Antolín & Buxó 2011c), while the quantification of chaff and straw follows that proposed by G. Jones (1987; 1990) and others (Hillman et al. 1996).

3.2.6.1.2. Hazelnut shells

Archaeobotanists and archaeologists have quantified hazelnut shells in very different ways (volume, weight, number of remains, number of remains in the 2 mm fraction, number of fragments with basal part, etc.). A recent experimental evaluation of several methods showed that some of these do not produce a reliable MNI, while those dealing with weight are only applicable within a single site and only in the case when whole or half hazelnut shells are preserved (charred or dried) (which is rare) (Berihuete & Antolín in press). The formula that seems to give a more accurate MNI requires counting each identifiable item and record separately **items below 4 mm^2 (type 1)**. The total number of type 1 fragments is **divided by 2** and then the result is **added** to the total number of **fragments above 4 mm^2 (type 2+3)**. The **resulting number is divided by 8**. This method seems to produce a relatively good MNI, especially among fragmented assemblages, which is our case. Among extremely well-preserved large assemblages of hazelnuts, establishing an average weight per fruit by weighting full or half nuts and then weighting the rest of the fragments and produce an MNI is a time-saving and reliable method (McComb & Simpson 1999).

TAXON OR GROUP OF TAXA	**METHOD FOR COUNTING MNI/CU**	**REFERENCE**
Chaff of glume wheats (CU)	Each glume base = 1	(Jones 1990, Hillman et al. 1996)
Chaff of free-threshing cereals (CU)	Each node = 1	(Jones 1990)
Cereal straw (CU)	Each node = 1	(Jones 1990)
Cereal grain (MNI)	The largest number among TA/TE/TM + the largest number among LV/LD + LVD/2 + complete grains (see Fig. 3. 29 for abbreviations)	(Antolín & Buxó 2011c)
Hazelnut shells (MNI)	(fr. type 1 /2 + Fr. type 2 + type 3) /8 + half shell/2 + complete shell	(Berihuete & Antolín in press)
Acorn – kernels (ch) (MNI)	(fr. type 1 /2 + Fr. type 2 + type 3) /4 + complete acorn	
Acorn – fruits (wg) (MNI)	CU/4	
Acorn – fruits (wg) (CU)	Highest number between the CU of pericarp fragments and bases	
Acorn – pericarp fragments (CU)	(fr. type 1 /2 + Fr. type 2 + type 3) + complete pericarp	
Acorn – bases (CU)	fr. type 2 /2 + full bases*4 (fr. type 1 are counted when no type 2 are found and only counted as 1, no matter the number of fragments)	
Strawberry tree fruits (MNI)	(fr. type 1 /4 + type 2) /2 + whole fruits	
Cladium mariscus (CU)	Fr. with tip + seed/fruit (fr. type 1 or without a tip are counted when no type 2 are found, and only counted as 1, no matter the number of fragments)	
Rest of the taxa (CU)	Fr. type 2 + complete seed or fruit (fr. type 1 are counted when no type 2 are found, and only counted as 1, no matter the number of fragments)	

Fig. 3.31. Summary table for the methods of calculation of the MNI per taxon or type of remain. For a description of type 1,type 2 and type 3 see Fig. 3.30.

3.2.6.1.3. Acorns: kernels, pericarp fragments and bases

Different parts of the acorn have been recovered in our samples, mainly cotyledon fragments, fragments of pericarp and acorn bases. Usually, cotyledon fragments are found in charred state, while fragments of pericarp or acorn bases are most commonly recovered in waterlogged state. Quite the opposite, several parts of the acorn appeared in the same sample when waterlogged conditions were present. In such cases, the higher CU obtained per type of fruit part was the one that was finally taken to quantify acorn remains from that sample. As mentioned above, attempting an MNI of pericarp fragments of acorn is rather difficult, for which CU were used, like in other sites with waterlogged preservation. The proposed quantification methods were not experimentally tested.

For charred cotyledons, I counted **fragments type 1** (see Fig. 3.30) and **divided** them by **2**, then **added** the result to **fragments type 2 and 3 and complete cotyledons**. Finally, the total **sum** was **divided by two**.

For acorn bases, **fragments type 2** (half or more than half of the base) were counted and **divided** by **two**, then **added** to **complete bases**. Fragments type 1 were not considered in most occasions, only when no other fragments were present. The resulting number was multiplied by 4, since each acorn basis was considered to equal a minimum of 4 CU of pericarp fragments (1 CU= c. 25 mm^2 (Hosch & Jacomet 2004).

Acorn pericarps were counted by **adding** the number of **fragments type 1 divided by two** plus **fragments type 2 and 3.** The total sum was **added** to the number of **complete pericarps**.

3.2.6.1.4. Strawberry tree fruits

Strawberry tree fruits are not a common find in archaeobotanical samples. Nevertheless, hundreds of fragments of this specie were retrieved in Can Sadurní Cave, which made it necessary to produce a formula in order to quantify them with some reliability. **Fragments type 1** (see Fig. 3.30) were **divided by four** and **added** to fragments **type two**. The total **sum** was then **divided by two and added** to the number of **whole fruits**.

3.2.6.1.5. Other items

For the rest of the taxa, usually only complete seeds and fragments type 2 (see Fig. 3.30) were considered, but fragments type 1 were counted as 1 item when no other fragment types were present.

3.2.6.2. Density

In all dry mineral sites, the density of remains per sample (number of remains per litre of sediment that has been processed) was calculated. Density is thought to inform of the formation processes of the assemblage (e.g. van der Veen & Jones 2006) and it has been considered of major importance for the numerical description of our data. At La Draga, all results are presented both in the conventional way (NR/CU/MNI) as well as the density (per taxon and per sample). It is the only way in which the data can be made comparable from sample to sample, and with respect to other sites. Equally, in sites with waterlogged preservation, these densities are considered to be informative concerning layer formation processes and for the interpretation of the horizontal distribution of the material.

3.2.7. The ecological classification of the taxa

Taxa have been ascribed to general ecological groups on an actualistic basis, following the *Flora Manual dels Països Catalans* (de Bolòs et al. 2005) or (Brombacher & Jacomet 1997) when the Flora did not give a precise description (only for the taxa from the lakeshore site of La Draga). It is not directly assumed that present plant associations are applicable to the past. It must be kept in mind that present plant distributions and associations are the result of millennia of human-plant interaction and environmental evolution, and that significant changes could have taken place in the last 7000 years. This classification is only aimed to get a general picture of the potential ecological distribution of the taxa considering what is known of their present distribution in the same territory (for a wider discussion on this topic see, for instance Behre & Jacomet 1991, 101-109, Van der Veen 1992). Very frequently, deposits of waterlogged (but also charred) plant macroremains originated from thanatocoenosis: "plant materials with different origins that were deposited in the same spot as a result of human activity" (Behre & Jacomet 1991). The classification of taxa into ecological groups aims to disentangle this process. As other authors have stated (see for instance (Willerding 1991) taphonomic analysis of the sample and the plant remains is indispensable for a proper ecological and economic evaluation of archcaeobotanical assemblages.

The ecological groups and abbreviations that have been used in this work are as follows:

- C: cultivars (C CER: cereals; C OIL: oil plants; C LEG: legumes);
- WER: weeds and ruderals;
- WEC: woodland edges and clearings;
- WO: woodland;
- PG: pastures and grasslands;
- MA: maquis;
- LS: lakeshore;
- WP: water plants;
- DIV: diverse or unknown ecologies

3.2.8. Sample amalgamation

As mentioned above, I have deliberately separated the concept of sample from the concept of archaeological context or feature. A numerical description and densities are initially presented at a sample level. Proceeding with the archaeobotanical interpretation without amalgamating those samples which prove to correspond to the same behavioural episode would over-represent this episode and, consequently, affect our interpretations. As already stated by other authors, each behavioural episode should be represented only once in our analyses (Jones 1991).

Several elements have been considered in order to define contexts or behavioural episodes in dry mineral sites: the density of remains, the composition of the assemblage and the spatial distribution.

3.2.9. Quantitative techniques and multivariate analyses used to compare archaeological contexts: Relative frequencies (proportions), Ubiquity, the Index of Relative Abundance and Correspondence Analysis

Quantifying the economic role of plants in Prehistory is a rather complex issue (see, for instance, Popper 1988). Taphonomic factors must always be considered: a large number of taxa are systematically absent from dry sites with charred preservation and quantification issues make it equally difficult to compare among taxa. Despite this, there exist several methods for evaluating the economic role of plants within a settlement: relative frequency (proportion of one taxon in relation to the total number of identified items), ubiquity (percentage of the contexts in which the taxon is present, considering only those contexts which contain plant remains) and the index of relative abundance, which results from the sum of the percentage over the total identifiable items and the ubiquity (see Hastorf, Whitehead & Johannessen 2005). These are three techniques of description that, all together, can act as a powerful tool for approaching the economic relevance of some of the taxa that were consumed in the past. Relative frequencies (proportions) allow the detection of the best-represented taxa. They should not be calculated when less than 30-35 items are compared. In those cases when systematic sampling has been carried out, one can also evaluate the ubiquity of each taxon. Ubiquity analysis is usually carried out considering the presence of one taxon within a sample that at least contained two taxa (Hubbard 1980, Popper 1988). Ubiquity cannot be compared from one site to another if the number of samples is low. Finally, both percentages can be merged into the index of relative abundance. Behind the use of this index is the assumption that those taxa that appear more repeatedly and in larger numbers were either frequently consumed, or frequently deposited as unintended refuse from processes of production which were targeting other plants or plant parts.

Correspondence Analysis is a useful multivariate statistical technique which aims to represent the dependence between rows and columns of contingency tables. The more a row point is close to a column point, the greater is the "correspondence" between both (Alberti 2013). It can be used to look for "patterns in complex variable-by-sample data, including compositional data" (e.g. Bogaard 2004b, 92-94). It was only applied when 35 identified remains were available at a sample level; in addition, taxa which appeared in less than 10% of the samples were not considered (partly following van der Veen 2007). It was not used when the sum of the inertia (eigenvalue) of Axis 1 and 2 was below 40%, which is the threshold between a low and a moderate association between a row and a column (optimally it should be above 80%) (Alberti 2013).

The free software PAST (Hammer, Harper & Ryan 2001) was used to produce histograms and XY diagrams, while C2 (Juggins 2007), also a free software, was used to produce stratigraphic diagrams. CANOCO (version 4.51) was chosen for carrying out Correspondence Analysis (Ter Braak & Smilauer 2002).

3.2.10. Taphonomic analysis of charred seed and fruit assemblages

Understanding the processes of formation of the archaeobotanical record is essential for the economic characterization of Neolithic societies. Overlooking taphonomy not only could lead to misleading conclusions but it would also neglect an important source of information concerning plant management, consumption and refuse management. Taphonomy includes the study of all processes of formation affecting the archaeological record, from those activities which generated the assemblage, the process of deposition and all the subsequent postdepositional processes that have had an effect on archaeological material since that moment. Schiffer defined both the properties of the archaeological record (Schiffer 1983) as well as the formation processes that affect it (Schiffer 1987). I already presented elsewhere, based on Schiffer's statements, a number of variables to analyse from seed and fruit remains. Each variable refers to one or more than one of the properties and to the processes of formation (see Antolín 2010a, Antolín 2010b).

Taphonomic analyses must be carried out separately for charred material and for waterlogged material, since the origin of both assemblages is most probably different. It cannot be assumed that the charred and the waterlogged remains that are recovered in one sample can respond to the same action. Whatever the case may be, this can only be interpreted after evaluating each record separately. The taphonomic analysis of waterlogged material is presented in chapter 3.2.11 since a rather different approach to the one presented here (for dry mineral sites) was used.

It must be noted here that any taphonomic analysis should be carried out from an interdisciplinary perspective. Nevertheless, this was not possible within the frame of this project. It must also be highlighted that taphonomic analyses must be carried out from the more recent aspects (archaeological work) to the most ancient ones (post-depositional, depositional and pre-depositional processes).

3.2.10.1. Pre-depositional processes

Most of the literature on taphonomy of plant macrofossils (mainly cereal remains) from dry mineral sites deals with pre-depositional processes, that is, the agricultural processes that shaped the composition of the final assemblage. For such aspects I refer to the work of other researchers (Jones 1987, Jones 1990, Van der Veen 1992, Bogaard 2004b, Bogaard, Jones & Charles 2005, van der Veen 2007) and I will go back to the analysis of crop husbandry practices further on (chapter 3.2.12).

I have focused my analysis on the identification of crop processing strategies based not on the overall botanical composition of a sample (which was already successfully defined by several other people (Dennell 1976, Hillman 1981, Jones 1987), but on the grains themselves. For this, I did some research on the literature and performed some analysis of experimental samples (see Annex II). Material coming from the traditional threshing fair of La Fuliola (Lleida, Catalonia) was observed under the binocular and charred under controlled conditions for comparison (Antolín 2012). This fair was celebrated in 2008 and a large naked wheat harvest was processed. The material from la Fuliola allowed an approach to the effects of threshing (at a large scale), using a stone cylinder and a threshing sledge, both pulled by a horse, on a naked wheat crop. Besides, I also analysed material coming from an experimental dehusking of hulled barley carried out by M. Bofill in the framework of her PhD (see Annex II; M.Bofill, PhD in progress, Universitat Autònoma de Barcelona). Hulled barley grains were soaked in water for 30 minutes and then processed on a saddle quern, carrying out a rotary movement with a hand stone.

After this research, several potentially significant variables were identified: grain fragmentation (including cracking or cut marks), presence/absence of the embryo, grain germination, presence/absence of insect holes and charred grains with a shiny surface.

It was observed that the vast majority of the material was virtually intact in the case of the naked wheat crop from La Fuliola (that is, no damage on the surface of the grain, embryo present). But a low number of **grain fragments**, **cracked grain and** grains that presented some sort of **cutting or peeling** on their surface were recovered in the ethnographic material from La Fuliola (Fig. 3.32). Cracked grains and a larger number of fragments were also obtained in the experimental dehusking that was carried out by M. Bofill. A more detailed description is presented in Annex II (for recording these features on archaeobotanical materials see Fig. 3.27). Other references are available concerning grain fragmentation after dehusking. Meurers-Balke and Lüning carried out an experimental dehusking of several types of glume wheats (see Meurers-Balke & Lüning 1992) using a wooden mortar and a saddle quern. A higher fragmentation was produced with the saddle quern. Recent work also targeted the effects of dehusking on a variety of cereals (Alonso et al. 2013). Unfortunately, their results are not comparable, since the method used by M.Bofill was different from those practiced in these experiments and none of them undertook experimental threshing works. From this, one can conclude that small proportions of fragments produced prior to charring might respond to threshing activities (max. of 5%?). Larger proportions can be achieved by dehusking spikelets of glume wheats, up to 40%, depending on the technique. Therefore only when fragments are a major proportion of the assemblage or when they form aggregates, it is possible to say that they could respond to the production of some sort of bulgur-type product.

After the experimental dehusking of barley, around 8% of the grains had **lost** their **embryo**. It is interpreted that this was a direct result of the process. This percentage could be larger in other contexts, since 28% of the grains were not dehusked and more than 40% only partially dehusked. This observation was of extraordinary significance, since, before this experiment, I had no real explanation for the existence of charred grains that had lost their embryo (see Antolín 2008b, Antolín & Buxó 2011c). Of course, other factors must still be evaluated experimentally, for instance the effects of insect pests which can feed from embryos during long-term storage (Bewley & Black 1994).

A summary of the observed effects produced by threshing and dehusking is presented in Fig. 3.32 and 3.33.

CASE STUDY	Total number of grains of the main crop	Total number of fragments produced during the experiment	Total number of cracked grains	Total number of peeled/cut grains
Threshing – Naked wheat	8726	10 (0,01%)	17 (0,19%)	2 (0,02%)
Dehusking – Hulled barley	1293	47 (3,63%)		2 (0,15%)

Fig. 3. 32. Number and percentage of fragments, cracked grains and peeled/cut grains obtained in the experiments.

Further elements were considered significant after going through the archaeobotanical literature. The **presence of germinated embryos** was also recorded (see Fig. 3.27). This was not always easy to detect but, following M. Van der Veen, it was decided to count those grains in order to get the percentage of germinated grains. One should assume that malting was being practiced at the site when more than 75% of the assemblage consists of germinated grains (van der Veen 1989). Germinated grains might also inform on weather conditions before harvesting (sometimes small proportions of the crop start germinating before the harvest, especially when the weather is humid) or on the quality of storage (for some further discussion see, for instance, Matterne, Yvinec & Gemehl 1998). Usually, sprouted grains are not wanted for milling due to their higher sugar contents (Bewley & Black 1994).

It is not rarely the case in archaeobotanical assemblages that accidental fires of storages are encountered. In such cases, documenting the presence of **insect holes** within the assemblage can inform us of the quality of the storage conditions and the time that passed between its deposition and the accidental charring. This was only recorded on a presence/absence scale (Fig. 3.27).

Finally, observations performed by S.Valamoti were equally followed in order to detect grain soaking before charring, as a processing strategy (see (Valamoti 2002). This is only observable after charring. For this reason, the presence of grains with a **shiny surface** was recorded (see Fig. 3.27). Nevertheless, high charring conditions might produce similar effects (Valamoti 2002), for which this characteristic is only useful when a low heating treatment was applied on the assemblage.

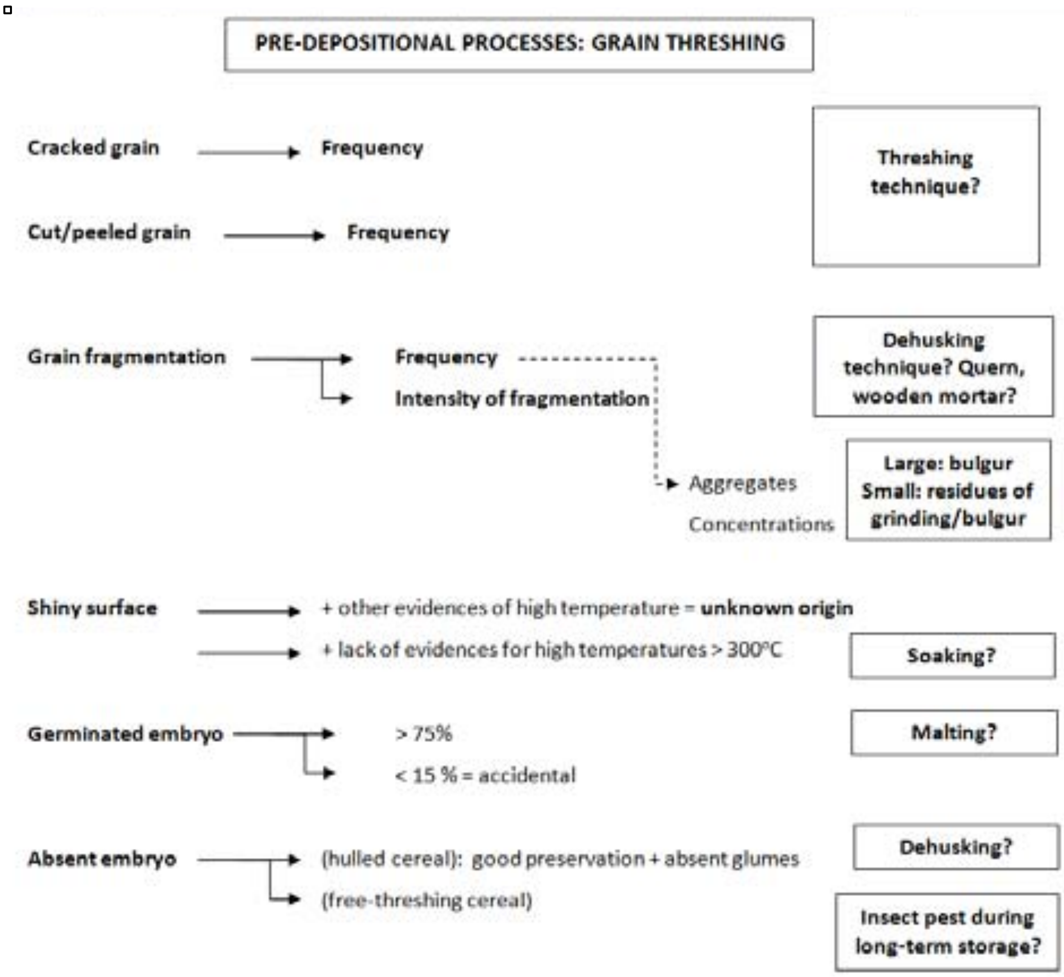


Fig. 3.33. Effects of threshing and dehusking detected on the grains and potential interpretation.

Fig. 3.33 summarizes the relationships that have been observed between the state of the properties of the seed and fruit remains and the processes that could have originated them. The appearance of cracked grains and cut/peeled grains could potentially identify certain types of threshing techniques, but this remains to be experimentally and ethnographically tested (Alonso *et al.,* forthcoming). On the other hand, grain fragments can originate during threshing, dehusking or culinary processing. The frequency and intensity of this fragmentation might allow the distinction between dehusking techniques or the intentional production of bulgur-type products. As already commented, the absence of the embryo could indicate that the grain has been dehusked, but since other factors might produce the same effect, more variables should be taken into consideration. This might be especially true for hulled cereals. In order to discard a depositional or postdepositional origin for the absence of the embryo, one should see no evidences of surface degradation and low fragmentation. In addition, a dominant proportion of sprouted grains is considered to indicate the practice of some sort of malting process. Finally, the shiny surface of charred cereal grains is only a significant indicator of grain soaking when we know that the heating temperatures were low, since high temperatures also produce a shiny surface (Valamoti 2002).

3.2.10.2. Depositional processes

Depositional processes of plant macroremains can be rather complex. Only charred material is usually recovered from dry mineral sites, for which **charring** becomes the only factor for the preservation or destruction of this material. The effects of charring on seeds and fruits have been approached in a relatively large number of publications. Most of them aimed to establish the necessary charring conditions for one seed or fruit to get carbonized and keep a recognizable form, as well as under which conditions some fruit or plant parts (for instance, chaff remains) turn into ashes (Wilson 1984, Boardman & Jones 1990, Gustafsson 2000, Jacomet et al. 2002, Jacomet 2003, Wright 2003, Wright 2005, Märkle & Rosch 2008, Sievers & Wadley 2008). Thus, understanding the heating treatment that generated past assemblages was not always the aim of these experiments.

The work of F. Braadbaart set a milestone on this issue (see, for instance, (Braadbaart et al. 2004, Braadbaart 2004, Braadbaart 2008). It was mainly devoted to the testing of reflectance and digital image analysis as methods to get a reliable approach to the temperature and heating rates that were experimentally applied to single grains using a muffle furnace. The precise descriptions of the morphological changes of the grains that were observed by Braadbaart can easily be recorded during everyday archaeobotanical work. If one could demonstrate that the proportions in which those traits appear correlate with a particular heating treatment, such work could be carried out by any archaeobotanist (thus, avoiding the expensive reflectance analyses). With this idea in mind, I decided to carry out some experiments. I must here advance that I could not reach the ideal target during this work. The parameters that I will propose to guess the heating treatment that took place in the past are based on an extremely low number of experiments and I will largely rely on the results of the experiments carried out by F. Braadbaart. Despite this, it is still worth considering the results of my experiments because, to my knowledge, these are among the very few that were carried out with relatively large assemblages of grain, which make them more directly comparable to our archaeobotanical samples.

Six different sets of grain were put under the same heating treatment: the grains were put between two layers of sand (to create a relatively anoxic environment) in two aluminium trays and they were heated at 150ºC for 20 minutes, then at 180ºC for 60 minutes, at 200ºC for 40 minutes and finally at 250ºC for 45 minutes (which could be described as a low heating rate in Braadbaart's terms). These sets consisted of a mixture of naked wheat (*Triticum aestivum* s.l.) grain (and some chaff), a small number of barley grains (contaminants in the wheat fields), and lentil seeds. The total amount of items ranged from 875 to 5111 and the proportion of lentils within the total went from 21,09 up to 45,95%. Consequently, naked wheat was always the principal component of the assemblages. The overall results obtained can be observed in Fig. 3.35 and 3.36 (for more detailed results see Annex II).

The obtained results are, to some extent, diverse (Fig. 3.35). After the heating treatment, the **proportion of charred naked wheat** went from 66% to 100%, similar for lentils. The proportion of charred material seems to depend on more variables besides time and temperature. These would include the total size of the assemblage and the composition of the assemblage. The first one could be considered rather obvious, while the second one was not so much foreseen. On the one hand, the two smallest assemblages showed the lowest proportions of charred grain, which was rather surprising. On the other hand, these are the two samples with a higher percentage of lentils. It is possible, then, that the presence of lentils affects the heating treatment of the assemblage and makes it more difficult for the cereal grains to become charred. It is interesting, though, to see that there is always some proportion of uncharred material, which brings us back to the classic statement by Wilson: "(…) *Any single heating episode in antiquity is thus likely to have left some seeds uncarbonized, whilst carbonizing others, while others again will have been burned to destruction*" (Wilson 1984).

Despite these observed variations, though, the **morphological modifications** of the grains produced by the heating treatment were rather homogeneous. Between 13 and 17% of the cereal grains were popped, while between 2 and 7% had produced protrusions (see Fig. 3.36). The proportion of grain aggregates was also low, less than 7%. I could not find an official terminology to describe the effects observed in lentils. Consequently, I had to create two new concepts (Antolín 2012): seeds with a cracked testa and seeds with opening cotyledons (the edges of the cotyledons seem to fold outwards or open as a result of charring) (Fig. 3.38). These evidences were rare under the present heating treatment and one should expect more cases at higher temperatures.

NUMBER OF REMAINS	% naked wheat grains	% lentil seeds	% charred naked wheat grains	% uncharred naked wheat grains	% charred naked wheat chaff	% uncharred naked wheat chaff	% charred lentil seeds	% uncharred lentil seeds
5111	78,91	21,09	88	12	88	12	69	31
2190	65,89	34,11	99,5	0,5	81	19	85	15
1998	64,77	35,23	99	1	83	17	99	1
1507	73,46	26,54	100	0	100	0	100	0
914	54,05	45,95	66	34	0	0	72	28
875	62,17	37,83	72	28	0	0	85	15

Fig. 3.35. Proportion of charred and uncharred grain and chaff from the 6 experimental assemblages exposed to the same heating treatment.

Based on these results and those published by F. Braadbaart, it was decided to put forward a preliminary table of equivalences (see Fig. 3.37). At the moment, it seems possible to distinguish several stages. At 250ºC one should get low percentages of popped grains and grains with protrusions. Between 300 and 350ºC, the first grains with concave flanks appear in low proportions at a low heating rate and they become more frequent at a high heating rate. Above 350ºC the preservation of some seed and fruit remains can become problematic. Determining the heating treatment above this temperature seems only possible through the use of reflectance analysis. This method could actually be complementary to the use of grain morphology modification, since it seems that better results are obtained at above 370º C (Braadbaart 2008).

NUMBER OF REMAINS	Popped	Protrusions	Grain aggregates	Cracked testa	Open cotyledons
5111	13,49	1,78	5,7	0,01	0,01
2190	13,97	2,63	0,86	0,48	
1998	17,07	5,76	6,45	0,29	
1507	13,64	6,4	3,8	1,5	1,25
914	16,42	3,18	3,79	0,27	
875	16,72	6,99	0,45	0,3	

Fig. 3.36. Effects on grain general morphology or surface originated by the experimental heating treatment.

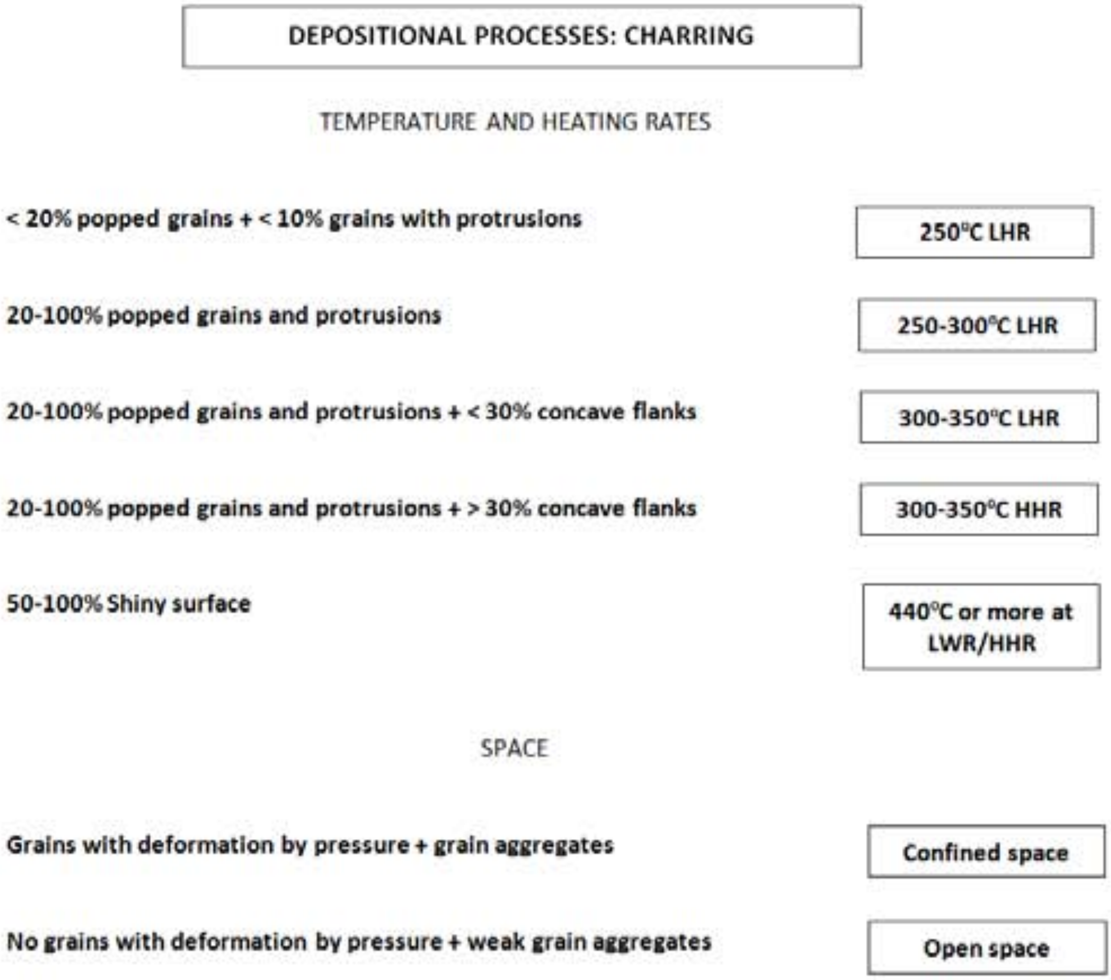


Fig. 3.37. Summary of the criteria that have been followed to make a guess on charring conditions (LHR: low heating rate; HHR: high heating rate).

Furthermore, some additional insight into heating treatment was intended by trying to determine the **space** where the assemblage was located when the heating treatment was applied. When grain assemblages are located within a confined space (e.g. a pot), they usually adopt abnormal shapes (see Antolín & Buxó 2011c). At the same time, these charring conditions can also end up generating large lumps of aggregated grains. Grain aggregates are also produced when grains are charred in a more open space but these aggregates are weaker because they are produced by the explosion of the endosperm of the grain, which sticks to the nearby material before solidifying when contacting with air (see Fig. 3.38). Nevertheless, these aggregates are weaker and they would probably not survive in an archaeological context.

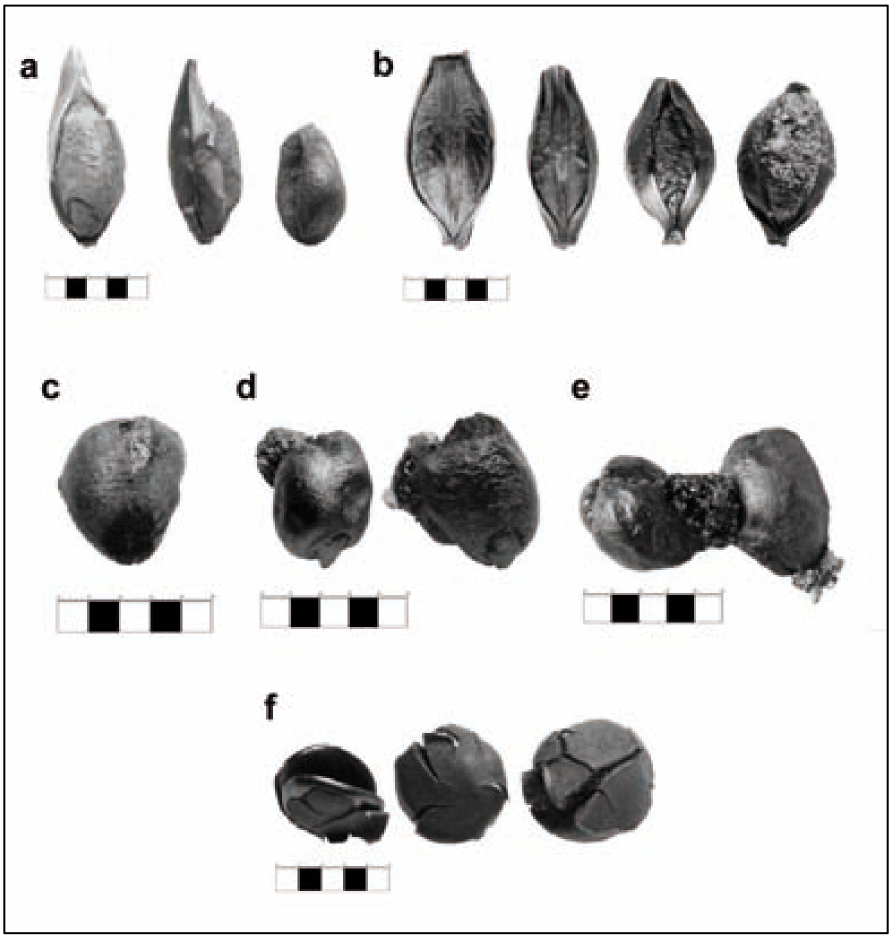


Fig. 3.38. Pictures of the different effects produced by charring of naked wheat and lentil grains: a. *Naked wheat grains with different degrees of charring;* b. *Barley grains with different degrees of charring and distorsion;* c. *Popped grain of naked wheat;* d. *Naked wheat grains with protrusion*; e. *Aggregates of naked wheat grain; f. Lentil seeds showing a cracked surface and open cotyledons after charring.*

3.2.10.3. Post-depositional processes

Post-depositional processes are very diverse and their identification has rarely been targeted from an archaeobotanical point of view, at least concerning dry mineral sites. Most of the discussion has focused on the identification of deposits which result from single events (a pre-depositional process, in fact). This has been targeted from the botanical composition of the samples (e.g. Bogaard 2004b) or their stratigraphic position (e.g. (Kreuz 1990b). Some attention has also been put into the identification of **primary and secondary refuse deposits** (in terms of Schiffer 1972, Schiffer 1987). Primary refuse deposits were defined by Schiffer (*op.cit.*) as those which accumulate in the place where the refuse was generated. Secondary refuse deposits would designate all other possibilities, including those resulting from cleaning and discarding of refuse. Some authors, in fact, consider that secondary refuse deposits are of little relevance for archaeobotanical interpretations (see Hubbard & Clapham 1992), although the many archaeobotanical studies which are based on such contexts and resulted in major contributions to the history of human and plant interaction indicate otherwise.

Many taphonomic agents (or formation processes) can act on *in situ* primary or secondary refuse deposits. The identification of these processes is equally necessary in order to understand their representativity. The optimal way of targeting this issue would be through the study of the archaeobotanical remains themselves, in a comparable way as faunal remains are analysed (e.g. (Lyman 1994).

In the following lines a proposal for approaching several of these processes is presented. My own experimental data are still very preliminary, so they will only be considered for very particular issues. As a consequence, this methodology remains at a rather theoretical level for the moment. A lot of experimentation is required for its improvement. I use the classification of "charred *in situ*" and "charred *ex situ*" because one should keep in mind that the taphonomy of archaeobotanical assemblages is not comparable to that of potsherds or lithic debris. Charring must have taken place at some point, and charring did not necessarily take place where the refuse was originated. For instance, the crop processing residues of fine sieving could have been swept and thrown into a fire. That would be a secondary refuse deposit but if we happened to find those remains inside the hearth remains some millennia after, one could still say that they had been charred *in situ*. This is relevant for the archaeobotanical interpretations.

The variables that have been considered relevant for the study of postdepositional processes are shown in Fig. 3.39 and they have been described elsewhere (Antolín & Buxó 2011b, Antolín & Buxó 2011c). I will only name them here in order to proceed to explain how they have been evaluated: represented part (namely, complete grain or fragment), type of fragment, degree of fragmentation, state of preservation of the surface, presence/absence of the embryo, presence/absence of mineral concretions, presence/absence of fragile parts/items, presence/absence of insect holes. The density of remains is yet another factor that is considered by some authors as indicative of the *in situ*-ness of an assemblage (e.g. van der Veen & Jones 2006).

In order to evaluate the postdepositional history of the assemblage, first, the observation of relative proportion between **complete grains and grain fragments** already produces an overall impression of its state of preservation.

Then, I evaluated whether that **fragmentation** had originated **before or after charring** (in charred assemblages). As commented earlier on, cereal fragmentation before charring must respond to some sort of processing: threshing, dehusking or milling. Many formation processes can produce fragmentation after charring. In order to assess the agency of this type of fragmentation, I compared the proportion of **regular and irregular** (uneven) **fragments**. Regular fragments have a sharp straight section that can nearly only be produced during excavation (and recovery). Irregular fragments can be produced by a variety of agents. It is important then to attempt to locate those agents. I solved that issue by comparing the proportions among **complementary fragments** (that is apical vs. embryonal fragments, dorsal vs. frontal). If the fragmentation occurred *in situ*, one should expect a good correlation between both types of fragments. If a bad correlation is observed, then one could assume that the fragmentation was not *in situ*. Other possibilities should not be dismissed. Half-charred grains, after millennia, would certainly be confused with fragments of grain. In that case, this comparison between complementary fragments would become misleading. Some experimental work should be carried out to evaluate to what extent this could be relevant. It is likely that incompletely charred grains seldom make it through the pass of time (they are more fragile, prone to fungi attack, etc.).

One further factor may be informative concerning the intensity of the process that generated the fragmentation of the assemblage. That would be the **degree of fragmentation**. For this, I compared the relative proportions among the different sizes of fragments. In order to classify fragments within a size range, the fastest way is to always have a millimetered paper under the Petri dish. Size ranges are explained above (Fig. 3. 30).

Besides fragmentation, some postdepositional agents may have other consequences such as the erosion of the **surface of the grains**. For this reason, this has been described with an ordinal ranking value from intact (no evidences of erosion of the surface) to over-degraded (no surface preserved) (for further details see (Antolín & Buxó 2011c).

The possibility that **lacking embryos** may derive from erosion has also been considered. Consequently, it has been assumed that a combination of high surface erosion and lack of embryos might be the result of some postdepositional agents.

Presence of fragile items like glume fragments, awn fragments, hairs preserved on the apical part of the grain or on rachis fragments, etc., supports evidence of excellent preservation conditions and the *in situ*-ness of an assemblage.

There is also the potential to differentiate those materials that were naturally covered by sediment from those that were rapidly covered with soil. This is an important issue, since materials that remain exposed to weathering may suffer erosion and displacement. Experimental preliminary observations seem to indicate that mineral **concretions** (see Fig. II.8 in Annex II) form when soil is naturally deposited (Antolín 2012). Further research is needed on this topic, especially testing different types of sediment.

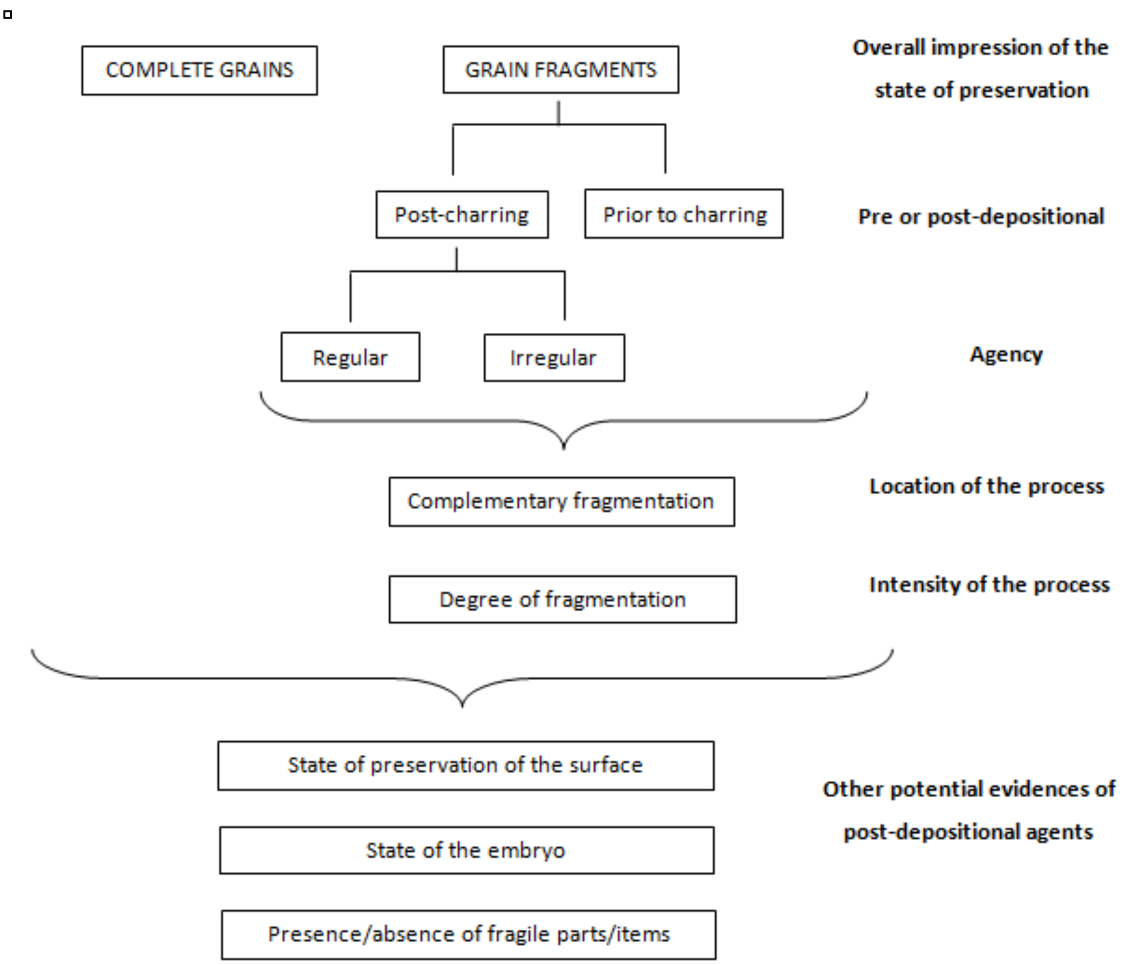


Fig. 3.39. Evaluated variables and potential taphonomic information that they can provide.

It was decided to record all these variables on a seed by seed basis in order to obtain a quantitative approach to taphonomy. Unfortunately, the state of research is not at the point of dealing with such precise data. For this reason, it was considered more adequate to develop some ranks from those quantitative data in order to proceed with the classification of the samples. Then, a more easy-to-handle classification into low, medium or high categories was possible. The proposed thresholds are arbitrary (Fig. 3.40).

A rather varied number of combinations can be obtained from all these variables and ranges. Some of these have been summarized and related to the postdepositional agent that *a priori* seemed most likely to be responsible for it (see Fig. 3.41 and 3.42).

Fragmentation	Low	main crop >70% complete seeds or total >70%
	Medium	main crop 50-70% or total 40-70%
	High	<50% of complete seeds
Complementarity	Good	50% to 50%, or 40% to 60%
	Medium	30% to 70%
	Low	20% to 80%, 0% to 100%
Erosion	High	<50% of intact +semi-intact
	Medium	50-75% of intact +semi-intact
	Low	>75% of intact +semi-intact
Adherence of the embryo	High	>75% of adhered embryo
	Medium	40-75% of adhered embryo
	Low	<40% of adhered embryo

Fig. 3. 40. Criteria for the classification of the quantitative taphonomic results into ranks.

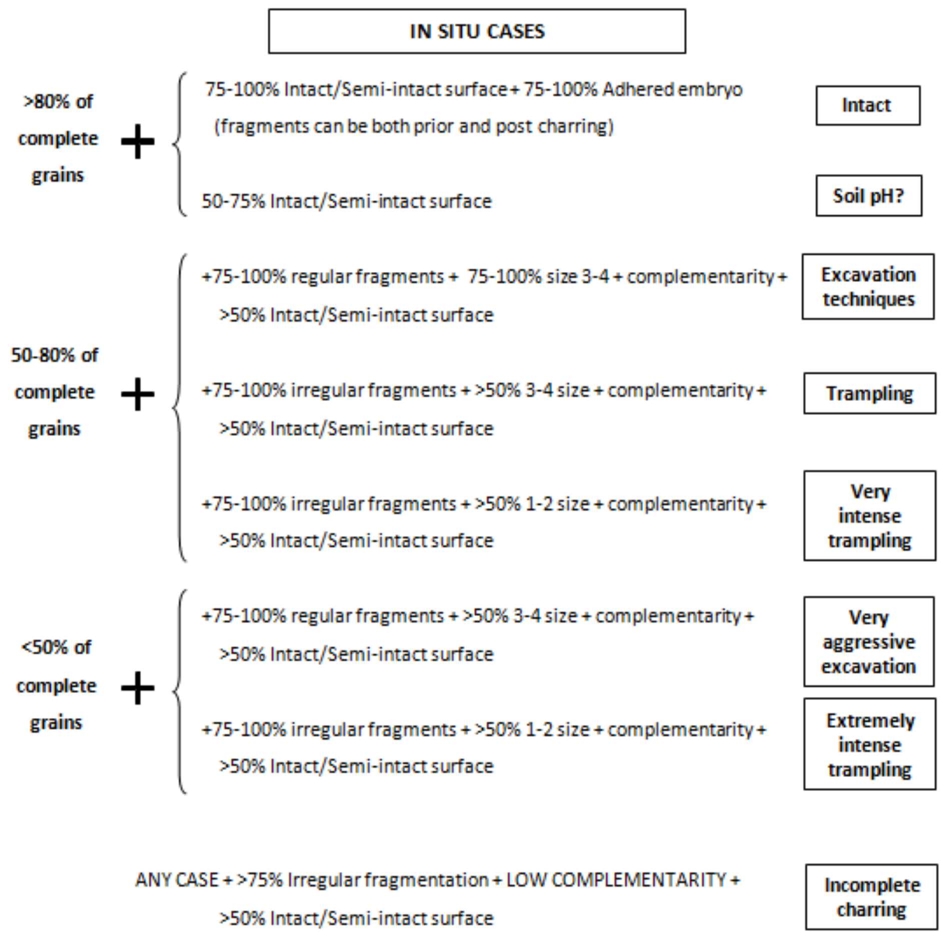


Fig. 3.41. Different combinations of the state of preservation of in situ *charred seeds and fruits and possible post-depositional taphonomic agents.*

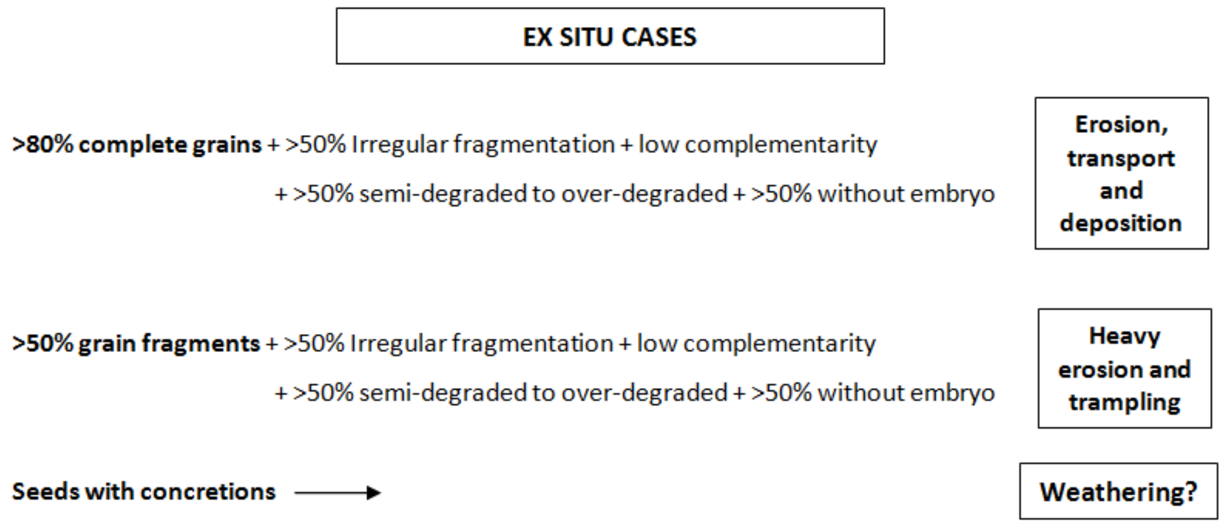


Fig. 3.42. Different combinations of the state of preservation of ex situ *charred seeds and fruits and possible post-depositional taphonomic agents.*

3.2.11. Taphonomic analysis of subfossil cultural layers: from the sample to the grain

The analysis of taphonomic processes is much more complex in wetland sites, since the amount of evidences is much larger. At least, there is the possibility to study a much wider variety of agents and processes. Kenward and Hall (Kenward & Hall 2004) already discussed the different origins of waterlogged samples. This often results in a differential preservation of the diverse materials. Decay occurs not only during the burial of the remains but also just after their deposition, when microorganisms, insects and animals may influence on the preservation of certain taxa or plant parts. The authors state that decay is minimal if waterlogged conditions are optimal and that one should do soil micromorphology analysis in order to prove the stability of soil conditions.

Palynologists have long been working on pollen grain preservation and its taphonomic significance (for a wider discussion on this topic see Birks & Birks 1980; Jones, Tinsley & Brunning 200)). It has been possible to detect corrosion, degradation, mechanical damage and authigenic mineral deposition.

Murphy and Wiltshire (1994) presented a proposal that consisted on a semi-quantified description of the most important taxa, which led to a final score that could be used to establish the quality of the preservation of each sample. Other approaches by specialists in plant macrofossils have included other types of materials in the analysis, such as the size and density of wood chips, bark, moss, bones, the inorganic component of the sediment, etc. (e.g. Jacomet 1985).

A seed-by-seed description was used by P. Vandorpe and S. Jacomet to compare the state of preservation of a number of samples after applying different pre-treatment techniques (Vandorpe & Jacomet 2007). The degree of fragmentation and the state of the preservation of the surface of the plant macroremains were evaluated.

For the work in the site of La Draga it was considered necessary to develop an accurate method that could combine the seed-by-seed description with a general evaluation of the composition of the sample.

3.2.11.1. Taphonomic analysis at a sample level

A list of materials to be recovered and described was designed. Some of these were fully quantified while others were semi-quantified. The fully quantified materials were bone remains (including mammal, amphibian, reptile, bird and fish bones), identifiable malacological and entomological remains, flint and pottery fragments, dung remains and parenchymatic tissue or amorphous objects. The rest of the materials (wood chips, roots, moss fragments, leaf fragments, etc.) were only semi-quantitatively described (see Fig. 3.43). For such purpose we used a reference model that was designed for soil analysis (Bullock et al. 1990). We used numbers to describe density and letters for size. Thus, if one says that wood chips are 1B it means that there are few remains but that these are considerably big. This semi-quantification is only indicative (an approximate proportion) and it does not mean absolute values. One should consider this description in relation to the total volume of the fraction.

The materials were grouped according to their origin: aquatic organisms/materials, lakeshore organisms/materials, and materials from outside the lakeshore area. It is considered *a priori,* that most of the materials from aquatic or lakeshore environments were naturally deposited in the layer. Fish remains were included in the group of materials from outside the lakeshore area because they are usually found in cultural layers by anthropic influence (Hüster-Plogmann 2004). In general, the classificaction is based on the abundant work that has been carried out in this sense in sites from the circumalpine region (e.g. Jacomet 1985, Maier 2001).

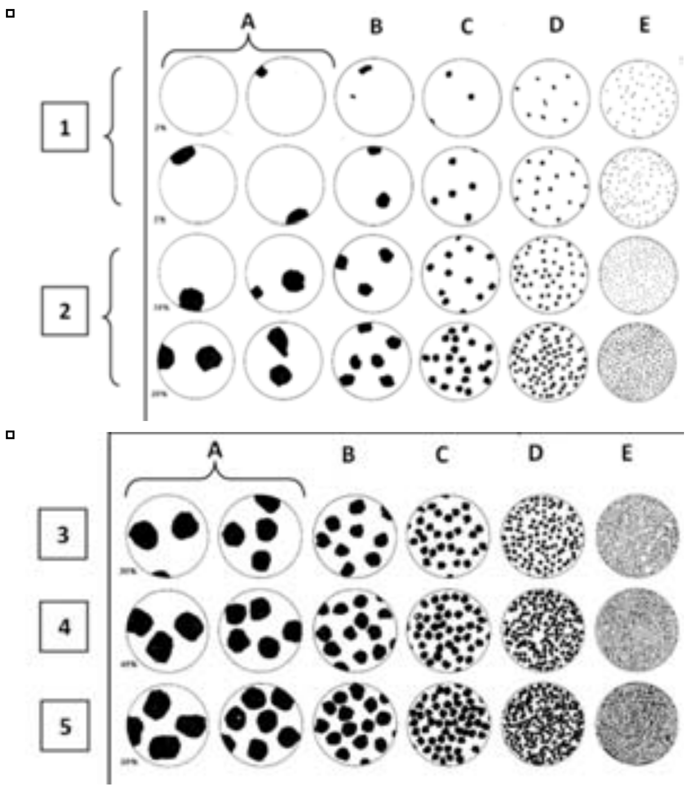


Fig. 3.43. Reference model used for the semi-quantitative description of the composition of the samples (image adapted from Bullock et al. 1990).

The semi-quantitative description of materials from woodland areas was turned into scores for further analyses. As previously described, the semi-quantitative description used a combination of numbers (1 to 5) and letters (A to E). Numbers from 1 to 5 have been given scores from 10 to 50 respectively. Letters A and

B added 5 to the total score (thus, 3A is 35 and 4B is 45 but 3C would still be 30 and 4D would remain as 40). This way, the representation of bigger materials would be slightly enhanced, making it more realistic. Big items are usually underrepresented in these small samples. In any case these results should not be interpreted as concentration values. They mean approximate relative proportions.

In those cases where a full quantification was undertaken (also including seeds and fruits), the concentration of remains per litre of soil was calculated. First the results of the 0,35 mm fraction subsample were multiplied to obtain the results for the whole fraction. Then the total of the sample was calculated. Finally the total numbers of the sample were used to calculate the concentration or density of remains per litre.

Group	Quantification method	Type of materials
Materials from outside the lakeshore area or most probably of anthropogenic origin	Quantified	Bone, dung, fish bone, fish scale, flint, pottery, straw, amorphous object
	Semi-quantified	Wood chips, charcoal, bark, twigs, buds, bud scales, leaf fragments, leaf scales, sclerotia, moss, travertine
Lakeshore organisms/material	Semi-quantified	stones with rounded edges, roots, sand
Aquatic organisms/material	Quantified	Malacofauna, *Cristatella* sp.[3], Trichoptera[4]
Other/several	Quantified	Other insect remains

Fig. 3.44. Groups in which the non-carpological components of the samples have been organized.

3.2.11.2. Taphonomic analysis of subfossil seed and fruit remains

For the description of the subfossil seed and fruit remains I considered a relatively low number of variables: represented part (complete seed, pericarp fragment, etc.), type of preservation, degree of fragmentation, state of preservation of the surface and presence of roots going through the material. The taphonomic interpretation of these data becomes more difficult in waterlogged contexts since the remains could have originated from a larger number of sources. It is for this reason that the interpretation at a sample level is considered as preferential in order to interpret its origin.

3.2.11.3. A step-by-step guide to a combined taphonomic analysis of subfossil cultural layers

In the following lines I will try to summarize the main steps that have been followed in order to characterize the taphonomic history of the analysed samples. These are based on previous work carried out in the circumalpine region (Jacomet 1981, Maier 2001, Favre 2002, Jacomet, Leutzinger & Schibler 2004, Jacomet & Brombacher 2005, Maier & Harwath 2011, Maier 2011). First of all, it must be stated that our efforts were concentrated on the postdepositional processes rather than the pre-depositional or depositional processes. That is partly derived from the characteristics of the samples from La Draga, which contain a lot

[3] Genus of bryozoan that lives in aquatic statoblastic colonies. It is probably the taxon *Cristatella mucedo* but their study is in progress (J.-B. Huchet, CNRS).

[4] This large order of insects has aquatic larvae which make protective cases of silk and gravel, sand or other debris.

of charred material. Thus, there was an important concern to establish the *in situ*-ness of the material and the possibility of detecting some spatial patterns in the record.

The first evaluation concerned a spatial representation of the samples showing the relative proportion between **charred and waterlogged seeds and fruits** and the overall density of remains. This general picture allowed a first look at the homogeneity of the layer, the identification of areas of concentration of charred and waterlogged material and its richness in remains.

Then a comparison with the distribution of other **potential residues of human consumption** (terrestrial animal bones and fish remains) was performed. The samples with larger accumulations of these materials could indicate the existence of rubbish heaps or areas where most of the residues of consumption were discarded.

Next, the relative proportions between all those **materials from outside the lakeshore** (charcoal, wood, twigs, buds, etc.) were evaluated at a spatial level in order to compare whether the concentration of charcoal matched that of charred grain (as a supporting evidence for the *in situ* burning of storages) or not, and whether the distribution of the different elements was homogeneous across the surface.

Subsequently, the density of **organisms of aquatic origin** were equally mapped and the areas where more water influence could have taken place were considered in relation to previous observations (e.g. are concentrations of charred material more or less free of aquatic influence?).

When possible, these results were confronted with the results of soil micromorphology, archaeozoological and wood analyses.

Once a general view of the samples was available, the particular observations on fragmentation and state of preservation of the surface of the fruits were evaluated. Unfortunately, the low number of subfossil seed and fruit remains did not allow representative evaluations.

3.2.12. Approaching plant food economy in the past

The study of Prehistoric plant food economy can be approached from different perspectives and materialities. Traditional archaeobotany (along with other techniques such as stable isotope studies) can help to clarify different aspects of crop husbandry and wild plant management, as well as to identify the different products or by-products originated in most of the phases that have been described in chapters 2.2.1. and 2.2.2. In this way, it can make a significant contribution to key social and economic aspects of past societies. In the next chapters, the methods for approaching plant food economy are presented and the criteria that have been used in this work to proceed with the analysis are specified.

3.2.12.1. Criteria for the classification of the samples according to their potential for the conduction of palaeoeconomic analyses

As previously stated, it is aimed to perform several analyses on the studied material at different scales: at a context level, at a site level, as well as at a regional and chronological level. Not all samples could be used for all levels of analysis. The method for a taphonomic analysis that was presented above allowed the classification of samples into a sort of “scale of potentiality” of the obtained data concerning crop husbandry practices and wild plant management. Only the samples with better chances for being *in situ* and with an appropriate charring history for the preservation of all plant parts were considered for a full analysis. Those samples which seemed not to be *in situ* or inadequately preserved were used for approaching certain aspects of food producing activities.

Thus, samples were classified according to the following criteria in order to perform analyses at different levels:

-assemblages that were probably not *in situ* primary or secondary deposits (that is to say, affected by more formation processes after their deposition) and with less than 30 crop items: used for presence/absence analysis and calculating the index of relative abundance. That is, they were included (along with all the samples listed below) for the evaluation of the significance of each taxon at a site, region or period level.

-assemblages that were probably not *in situ* but still contained more than 30 crop items or *in situ* samples of mixed nature (not pure crops, *sensu* Bogaard 2004b, 64): the stage of processing to which they could correspond was verified (following Jones 1990) in case of the free-threshing cereals) and they were included in the general analysis of the data using correspondence analysis (CA). That is, they were used (along with all the samples listed below) for general evaluations of significant distributions and associations of the samples but also for a thorough palaeoeconomic analysis of the plant economy at a site level.

-samples of pure crops that were likely to be *in situ*, showed good preservation quality and appropriate heating treatment: the stage of processing to which they corresponded was identified; the weed composition was analysed considering basic functional traits (for instance, life-form, flowering period and type of reproduction). They were used to characterize, as far as possible, plant husbandry at the site working at a context level.

-samples like the above but with more than 10 weed items would have been used (if a good number would have been achieved) to apply FIBS (see, for instance, (Bogaard et al. 2001, Bogaard et al. 1999, Charles et al. 2002, Jones et al. 2005, Jones et al. 2010). That would have allowed a reliable approach to crop husbandry at a site level. Unfortunately, this was not the case in our study.

At the last stage of the evaluation of the data, all available archaeobotanical studies from the studied region were included in the general analyses (Chapter 5) in order to detect general trends per type of context, type of site, region, chronology, etc. For this, some standardization of the data was necessary. For instance, all identifications of naked wheat (*Triticum aestivum, T. aestivum/durum, T. aestivum/durum/turgidum, T. compactum, T. aestivo-compactum*) were treated as *Triticum aestivum/durum/turgidum*. Spare finds (like single acorns collected by hand) or taxa that were not quantified were not included in the analyses. In one case, in Margineda Shelter, only the volume hazelnut shell fragments was published and not the number of fragments. Therefore, it was converted to an approximate MNI considering experimental data referring to the volume of fragmented hazelnut shells (Berihuete, Antolín in press). Finally, it must be mentioned that data from Font del Ros was included in the analysis despite archaeobotanical data had not been published at a context level, but only as an overall evaluation (Pallarès, Bordas & Mora 1997). I got the permission from P. González to use the data at a context level. The analysis was performed by the late V. López (unpublished).

3.2.12.2. The analysis of crop husbandry, crop processing strategies, storage and consumption

In chapter 2.2.1., a series of stages or subphases of the agricultural process were used in order to approach, at a theoretical level, intensive crop husbandry methods during the Neolithic. These stages were established mostly following well-known ethnographic records by G. Hillman (1981; 1984a, 1984b, 1985). In this chapter, a review of the existing methods to approach each stage is presented (Fig. 3.45). This is not aimed as a thorough compilation, just as a synthesis of the regular analyses that could be taken at any site, meaning one with no extraordinary findings such as ard marks or threshing floors. Besides, it was not the aim of this work to have a very interdisciplinary approach to crop husbandry (it would not have been possible). Instead, it was preferred to have an archaeobotanically based approach with as many hints from other archaeological evidences as possible. I will not go into further detail describing each stage and the different available methods for its scientific investigation (for this, see, for instance Pearsall 1989, Wilkinson & Stevens 2008, Antolín 2010a). In the next lines I will focus on the methods that have been used in this work.

	Plant remains (macros: X; micros: x)	**Weed**	**Other environmental proxies**	**Isotopes**	**Geoarchaeology**	**Archaeozoology**	**Archaeology**
Location of the fields		X	X	X	X		X
Permanence		X	X				X
Intensity		X				X	X
Sowing method		X					X
Sowing time		X					
Crop	X						
Maslin/Monocrop	X						
Crop rotation	X?	X					
Weeding		X?					X
Manuring		X		X	X?		
Irrigation	x	X		X			
Harvesting	X	X				X	X
Threshing	Xx	X	X			X	X
Dehusking	X						X
Winnowing		X					X
Coarse-sieving		X					X
Fine-sieving		X					X
Grain washing	X						
Storage	Xx					X (insects)	X
Grinding	Xx						X
Bulgur	X						X
Brewing	Xx						X
Baking	Xx						X?
Friké	X?						

Fig. 3.45. Summary table of the list of stages or products of the agricultural process of production and scientific fields from where they can be targeted. Only those mentioned in the text are shown.

The first concern one could have in relation to crop husbandry practices during the first stages of the Neolithic is: Are we dealing with farming populations or with hunter-gatherer communities who suddenly started receiving products from farming communities? This question was answered from an interdisciplinary approach to the subsistence strategies of these sites (significance of game in the diet, number of hunting tools, etc.).

In later periods of the Neolithic, it was proposed that some sites might be producing enough surplus to feed other communities (see chapter 2.4.2.5.). It would be a comparable situation to that of the **producer-consumer sites** from the British Iron Age (Jones 1985, Van der Veen 1992, Stevens 2003, van der Veen & Jones 2006). This issue was also targeted from an interdisciplinary perspective. The presence of cereal pollen was used to confirm a local cultivation or local threshing of the crop, the presence of sickle blades to support the hypothesis that the same group harvested the crop. The weed spectrum was used, in some occasions, to confirm the local origin of the consumed grain.

Once one can assume (if possible) that the crop production was local, questions shift towards **where** those **fields** were **located**. The best indicators are the weed assemblages that accompany crop processing residues. Through the study of functional traits of the weed spectrum recovered, the possibility that the fields were located in recently burnt woods (e.g. shifting agriculture) or flood plains (Bogaard 2004b, Bogaard 2002) was evaluated. The intensity of the management of the fields was used as an indirect evidence of their proximity to the site (intensively managed fields thought to be closer to the site, in most cases) (Jones 2005). The type of settlement is equally helpful in that sense. A nucleated settlement requires having more arable land at a larger distance, while disperse settlements can have the plots very close to the huts (Jones, *op. cit.*).

The **permanence of soil cultivation** and soil disturbance was approached through the evaluation of some weed functional attributes, namely life-form (Bogaard et al. 1998, Bogaard 2002) as well as their ecological classification (both Ellenberg et al. 1992 and de Bolòs et al. 2005 were used). The evaluation of the data was based on the criteria summarized by L. Bouby (Bouby 2010), Tab. 8, p. 122), which are, in turn, based on work carried out by A. Bogaard, M. Charles and G. Jones, amongst others.

The **intensity of soil disturbance** was equally approached through the evaluation of weed functional traits, such as their ability to reproduce vegetatively and the flowering period (Bogaard 2004b, Charles et al. 2002). The qualitative evaluation of the data was based once more on the criteria summarized by L. Bouby (*op. cit.*). The identification of wooden tools used for such purposes can be very informative, as well as pathological analyses of cattle bones that can demonstrate the use of animals for traction. Pathologies in cattle bones, however, do not necessarily originate from ploughing activities.

Archaeobotanical identification of the **sowing method** is not straightforward. On the one hand, some authors report that certain weeds (e.g. *Agrostemma githago, Adonis annua, Centaurea cyanus, Lolium temulentum* or *Bromus* sp.) mainly grow when broadcasting is practiced (Wilkinson & Stevens 2008), 190). On the other hand this weed diversity could not only depend on the sowing technique but also on the intensity of the husbandry practices. Two archaeological evidences might help on this issue in sites with waterlogged preservation (in our case, only La Draga): the sowing and the harvesting tools. Both are potential indicators of the distance between the plants to be sown or harvested. Experimental data seem to indicate that certain types of sickle hafts (like curved sickles) were more appropriate for densely-sown fields while others (e.g. sickles with an appendix) would be more adequate for more sparsely sown plots (Pétrequin et al. 2006).

The identification of the season of cultivation or **sowing time** was based on a combination of functional attributes (life-form, flowering period and germination period) of the weeds that were recovered with crop processing residues or crop storages (Bogaard et al. 2001, Bogaard 2004b).

Defining the main **crops** at a site level was not always possible. The quality of the data depends on the sampled contexts, the crop processing stages that are represented, the number of domestic units that are analysed, etc. Usually, only the best-represented taxa could be established. For this, relative frequencies among cultivated taxa were calculated (considering grain and chaff and comparing the results), the ubiquity of each taxon was considered and both data were finally compared using the index of relative abundance. Finally, particular consideration was given to the largest concentrations of remains. We tended to assume, at least for the cereal crops, that the best-represented ones were likely to be the most economically important ones, especially if the same pattern was observed in several sites. This assumption can only be done after a thorough evaluation of the taphonomic origin of the studied assemblages.

The identification of **maslin cultivation** in the archaeobotanical record is not easy (van der Veen 1995, Jones & Halstead 1995) and it mainly requires the availability of a good number of representative samples, a proper taphonomic evaluation of the origin of these samples and the detailed sampling of grain storages, avoiding postdepositional mixture of originally separated storages. Other indirect approaches to the identification of **monocropping** have been performed by finding evidences of separate processing of different crops found in a mixed state, that is through the observation of grain fragmentation produced during processing (Antolín & Buxó 2011c).

Crop rotation is not always easy to interpret from archaeobotanical studies. Ethnographic work shows that legume contaminants in burnt grain storages should not be considered as evidences of crop rotation (Jones & Halstead 1995), but there have been approaches to cereal crop rotation taking into consideration storages belonging to the same burning event (see e.g. Jacomet, Brombacher & Dick 1989,166-168). Some authors have highlighted the fact that the lack of ethnobotanical studies from multiple cropping systems makes it unlikely for archaeobotanists to identify them properly (Butler 1999b). Weed functional ecology proves itself to be useful to solve this problem (Bogaard et al. 1999) but it was not possible to apply it to our samples, for which this question was not possible to approach in a satisfactory way.

Some practices like **weeding** and **irrigation** have not been directly targeted in our studies. Weeding practices are hardly possible to identify from archaeobotanical data, though some inferences can be done from sowing methods and the intensity of the crop husbandry regime (see chapter 2.2.1.). Irrigation has been approached from weed functional ecology, stable isotopes and phytolith analyses (Jones et al. 1995, Charles & Hoppé 2003, Ferrio et al. 2005, Madella et al. 2009) and all techniques prove to be of high interest. Nevertheless, no such analyses were carried out on our materials.

The practice of **manuring** was not evaluated from direct evidences in this work, since the data did not allow a proper insight into this important issue. Until recently, only weed ecological analysis had been used to approach soil productivity (Bogaard et al. 1998) but isotope analysis seems to be a promising technique to obtain more precise information on the manuring of fields in the past (Bogaard 2012, Kanstrup et al. 2011, Fraser et al. 2011, Bogaard et al. 2007). In the meantime, only theoretical inferences can be made considering the type of crops, and the type of animal and crop husbandry practiced (see chapter 2).

The **harvesting technique** was approached from the weed assemblages accompanying cereal storages or crop processing by-products (following Jones 1990, Sigaut 1991, Maier 1996) as well as other crop processing residues (e.g. culm nodes). Available data on use-wear analyses of sickle blades, as well as from the sickle hafts from La Draga site, was also considered for the evaluation.

The **threshing and dehusking techniques** were analysed as described in chapter 3.2.10.1., considering some ethnographic data, as well as experimental data, along with some inferences from the type of crop husbandry and storage techniques practiced at the site.

The subsequent processing stages were not easy to identify. Taphonomic problems affecting the preservation of **winnowing** by-products (chaff and straw fragments) have already been discussed by many authors (e.g. Boardman and Jones 1990, Van der Veen, 1992: 82-83). For this reason it was not possible to specifically deal with this practice in the present study. Coarse and fine sieving might be detected by comparison to ethnographic data concerning weed grain size (Jones 1996) and the overall composition of the sample when dealing with crop processing by-products (Jones 1990).

The slight possibilities of identifying **grain washing** or soaking in archaeobotanical assemblages were evaluated by S. M. Valamoti (Valamoti 2002) and they were discussed above (chapter 3.2.10.1). No thorough evaluation of this practice was carried out in this work.

Storage practices were dealt both considering *in situ* charred grain storages and potential storage structures. No systematic evaluation of the latter was attempted (for this issue, see G. Prats, PhD in process, Universitat de Lleida). A similar approach was taken to **grinding** practices. In some sites, residue or use-wear analyses from quern stones were available and they were used to discuss the significance of these practices. In other sites, only the recovery of such tools was published. Potential residues or products of grinding or **bulgur** making are also dealt with at a qualitative level.

Evidences of **brewing** were considered when available. These consisted of phytolith and lipid residues on quern stones and potsherds. The possibility of identifying sprouted grain for malting was evaluated as described in chapter 3.2.10.1.

Potential **baked products** were recorded but not analysed. Recent investigations show that there is potential for the characterization of these products (Samuel 1996, Währen 1989, Valamoti et al. 2008, Valamoti 2009, Valamoti, Moniaki & Karathanou 2011, Valamoti 2011) but these techniques were not possible to apply to our material within the framework of this project.

The identification of other consumable products originated from cereals, like ***friké*** was difficult to carry out. Some possible ways of identifying this practice were presented by other authors (Hubbard & al Azm 1990).

The processing of legumes was not analysed in this work, due to the poor number of seeds that were retrieved. This field is rarely dealt with in archaeobotanical publications but recent experimental works demonstrate the potential for identifying some of the stages of processing of legume foodstuffs on the archaeobotanical record (Valamoti, Moniaki & Karathanou 2011). The processing and consumption of poppy is also poorly known. The finding of capsule fragments and the densities of poppy seeds will be used in this work to discuss on potential areas of processing (through smashing dry capsules).

3.2.12.3. Wild fruit management

In chapter 2.2.2., a number of possible strategies of wild fruit management were presented. The different aspects that can help describing such management strategies are specified in Fig. 3.46. In this work, though, I have concentrated on the evaluation of the economic significance of wild fruits and the potential evidences for roasting or their use for feeding animals.

	Plant remains (macros: X; micros: x)	Wood anatomy	Archaeology
Tending		X?	
Gathering technique	X	X	
Storage	X		
Grinding	x		X
Roasting	X		X
Foddering	X		

Fig. 3.46. Summary table of the list of stages or products of the management of wild fruit resources and scientific fields from where they can be targeted. Only those mentioned in the text are shown.

The edibility or medical properties of the taxa have been analysed by considering ethnobotanical and ethnographical works (mainly) from the Mediterranean region (Leporatti & Ivancheva 2003, Tardío, Pardo-de-Santayana & Morales 2006, Mears & Hillman 2007, Hadjichambis et al. 2008, Gausachs 2007, Gausachs 2008), as well as the Plants for a Future (from now on PFAF) database (www.pfaf.org), which classifies edibility and medicinal use of plants into rankings from 0 to 5. The obtained data are presented in Annex IV in a systematic way. Following the work of other authors (S. Colledge, oral com.), those taxa which were classified as category 3 or above were considered as edible or with medicinal value. All the compiled information for each identified useful taxon is presented in Annex IV. The use of ethnobotanical knowledge to classify archaeobotanical wild taxa as potentially gathered plants was recently criticized by K.-E. Behre. This author warns that the simple appearance of the seeds of some plants is not a direct evidence of the consumption of other plant parts (leaves, flowers, etc.) (Behre 2008). Nevertheless, ethnobotanical data is of major need for the interpretation of the archaeobotanical record, as demonstrated by other authors (Ertug 2000, Ertug 2009).

The evaluation of the economic significance of wild fruits is difficult to establish in most cases. The quantitative evaluation of wild plant management requires of samples with more than 35 items. This is not always the case in archaeobotanical assemblages. Nevertheless, in some occasions, relatively high numbers of items are found. Then one can either consider them as the result of accidental charring (when found in layers of occupation, or hearths), as discarded unedible fruits (also potentially recovered nearby hearths), as residues of roasting (when recovered in roasting pits) or residues of animal foddering, which get accidentally charred during episodes of cleaning of the accumulations of dung (when present in byre contexts). It is of extreme importance to take into consideration the archaeological context from where the items were recovered. Direct evidence of wild plant food consumption is found in the digestive tract of bog bodies or those preserved in ice, as well as in faecal material (see for instance (Dickson, Oeggl & Handley 2005, Harild, Robinson & Hudlebusch 2007, Oeggl 2009)). Other potential evidences are the food crusts inside pots (e.g. Martínez-Straumann 2004).

There is the potential to infer the total amount of fruits processed in roasting pits. Experimental data suggest that around 12-25% of the hazelnuts that are roasted in pits become charred and, consequently, end up being discarded (Mithen et al. 2001). Thus, assemblages of hazelnuts from such contexts might be representing 12-25% of the original quantity that was processed.

In order to compare the role of wild and cultivated plants, one can compare them on several levels: the number of items, the MNI, the ubiquity and the calories yielded by each taxon. In any case, the taphonomic history of these resources is so incomparable that any evaluation remains tentative. It is interesting, though, to compare how well represented is each group of plants within the site, as well as at higher levels of analysis (region, period, etc.). It is of particular significance to identify archaeological structures dedicated to their processing or their use as animal food, together with leaf/twig foddering. Animal foddering is better approached from the multidisciplinary analysis of dung remains, especially from waterlogged sites (Akeret, Jacomet 1997, Akeret & Rentzel 2001, Kühn et al. 2013).

4. Results and discussion per site

In this chapter, a detailed presentation of the results obtained at a site level is offered. The archaeological description of the sites can be found in chapter 3.1. The chronology and phases is repeated at the beginning of the presentation of each site in order to facilitate the reading. Particular aims, materials and methods are discussed for each case under study before dealing with the obtained results. Previous analyses from each site are presented as a separate chapter and only introduced in the general discussion of each site. Consequently, the tables presented in the chapter of results only represent the results obtained during this work. Then, a discussion on plant food production at the site is presented both considering archaeobotanical data and other archaeological data that might be relevant for our topic. Comparable cases from other archaeological sites were not commented within this chapter, unless they were totally necessary for the argumentation. This sort of data was left for the final discussion in chapter 5, also to avoid repetition. Finally, in order to facilitate the comprehension of the key aspects of each site, a summary and some final conclusions were added, thus closing the examination at this level of analysis. In general, the Latin names of plants will be used (vernacular names in English and Catalan can be checked in Annex I). The complete tables with the list of samples and the overall results per site can be found in Annex III.

4.1. Sardo Cave

4.1.1. Chronology and phases

The archaeological information concerning Sardo Cave can be found in chapter 3.1.1. A wide chronological sequence was uncovered. Several occupations took place in historical times (during the IIIrd, IXth, XVIth and the XVIIIth centuries AD). In addition, five Prehistoric phases of occupation were also identified: phase 5 (2900-2500 cal BC); phase 6 (3300-3100 cal BC); phase 7 (3900-3500 cal BC); phase 8 (4800-4400 cal BC); and phase 9 (5600-5400 cal BC) (Gassiot et al. 2012a, Gassiot et al. 2012b).

4.1.2. Aims of the study

The particularities of Sardo Cave as a site are several. On the one hand, it is the site (within this work) that is located at a highest altitude (1790 m a.s.l.). It featured several occupation phases during the Neolithic and archaeobotanical remains seemed to be very well preserved. Large pieces of charcoal were recovered during fieldwork, which indicated that it was possible that postdepositional processes had not damaged the (charred) archaeobotanical record in a harsh way. This excavation was included within a much larger project of systematic prospection of the National Park of Aigüestortes, in the Central Pyrenees (see, for instance, (Celma et al. 2008).

4.1.3. Materials and methods

A total number of 47 samples were taken (see. Fig. III.1). Of these, only 26 were reliably ascribed to one of the phases with which we are dealing in this work. One sample, A-9A2, belonged to the Early Neolithic phase but it was not in a context of clear anthropogenic origin and its interpretation remains problematic at the present state of research. Two samples (A-3B12 and AE-3A3) were dated to the Iron Age and, consequently, they were not incorporated into this analysis. Finally, one further sample (A-3B9) was dated to the Middle Ages, for which it was also not included in the analysis. Among the samples of unknown origin, it should be admitted that some samples were wrongly labelled during sieving works. These were equally not dealt with in any of the forthcoming analyses. None of these omitted samples contained significant numbers of plant macroremains (in total, ten items, of which only 6 were identifiable; see Fig. III.2).

Most of the analysed contexts were only described as occupation layers, meaning an amalgam of residues of different actions of anthropogenic origin. Contexts where large pieces of charcoal were observed during excavation were described as charcoal-rich layers.

As mentioned in chapter 3.2.1.1. (Fig. 3.21), a probabilistic sampling strategy was applied at the site. Around 20% of the sediment from all contexts was sampled and different volumes per context were obtained (Fig. 4.1). In total, nearly 800 litres of sediment were processed. Half of the samples were of less than 18 litres of volume, some samples were of between 20 and 60 litres and only one sample was of 155,50 litres (A-8A4). As mentioned before, the volume of the samples especially affects the chances of having represented seeds and fruits of large size. The botanical diversity represented in larger samples could be larger for a simple matter of probability. At this point it must be mentioned, though, that the location of Sardo Cave made it really difficult or even impossible for the archaeological team to sample much larger volumes of sediment.

The first samples that were analysed from this site were processed by water-screening, using sieve mesh sizes of 1 mm and 0,5 mm. A total of 37 litres were processed and it was rapidly observed that the extraordinary richness of charcoal remains at the site made the use of a flotation machine of absolute need. The remaining samples were processed through this system (see chapter 3.2.2. for futher details).

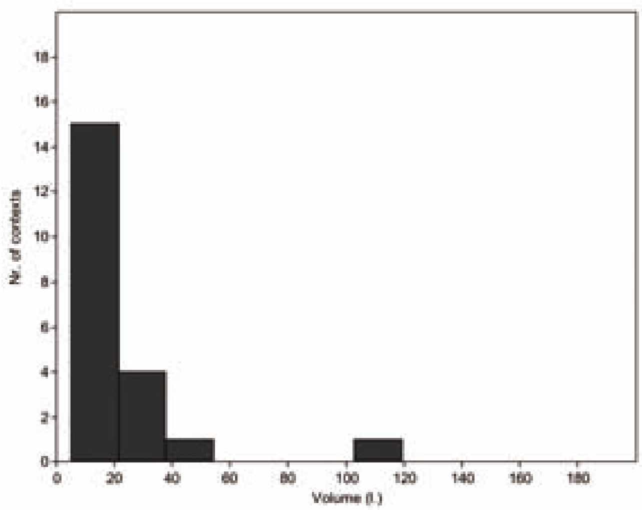


Fig. 4.1. Histogram of the volume of sediment treated per context at Sardo Cave.

4.1.4. Results

A total number of 136 items were recovered from the site, considering all 4 phases of occupation (one during the Late Early Neolithic, two during the Middle Neolithic and one during the Late Neolithic). These are not quantitatively significant. For this reason, results are also not discussed at a context level. The total results per context are presented in Fig. III.2. Here, data were grouped per context type and layer for a qualitative approach to the obtained results (Fig. 4.2).

Fifteen taxa were identified (Fig. 4.2). Two taxa belong to cultivated plants, more specifically, cereals: *Hordeum vulgare* var. *nudum* and *Triticum aestivum/durum/turgidum*. Weeds and ruderals are represented by two taxa: *Galium aparine* subsp. *aparine* and *Galium aparine* subsp. *spurium*. Three taxa grow in woodland edges and clearings: *Rubus fruticosus, Rubus idaeus* and *Sambucus* cf. *racemosa*. The woodland taxa can be grouped into taxa from open deciduous woodland, like *Corylus avellana* and *Cornus sanguinea*, deciduous woodlands from valley bottoms, like *Prunus padus*; and coniferous woodlands: *Abies alba* and *Pinus silvestris*. Other taxa were just not possible to ascribe to any ecological group (cf. Asteraceae, *Potentilla* sp., *Vicia* sp. and *Vicia/Lathyrus*).

Taxa	Represented part	Phase 8: 4800-4400 cal BC			Total Ph. 8	Phase 7: 3900-3500 cal BC		Total Ph. 7	Phase 6: 3300-3100 cal BC		Total Ph. 6	Phase 5: 2900-2500 cal BC	TOTAL SITE
		occup	ch-rich	stones		occup	Pit		ch-rich	occup		Occup.	
Cultivars													
Hordeum vulgare* var. *nudum	seed/fruit		1		1								1
Triticum aest./dur./turg.	seed/fruit									1	1		1
Weeds and ruderals													
Galium aparine* subsp. *aparine	seed/fruit		4		4	5		5				6	15
Galium aparine* subsp. *spurium	seed/fruit		2		2					1	1		3
***Rubus fruticosus* agg.**	seed/fruit					1		1					1
Rubus idaeus	seed/fruit									2	2		2
***Rubus* sp.**	seed/fruit											1	1
Sambucus* cf. *racemosa	seed/fruit	1			1					1	1	1	3
Woodland taxa													
Abies alba	**Total remains**	1			1	4		4				14	19
	needle frag.					2		2				2	4
	needle tip	1			1	2		2				12	15
	MNI	1			1	2		2				13	16
Cornus sanguinea	seed/fruit								1		1		1
Corylus avellana	pericarp frag.	3	3	1	7	1	1	2	1		1		10
Pinus sylvestris	cone scale					1		1					1
Pinus/Abies	needle frag.	1			1		1	1		1	1	6	9
Prunus padus	fruit stone		1		1								1
Diverse/Unknown													
cf. Asteraceae	seed/fruit									1	1		1
***Galium* sp.**	seed/fruit		3		3	14	1	15				2	20
***Potentilla* sp.**	seed/fruit									6	6		6
***Vicia* sp. (small)**	seed/fruit					1		1					1
Vicia/Lathyrus	seed/fruit					1		1					1
Rubiaceae	seed/fruit									1	1		1
Unidentified	**Total remains**		1		1	1		1		1	1	2	5
	Fragment											2	2
	seed/fruit					1		1		1	1		2
	Other		1		1								1
Unidentifiable	**Total remains**		10		10	4		4		1	1	15	30
	Fragment		4		4	2		2				14	20
	seed/fruit		1		1							1	2
	Other		5		5	2		2		1	1		8
Varia	**Total remains**								2		2		2
	Total remains	7	25	1	33	33	3	36	4	16	20	47	136
	Nr. contexts	1	2	1	5	6	1	7	1	4	5	4	21
	Volume (l.)	29	143,5	5	177,5	> 92	15	> 107	41	56,5	97,5	61	>420
	Density r/l	0,24	0,17	0,2	0,19	< 0,36	0,2	<0,33	0,10	0,28	0,21	0,77	< 0,32
	N. taxa	3	5	1	7	6	3	6	2	7	9	4	15

Fig. 4.2. Results of the seed and fruit analysis of Sardo Cave: identified taxa, part represented and ecological group (see abbreviations in chapter 3.2.7.). The results were amalgamated per type of context (ch-rich: charcoal rich layer; occup.: occupational layer; stones: circles of stones) and chronological phase.

Phase 8, dated to *c.* 4800-4400 cal BC corresponds to the Late Early Neolithic phase. Three types of structures were identified (Fig. 4.2): occupational layers, charcoal-rich layers and (hearth-type) circles of stones. The composition of each type of feature is slightly different. Occupational layers mainly contain woodland taxa or plants from woodland edges. The circle of stones only contained one fragment of hazelnut. Within the charcoal-rich layer, several potentially consumed plants were found: naked barley, *Corylus avellana* and *Prunus padus*. *Galium aparine* subsp. *spurium* was also identified.

A rather similar spectrum was observed in the next phase (Phase 7), corresponding to the first half of the IVth millennium cal BC (Middle Neolithic phase). No cultivars were identified within the seed and fruit record, but other potential ruderals were encountered, like some small legumes (*Vicia* sp.). No significant difference was detected between the different types of features.

During Phase 6, dated towards the end of the IVth millennium cal BC (Middle Neolithic phase), a completely opposed pattern of spatial distribution of the plant remains to that observed in layer 8 was found. Occupational layers include remains of cultivated plants (naked wheat), some potential ruderals, like *Galium aparine* subsp. *spurium* and taxa from woodland edges (*Rubus fruticosus, R. idaeus*). Hazelnuts and fruits of *Cornus sanguinea* were retrieved from charcoal-rich layers.

In the last Neolithic occupation, during 2900 and 2500 cal BC (Phase 5), a larger number of coniferous plant macroremains (fragments of needles) were recovered, along with other taxa that had also been identified in other layers of the site (*Galium aparine, Rubus* sp., etc.).

The state of preservation of the material was good, even though hazelnuts were heavily fragmented (around 50% of the fragments of shell measured less than 4 mm^2) and cereal grains were relatively badly preserved. Densities remained below 1 item per litre (r/l).

4.1.5. Discussion

4.1.5.1. Why was the site so poor in seed and fruit remains? Settlement nature, taphonomic or methodological reasons?

Preservation by charring is complex and many factors influence the type and quantity of charred plant macroremains that are recovered in a soil sample. *A priori*, Sardo Cave could have yielded much more quantitatively significant results. Several possibilities should be considered to explain the paucity of recovered remains in our analysis.

One possible explanation could be that the occupations of the shelter were majorly short (overnight stays?) and that the role of plants within the diet (or the refuse originated by their consumption) during those stays was reduced to a minimum. The results of the systematic project of prospection of the area around Sardo Cave can relatively reliably discard the existence of any large important site from the same chronology (Rodríguez-Antón 2011). As a result, it is unlikely that Sardo cave only had a secondary or specialized role within the economy of a group that was settled in the vicinities. In that case, the question is: was it only occupied for short periods or did some groups stay for long periods (over a year)? The archaeological record preserved supports at least slightly longer occupations. The space seems to be clearly structured in each dwelling phase (see chapter 3.1.1.3.) and some recurrent patterns are observed in the productive behaviour of each group in all settlement phases (Gassiot et al. 2012a). Phase 8, the oldest one, appears to be one of the more intense and long-lasting episodes. Phase 7 seems to be the result of a series of short-term occupations. Phase 6 could have been of larger significance and duration, since a dwelling structure of *c.* 15 m^2 was built at the front of the cave. This phase is contemporary to most of the known occupations close to the National

Park of Aigüestortes. The last Neolithic phase of occupation is phase 5, which seems to be of much more intermittent nature, similar to Phase 7 (Gassiot et al. 2012a). In such a context it is significant that cultivars appeared in the two settlement phases that seem to belong to long-term occupations (phases 8 and 6). Besides, none of the occupations seem to be of specialized nature, for which one should assume that a relatively wide variety of productive and reproductive activities could have taken place at the site. Whatever the case may be, other explanations must be considered to explain the relative absence of seed and fruit remains in the record of the site.

A second possibility would be that the charring conditions were not appropriate enough for the preservation of plant macroremains other than charcoal. That possibility exists but it is unlikely. The preservation of the charred material (e.g. charcoal) at the site is of excellent quality and very abundant. One would tend to think that more seed and fruit remains should have survived under such conditions.

Then, a third possibility must be faced. The consumed plant foods could have not been processed with fire and, as a result, very few traces of their consumption would have remained the site. This is always a possibility, especially for some fruits like hazelnuts, but it also sounds unlikely for other plant foods, like cereals.

One further taphonomic issue should not be discarded. The large number of charcoal fragments that were recovered outside the combustion structures at the site is probably the result of an intensive cleaning of these structures. One should not discard the possibility that the repeated cleaning of the dwelling area displaced most of the plant macroremains. These were consequently exposed to several processes of erosion and transport (downslope) and, eventually, only a very small part of them were recovered during the excavation of the site (mainly the larger and heavier items). This possibility, together with some of the previously outlined ones, seems to be the most plausible at the present state of research.

Finally, the applied sampling strategy ought to be considered, since one cannot discard the possibility that it had some impact on the final number of recovered items. As mentioned above, more than half of the samples were of less than 20 litres of volume of sediment. In order to evaluate the efficiency of sampling strategy, I compared the number of identified items, the number of taxa and the volume taken both per context (Fig. 4.3) and per amalgamated group of contexts and chronology (Fig. 4.4). The first graph shows that the number of items and taxa is low in all contexts. The second graph shows a more interesting tendency, which is that only those amalgamated contexts that add together more than 50 litres show an increase in the number of items and taxa recovered. This number seems not to grow much despite raising the processed volume above this threshold. This could mean that it is likely that the taxonomic diversity is low at the site, and that the density of items is also very low, but that somewhat larger volumes could have produced better results. However, very large samples like the one of A-8A4 did not produce, proportionally, much better data, for which it was probably not necessary to process such a large number of litres. In conclusion, the probabilistic sampling strategy applied in Sardo Cave may have not allowed the recovery of all the taxa present in all types of context. Volumes of around 80 litres per type of context might have yielded better results. Nonetheless, this sampling strategy was not responsible for the meagre results obtained for this site.

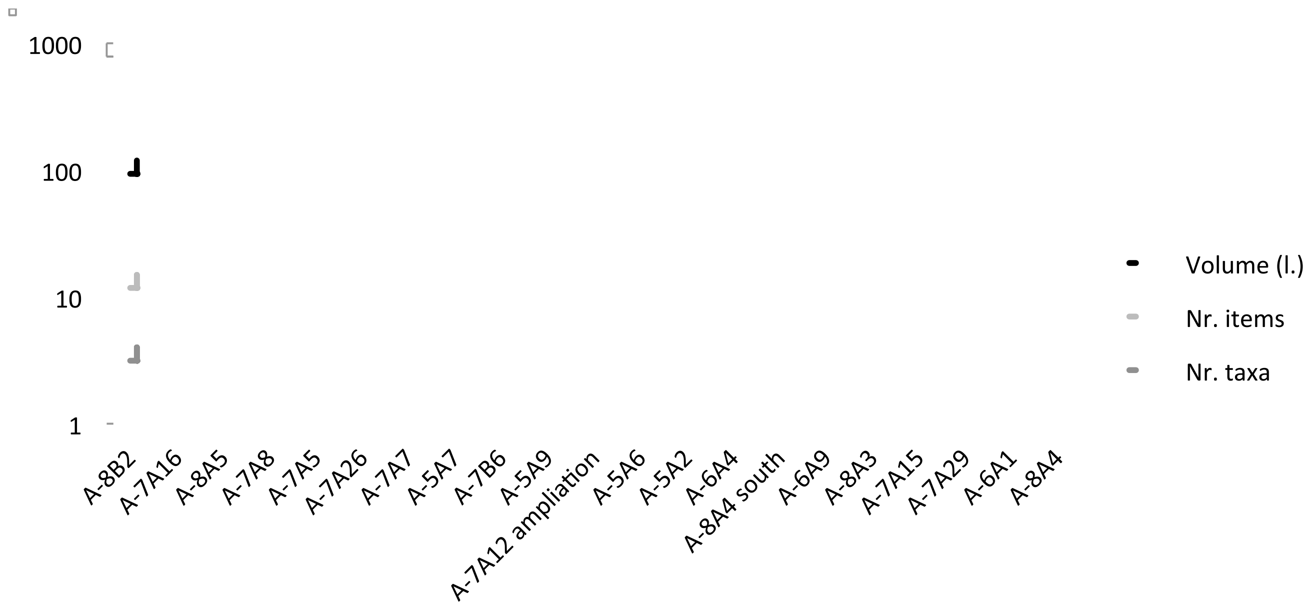


Fig. 4.3. Number of taxa and volume of sediment processed per context in Sardo Cave.

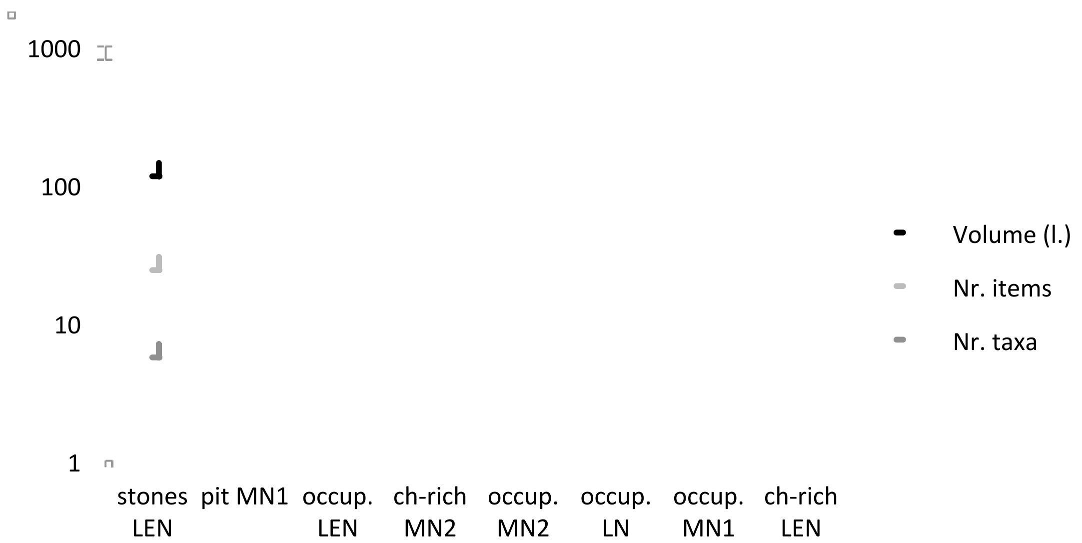


Fig. 4.4. Number of taxa and volume of sediment processed per type of context and chronology in Sardo Cave (see abbreviations in Fig. 4.3).

4.1.5.2. Was agriculture practiced in high mountain areas during the Neolithic?

The scanty results obtained at Sardo Cave can only be evaluated at a qualitative level. Despite this, one interesting issue can be raised from these data. Are the cereal grains recovered in phases 8 and 6 evidences of high mountain agricultural practices? Otherwise, were they transported from a base camp? Or obtained through trade?

Phase 8, dated to the first half of the Vth millennium cal BC, was interpreted as a relatively long occupation, just like phase 6 (3300-3100 cal BC). Naked barley was identified in a charcoal-rich layer of phase 8, and naked wheat was recovered in an occupational layer from phase 6. Both barley and naked wheat could grow as cultivars at such altitudes, but the number of recovered items is so low that one cannot argue in favour of any of the possible interpretations from above, based only on the plant macroremains.

According to F. Burjachs, cereal pollen was not identified at the site (Gassiot et al. 2012b). However, recent results from the use-wear analyses carried out on knapped lithic tools from the site revealed that sickle blades were present and, consequently, it is possible that cereals were not only consumed at the site but also cultivated, harvested and processed (N. Mazzucco et al., oral com.; Gassiot, pers.com.). Nevertheless, one should take care when interpreting this evidence, since most of the tools found at the site were brought from elsewhere (due to the lack of appropriate lithic resources around the cave) (Gassiot et al. 2012a), where they could have been used for different purposes (including harvesting). At the present state of research, no definite conclusions can be proposed.

4.1.5.3. Wild fruit exploitation at Sardo Cave

Among the wild taxa, several edible fruits were identified. A compilation of the different traditional uses of the identified taxa is presented in Fig. 4.5. Six taxa have edible fruits, or other aerial plant parts, while four of them have medicinal uses. According to the PFAF database, only three taxa have real edible value and all have some medicinal properties.

	Fruits	Flowers	Young shoots	Aerial parts	Roots	Edibil. rank.	Medic. rank
Galium aparine s.l.				Medicinal uses		2	3
Rubus fruticosus	Eaten raw, in jam or liqueur	Eaten raw	Peeled and eaten as a snack	Medicinal uses	Medicinal uses	5	3
Rubus idaeus	Eaten raw or drank as liqueur or other beverages; with medicinal value			Medicinal uses	Medicinal uses	5	3
Abies alba	Cones are used for making beverages and infusions with medicinal value			Resin, with medicinal value		2	3
Corylus avellana	Eaten sometimes unripe, mostly raw, dried and put in cakes, stews or as condiment			Bark, leaves used for medicinal purposes		5	2
Pinus sylvestris	Seeds are eaten raw, as snacks or in pastries	Edible pollen after cooking	Used for medicinal purposes	Young leaves edible and mature leaves in infusion with medicinal value		2	3
Prunus padus	Fruits (and stones) pounded, made into cakes and roasted					3	2

Fig. 4.5. Ethnobotanically known uses among the plants that were identified in the seed and fruit record of Sardo Cave and edible and medicinal ranks for each taxon (from www.pfaf.org).

During Phase 8, the only clearly edible fruits are hazelnuts. They are present in all of the types of contexts shown in Fig. 4.2. Hazel wood was used for fuel during this phase (Obea et al. 2011) but it is unlikely that its fruits were not consumed, especially given their relatively ubiquitous presence at the site. It is difficult to tell, though, whether they were processed before consumption or whether they were eaten raw. The low number of recovered items, along with the lack of clear roasting pits at the site could be interpreted as a support for the latter possibility. Besides, roasting is usually practiced to facilitate storage and it is possible that storage practices were not necessary if the settlement was not completely permanent. Other fruits were also identified, like *Prunus padus*. Bird cherries are certainly not poisonous but they have a disagreeable flavour (Dallimore 1914), for which some processing is required (Mears & Hillman 2007). The leaves are toxic to goats, which makes it unlikely that this fruit reached the site due to grazing practices. In any case, one should not rule out the possibility that this fruit was accidentally burned when using branches of this taxon as fuel. The only recovered fruit stone was found in a charcoal-rich layer, which could support this hypothesis. The use of wood of *Prunus* sp. as fuel is attested on the results of the charcoal analyses (Obea et al. 2011).

In Phase 7, *Rubus fruticosus, Corylus avellana* and *Pinus sylvestris* were identified and one could interpret that they were gathered and consumed for alimentary purposes, The low number of items retrieved does not allow anything more than speculations. It must be noted, though, that only a cone scale of scots pine was recovered, not the shell of the kernel or the kernel itself. Thus, if these fruits were eaten, this cone scale would be the residue obtained after extracting the kernels from the pine cones. Besides, one should consider that cones of *Pinus sylvestris* could have also arrived to the site to be used as fuel or along with its wood, which was probably gathered as fuel rather frequently, given its representation in the charcoal record of the layer (Obea et al. 2011). Furthermore, one should note that the chances for a seed of *Rubus idaeus* or *R. fruticosus* to get charred after consumption are very low, unless one burns dung. Their seeds are very small and eaten without noticing. Thus, the recovered remains might be indicating a frequent consumption of this fruit.

A similar situation is observed in phase 6, where only raspberry and hazelnut were identified as potentially consumed taxa. In phase 5 only an unidentified specimen of *Rubus* sp. was retrieved. In both cases it is difficult to establish their anthropogenic origin based only on the seed and fruit record.

Other wild plants were recovered along the different occupations. The two different sub-species of *Galium aparine* that were identified were probably brought to the site by animals, since these fruits can very easily stick to their hairs, and maybe grew in front of the shelter, where rubbish and dung would potentially accumulate. Consequently, they could have accidentally got burnt. Finally, a relatively large number of fragments of needle of silver fir and other coniferous were identified along the stratigraphy at the site. These taxa were present in the surroundings of the settlement, especially during the Late Neolithic, when an increase of the pollen record of this taxon is observed (Gassiot et al. 2012b). *Abies* is not recorded in the charcoal record (Obea et al. 2011), for which other uses of this taxon might be speculated (bedding?).

4.1.6. Summary and conclusions at a site level

The results from Sardo Cave are rather meagre but of very high importance at a qualitative level. First of all, it must be reminded that a probabilistic sampling strategy was applied at the site. This strategy allowed the recovery of a relatively large number of taxa, but it was argued that it could have not been totally efficient, since some contexts were poorly sampled while excessively large samples were taken from others. In any case, this strategy was not responsible for the poor results. Also at a methodological level, water-screening of the samples was observed to be inefficient due to the richness of charred material in the samples. The use of a flotation machine was preferred.

After the evaluation of several possibilities, it was concluded that the low number of items recovered at the site was due to taphonomic reasons. It is likely that most plant foods were not processed with fire. Besides, those which *were* processed and eventually produced charred residues were deposited outside the shelter after cleaning the hearths and postdepositional processes would have eliminated most of them from the record.

Of special significance for the comprehension of Neolithic farming are the multiple evidence related to agricultural practices at the site. Both charred grains and sickle blades were identified. It would be convenient, though, to confirm these evidences with other finds of archaeobotanical microremains (pollen and phytoliths, for instance).

Other wild plant resources were recovered at the site, of which only hazelnuts are well represented enough to argue in favour of their use as an alimentary resource. It was proposed that the low number of shell fragments that were recovered could correspond to the preferential consumption of the fruits in raw state.

4.2. Camp del Colomer

4.2.1. Chronology and phases

The site is dated around 4500-4200 cal BC (A. Vidal, pers.com.). All features seem to belong to the same phase of occupation (for further details, see 3.1.2)

4.2.2. Aims of the study

The interests of Camp del Colomer site are many. This is the first large excavation that has been conducted on a Neolithic open-air dwelling site in Andorra. Human presence in this area was already known but little information was available on subsistence strategies. The excavation of Camp del Colomer presented the possibility of conducting a first approach to Neolithic agriculture and plant food economy (among many other subjects) in the Pyrenees. The site consisted of excavated or negative structures, which opened the possibility to study the management of residues within the site, as well as potentially detect particular uses of those structures.

4.2.3. Materials and methods

A total number of 61 samples from 32 different archaeological features were taken (Fig. III.3). One should consider each sample as a context, since they belong to different stratigraphic units (abbreviated in the text as **UE**) that were individualized during fieldwork by the archaeologists of the site. Several types of features were uncovered (see chapter 3.1.2.3.) and the references in the text and figures follow the nomenclature that they received during field work. Dwelling-type pits appear in the text and figures as EI-5 and EI-2 (**EI** was used during fieldwork to name “unknown type of features”); silo-type pits are abbreviated in the text as **SJ**; and other sorts of excavated features either as **FS** (the abbreviation used for ordinary pits of concave shape), or **EI**. Sampling was carried out in a very systematic way, taking samples from as many features as possible, as well as from several stratigraphic units within each feature (for indications on the stratigraphic location of the different stratigraphic units mentioned in the text, see Fig. III.3 or Fig. 4.22).

The total volume of sediment processed was 673,6 litres. But volumes range from 0,1 to 54 litres, mainly below 12 litres (see Fig. 4.6.). The average volume per sample is of 11 litres. All samples were processed with a flotation machine.

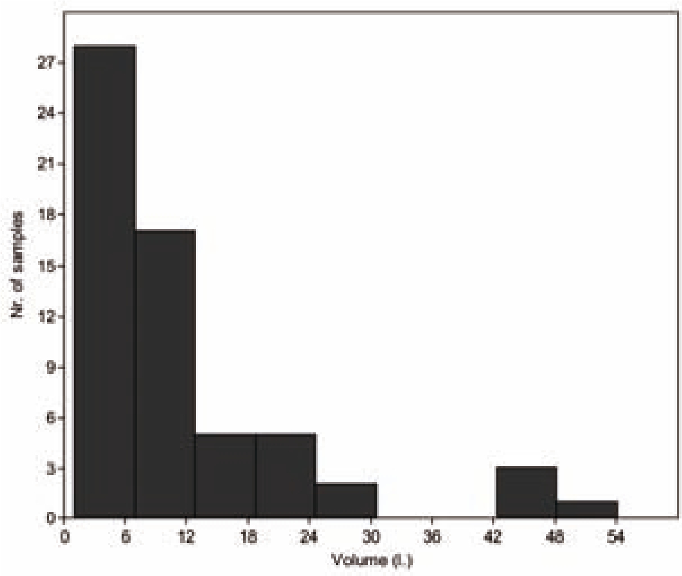


Fig. 4.6. Histogram showing the number of samples according to the volume of sediment of the samples of Camp del Colomer.

Most of the sampled contexts come from either storage pits or pits of undefined functionality (Fig. 4.7). Only three samples were taken from dwelling structures. The type of fillings of all negative structures, though, could have been similar, in spite of their primary use. The initial hypothesis is that the sampled contexts were mainly secondary refuse deposits (following observations from previous work, e.g. Jacomet & Petrucci-Bavaud 2006), but a taphonomic analysis is necessary to support this interpretation. Consequently, the sampled features should inform us of the management of the refuse at the site and, potentially, they could represent single activities.

All structures are considered to belong to the same phase of occupation, but their stratigraphic position denotes some diachrony among some of them. One clear case can be observed on the north-western sector of the excavation (see Fig. 3.3.) where several pits cut one another. The time during which this superposition could have taken place is unknown and the excavated area is insufficient to interpret the distribution of the structures and the number of dwelling structures.

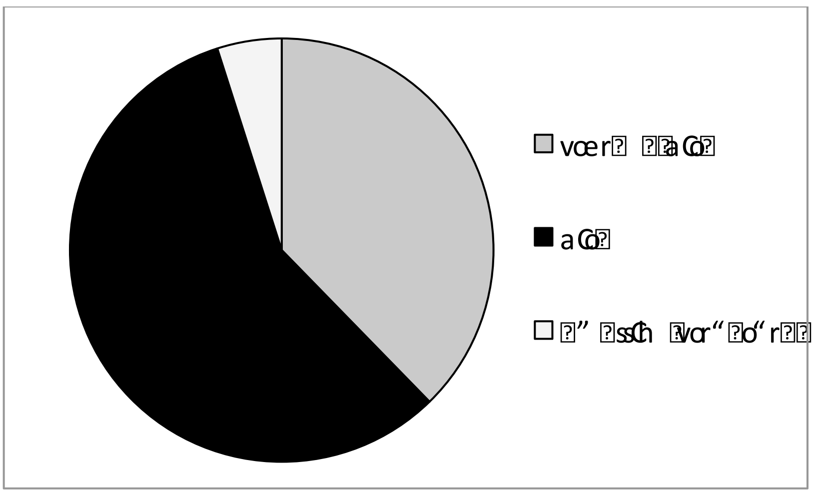


Fig. 4.7. Number of samples per type of context in Camp del Colomer.

4.2.4. Results

A total of 3447 plant macroremains (other than charcoal) were retrieved from the samples taken from Camp del Colomer. The results per stratigraphic unit are presented in Fig. III.4.

4.2.4.1.The number of remains and the number of taxa per context

The distribution of the seed and fruit remains was not homogeneous along all the sampled units. Eleven samples did not contain any plant remain. As can be observed in Fig. 4.8., among the 50 remaining samples, more than half of them yielded less than 30 items and only a few samples contained between 100 and 900 items. A similar picture is observed when considering the number of taxa per sample. Only 11 samples yielded between 7 and 25 taxa and 18 samples yielded 1 or no taxa (these samples were not included in ubiquity analyses, following the criteria mentioned in chapter 3.2.9.).

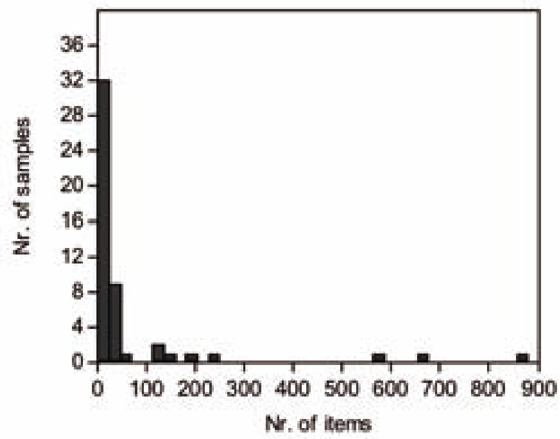


Fig. 4.8. Histogram showing the number of items per sample in Camp del Colomer.

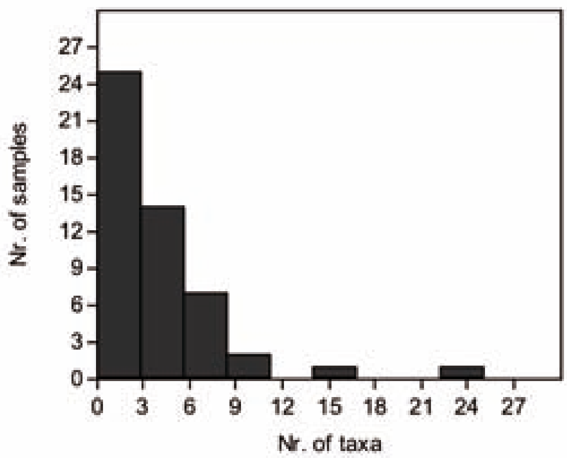


Fig. 4.8. Histogram showing the number of taxa per sample in Camp del Colomer.

As explained in chapter 3, optimal seed assemblages for palaeoeconomic evaluations at several scales should be of around 400 items. Samples above 35 items, though, can be considered for quantitative analyses. Only three samples (UE103, 109, from the storage pit SJ-1 and 210, from the storage pit SJ-24) produced more tan 400 plant macroremains (other than charcoal). Nine more samples contained more than 35 items. These were retrieved especially from storage pits, but also from a dwelling pit (EI-2) and from pit FS-29 (for details see Fig. 4.22).

In Fig. 4.9 one can observe that samples with more that 100 items are more frequently encountered in samples of more than 10 litres of sediment, and especially in those of more than 20 litres. Six of these samples belonged to storage pits (UE103, UE108 and UE109 of SJ-01, UE 127 and UE130 of SJ-07 and UE210 of SJ-24) while two were obtained from pits (UE222 of FS-29 and UE 243 of FS-45). A similar pattern is detected when considering the number of taxa. Most of the samples which contained more than 5 taxa are of 9 or more litres of sediment. The samples with a larger number of taxa (ten or more) come from storage pits (UE 209 and 210 from SJ-24, UE 127 from SJ-07, UE 109 from SJ-01).

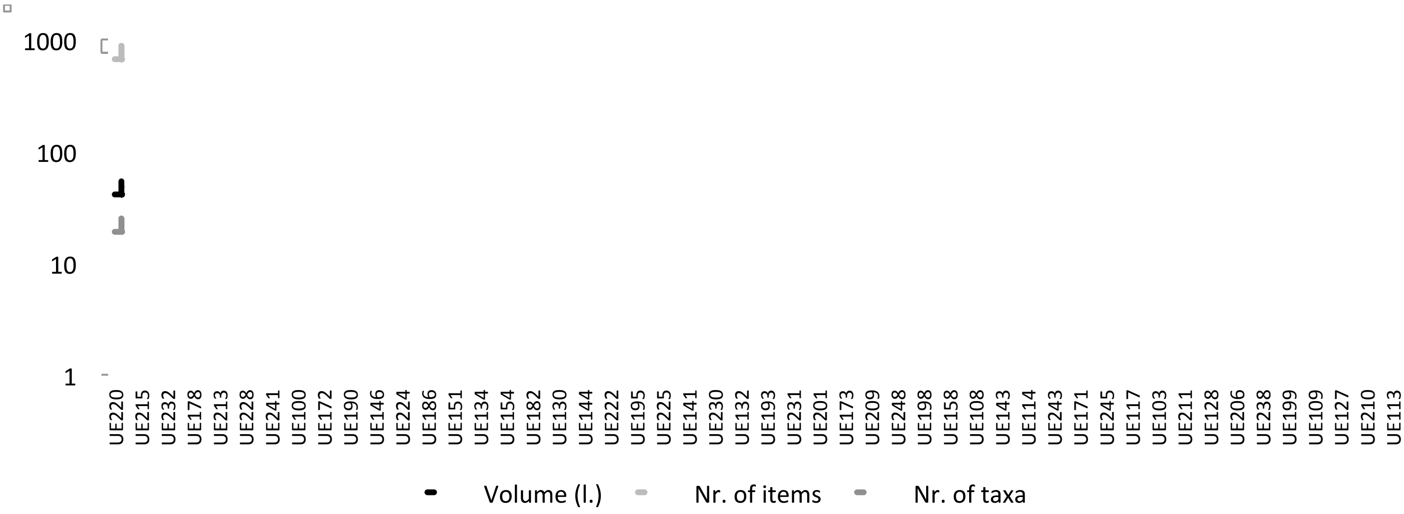


Fig. 4.9. Volume of sediment, number of items and number of taxa per sample in Camp del Colomer.

4.2.4.2. The density of remains per context

The average density of remains per litre of sediment is 5,60, which is rather high for a dry site where only charred material is preserved. Most of the samples had a density much below 4 r/l and more than half had over 1 r/l. A few samples had more than 10 r/l (UE 232 from the pit FS-29, 210 from the storage pit SJ-24, 108, 109, 103 and 100 from the storage pit SJ-01, 130 from the storage pit SJ-07, and 222 from the pit FS-29). Most of the samples with a higher density of remains were from samples of 5 litres of sediment or less. The samples with a higher density of remains were concentrated in the north-western sector of the excavated area and these came from pits or storage pits. No seed and fruit remains were retrieved from the dwelling structure EI-5, while some remains were recovered in EI-2.

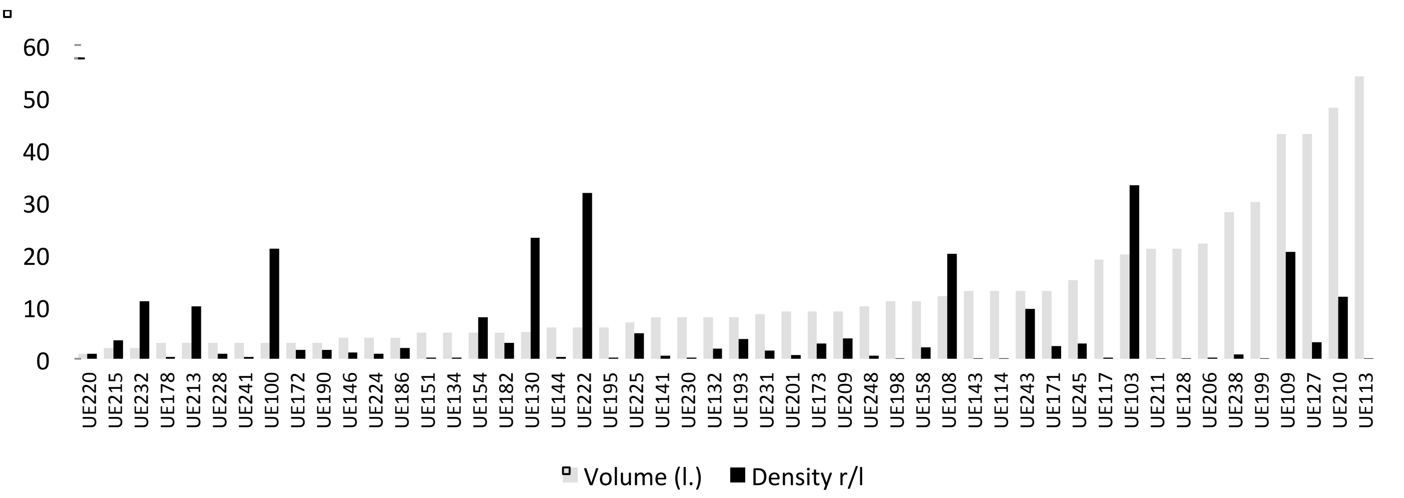


Fig. 4.10. Volume of sediment per sample and density of remains per litre in Camp del Colomer.

In all these storage structures except for SJ-01 there is one sample with a clearly higher density of remains (UE 130 in SJ-07, UE 154 in SJ-19, UE210 in SJ-24). Only in the case of SJ-01, similarly high densities were observed in four different samples (UE 100, UE103, UE108 and UE109). This latter case is significant because the stratigraphic position of the different units indicates the existence of several different episodes (see Fig. 4.36).

In short, 12 samples had more than 35 items, and 7 of them had a density of remains per litre of sediment above 10 r/l. Only three samples yielded more than 400 items. Most of the samples had a low diversity of taxa (below 6), while a small number showed a rather wide spectrum. Most of the materials were recovered in the north-western sector of the site, where most of the negative structures were also found. Those features identified as storage pits yielded better results, in general, in comparison to other sorts of pits or dwelling features.

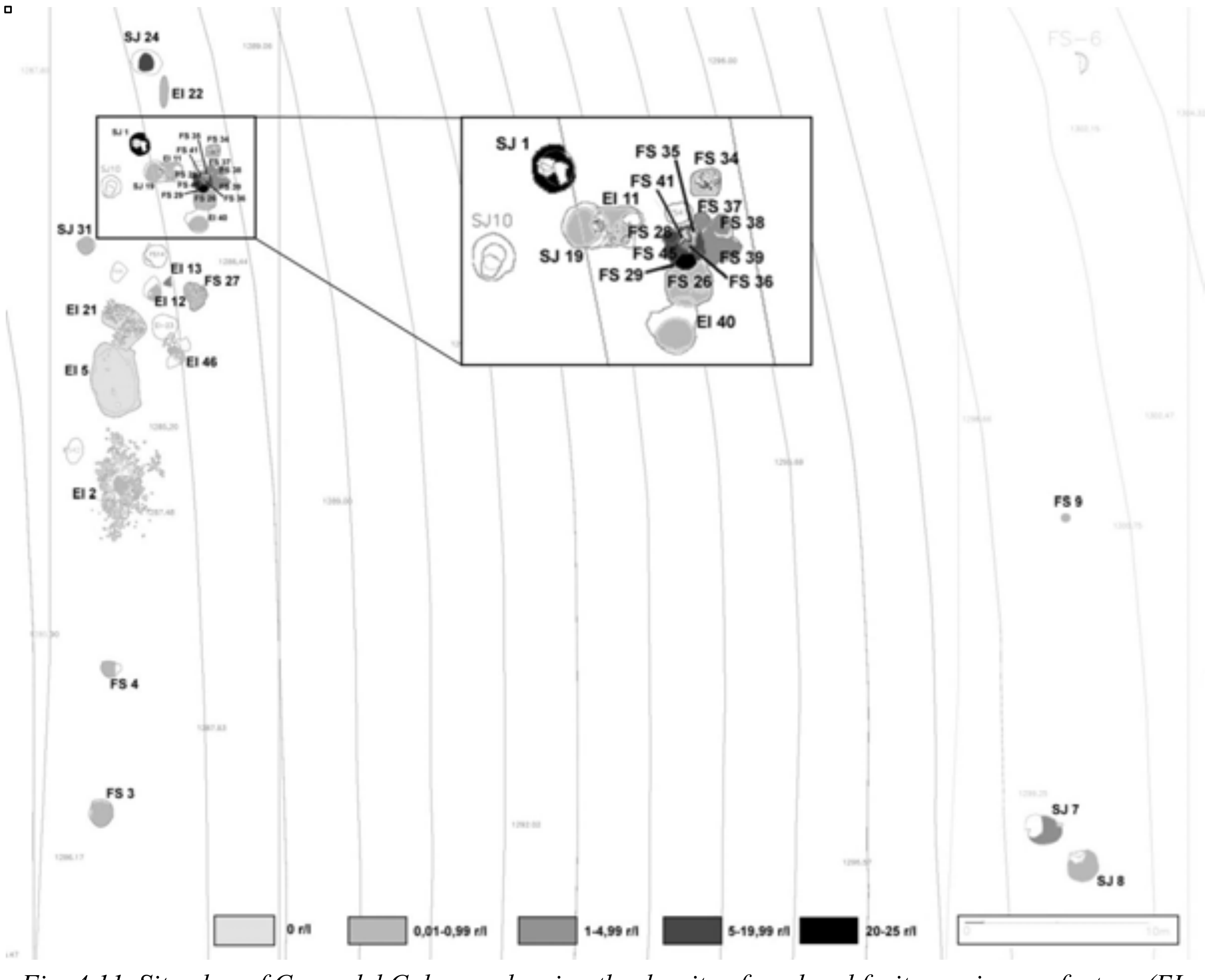


Fig. 4.11. Site plan of Camp del Colomer showing the density of seed and fruit remains per feature (EI: unknown type of feature; FS: pit; SJ: storage pit) (Plan: Patrimoni Cultural d'Andorra).

4.2.4.3.The botanical spectrum and the representation of the different ecological groups

Forty-three taxa were identified, all of them preserved in carbonized state (see Fig. 4.12 for a complete list). The group with a larger botanical diversity is that of the weeds and ruderals (12 taxa), but it is not so significant at a quantitative level. The ubiquity of some of the taxa within this group is rather high. Cultivars are the better represented among the different groups (55,65% of the total identified remains), followed by the woodland taxa (around 20%) (Fig. 4.13). These two groups are, in fact, the most ubiquitous (they were found in around 80% of the samples) (Fig. 4.14). Among the cultivars, cereals are the better represented, both considering the number of remains and their ubiquity.

Taxa	Ecological group	Total nr. of items	Ubiquity (%)
Cultivars: cereals			**(total: 32 samples)**
***Hordeum vulgare* var. *nudum* (cf. included)**	**C**	**1164**	**62.5**
***Triticum aestivum/durum/turgidum* (cf. included)**	**C**	**9**	**18,75**
***Triticum dicoccum* (cf. included)**	**C**	**9**	**12.5**
Triticum monococcum	**C**	**1**	**3.1**
Cultivars: oil plants			
cf. *Linum ussitatissimum*	**C**	**1**	**3.1**
Papaver somniferum	**C**	**12**	**15.6**
Cultivars: legumes			
***Pisum sativum* (cf. included)**	**C**	**12**	**28.1**
Weeds and ruderals			
cf. *Artemisia vulgaris*	**PG**	**12**	**12.5**
***Capsella bursa-pastoris* s.l.**	**WER**	**10**	**3.1**
***Chenopodium album* (cf. included)**	**WER**	**20**	**25**
***Chenopodium polyspermum* type**	**WER**	**1**	**3.1**
Galium aparine* subsp. *spurium	**WER**	**1**	**3.1**
Hyoscyamus niger	**WER**	**4**	**3.1**
***Polycnemum arvense* s.l.**	**WER**	**20**	**21.9**
Polygonum aviculare	**WER**	**1**	**3.1**
Polygonum convolvulus	**WER**	**6**	**9.3**
***Reseda luteola* (cf. included)**	**WER**	**3**	**6.2**
Sherardia arvensis	**WER**	**1**	**3.1**
Solanum nigrum	**WER**	**11**	**3.1**
***Thlaspi arvense* (cf. included)**	**WER**	**200**	**46.8**
***Urtica dioica* (cf. included)**	**PG**	**53**	**18.75**
Pastures and grasslands			
cf. *Linum catharticum*	**PG**	**1**	**3.1**
Myosotis* cf. *scorpioides	**PG**	**2**	**3.1**
Plantago major* subsp. *intermedia	**PG**	**3**	**6.25**
Thymus serpyllum* subsp. *chamaedrys	**PG**	**14**	**6.25**
Woodland			
Corylus avellana	**WO**	**463**	**56.25**
***Pyrus malus subsp. sylvestris* (cf. included)**	**WO**	**18**	**15.6**
cf. *Pyrus communis* subsp. *pyraster*	**WO**	**1**	**3.1**
***Quercus* sp.**	**WO**	6	6.25
Veronica* cf. *officinalis	**WO**	**21**	**21.9**
Woodland edges and clearings			
Fragaria vesca	**WEC**	**181**	**21.9**
Physalis alkekengi	**WEC**	**1**	**3.1**
***Rubus fruticosus* agg.**	**WEC**	**2**	**6.25**
Sambucus nigra/racemosa	**WEC**	**1**	**3.1**
***Verbascum* sp.**	**WEC**	**4**	**6.25**
Diverse			
Amaranthus* cf. *graecizans	**DIV**	**1**	**3.1**
cf. *Artemisia campestris*	**DIV**		**25**
***Atriplex* sp.**	**DIV**	**1**	**3.1**
***Cerastium* sp.**	**DIV**	**2**	**3.1**
***Potentilla* sp. (cf. included)**	**DIV**	**2**	**6.25**
***Ranunculus* sp.**	**DIV**	**1**	**3.1**
***Trifolium* sp.**	**DIV**	**1**	**3.1**
***Vicia* sp. (large)**	**DIV**	**1**	**3.1**
***Vicia* sp. (small)**	**DIV**	**1**	**3.1**

Fig. 4.12. List of identified taxa, ecological group in which they have been classified, total number of items recovered and percentage of ubiquity in Camp del Colomer.

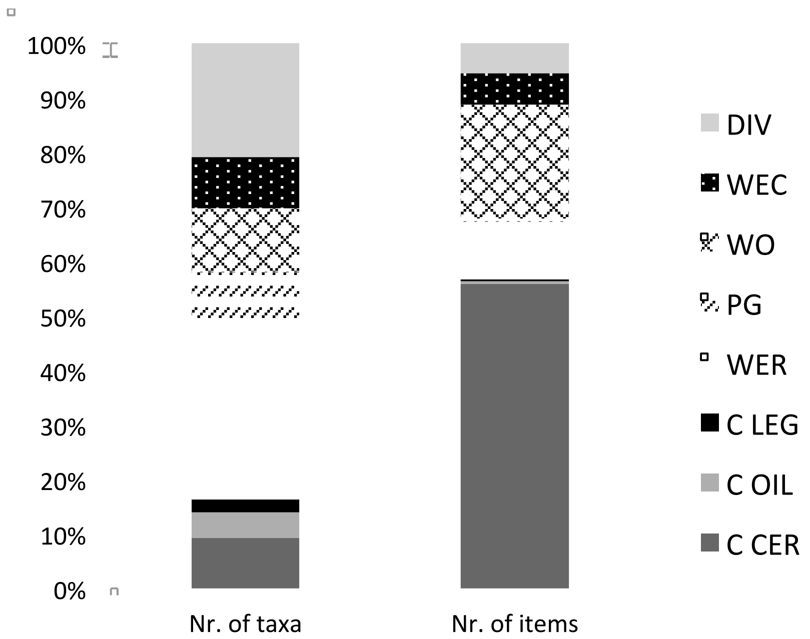


Fig. 4.13. Relative frequencies of the ecological groups according to the number of taxa and to the number of items at Camp del Colomer.

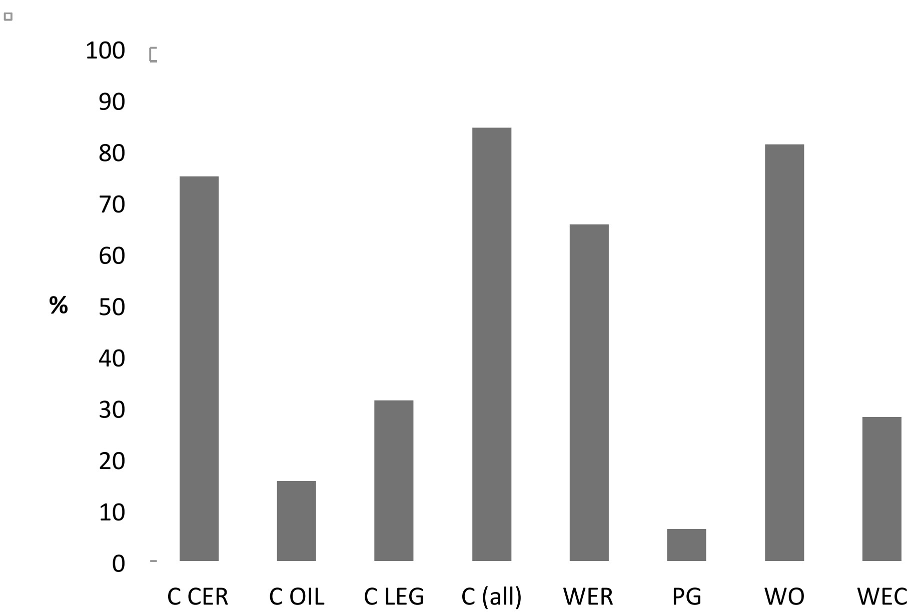


Fig. 4.14. Percentage of ubiquity of the main ecological groups at Camp del Colomer (see chapter 3.2.7. for the abbreviations)

4.2.4.4. Evaluation of the representation of the taxa within the ecological groups

Cultivated plants: cereals, oil plants and legumes

Seven taxa from potentially cultivated plants were identified. Cereals were present in 75% of the 32 samples with more than one taxon. They were more abundant in storage pits, especially in the feature SJ-01 (UE103, UE108, UE109), where more than 1500 remains were recovered, with densities of between 13 and 25 remains per litre of sediment. UE 108 and 109 are at the bottom of the pit and UE 103 at a medium depth (Fig. 4.36). Naked barley was the best represented cereal both in a quantitative sense and considering its ubiquity (Fig. 4.12), followed by naked wheat. One fragment of grain produced prior to charring was recovered in UE103 of SJ-01.

Naked wheat was present in 18,75% of the samples, in features SJ-01, SJ-07 and SJ-24 (storage pits), and FS-29 (a pit). It appeared in low concentrations, below 1 remain per litre. Emmer was recovered in 12,5% of the samples, but only a very low number of grains were identified. Einkorn was only identified in UE154, in the storage pit SJ-19.

Only cereal grains were recovered, no chaff remains or fragments of straw.

Pea was, after naked barley, the best represented cultivated taxon (present in *c.* 28% of the samples). It was found in storage pits, always in low amounts. Poppy and flax were much more scarcely represented. Poppy was found in 15,6% of the structures and flax in 3,1%.

The identification of poppy as a cultivar was done on an ecological basis, since the wild variety of poppy is extremely rare above 1200 m a.s.l. in our region at present.

	Naked barley	Naked wheat	Emmer	Einkorn	Flax	Poppy	Pea
Naked barley		X	X	X	X	X	X
Naked wheat	X		X		X	X	X
Emmer	X	X		X			X
Einkorn	X		X				X
Flax	X	X				X	X
Poppy	X	X			X		X
Pea	X	X	X	X	X	X	

Fig. 4.15. Co-occurrence of the different cultivars in the samples from Camp del Colomer.

By the co-occurrences of the different cultivars in the samples (Fig. 4.15) one can observe that naked barley, naked wheat and pea appeared with most of the taxa, while flax and poppy were never recovered in the same samples than the glume wheats.

Weeds and ruderals

Fourteen taxa and 343 remains were ascribed to this group. They were present in *c.* 65,3% of the samples. The better represented taxa were *Thlaspi arvense* (ubiq.: 46,8%), *Chenopodium album* (ubiq.: 25%), and *Polycnemum arvense* (ubiq.: 21,9%). Six samples had more than ten weed macroremains: UE 245 from the dwelling pit EI-2, UE103, UE108 and UE109 from the storage pit SJ-01, UE127 from the storage pit SJ-07 and UE 210 from the storage pit SJ-24. The four samples that yielded more than 35 weed items were represented in Fig. 4.16 in order to evaluate the relative proportions considering the number of remains per taxon. *T. arvense* is dominant in UE103 and UE109, but UE 108 and especially UE210 presented a much wider diversity, yet with a significant presence of *T. arvense*. *Urtica dioica* is better represented in UE 108. In UE103, UE108 and UE109 (all from SJ-01), a large number of cereals were also recovered.

Some sparse finds of macroremains from this group were found in several structures where no cultivars were present. In these pits (EI-11, EI-12, EI-3, EI-40, EI-46, FS-4 and FS-26) and one of the dwelling pits (E-02)

Chenopodium album, *Polygonum aviculare*, *Polygonum convolvulus* and *Polycnemum arvense* were recovered.

It is worth to highlight the presence of two toxic taxa: *Hyoscyamus niger* and *Solanum nigrum*.

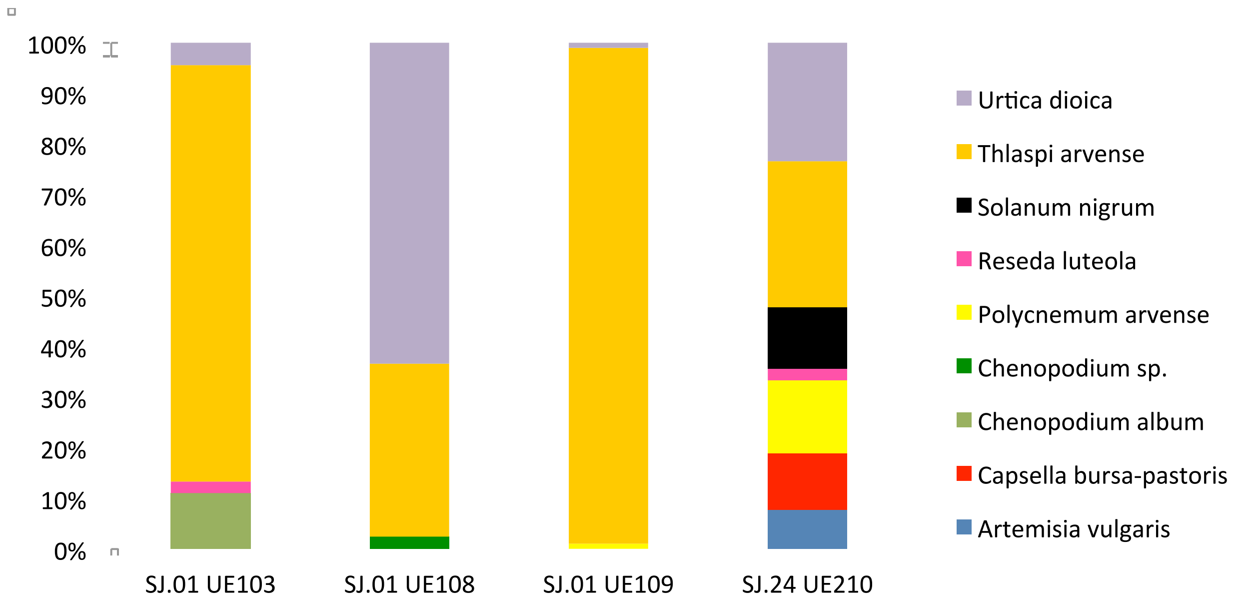


Fig. 4.16. Relative propotions of the remains of weeds and ruderals per sample in Camp del Colomer (only the samples with more than 35 items are shown).

Pastures and grasslands

Four taxa were included in this group, and they appeared in 6.25% of the samples. They were only identified in the UE 238 of the pit EI-40 and in the UE210 of the storage pit SJ-24.

Woodland

Five taxa were identified within this group, a total number of 675 items. They appeared in around 80% of the samples. The largest concentrations of items were in features FS-28, FS-29, FS-39, FS-45 (these are all pits) and SJ-7 (a storage pit). FS-28 and FS-29 as well as SJ-7 were associated with hazelnuts, while FS-39 and FS-45 were associated with acorns (see their location in Fig. 4.11).

Corylus avellana was the best represented taxon, both considering number of items and ubiquity (56,25%). Only hazelnut shell fragments were recovered. Charred cotyledons of acorns were present in 21,9% of the samples. They probably belonged to a deciduous variety of *Quercus*, considering the results of the anthracological analyses (see chapter 3.1.2.4).

Furthermore, some fragments of fruits and seeds of apples and pears (especially from the first one) were also recovered. Wild apple appeared in 15,6% of the samples.

The distribution of the taxa in the different stratigraphic units showed some clear patterns. Around 75% (n: 14) of the samples that contained hazelnut shells did not contain any other of the mentioned fruits. Three samples only yielded fragments of acorns, and two samples only contained fragments of wild apple/pear fruits. Only four samples showed some mixture, especially UE210 of the storage pit SJ-24 (this is a relatively small stratigraphic unit in an intermediate position within the stratigraphy of the storage pit), where all taxa were identified.

Finally, some seeds of *Veronica* cf. *officinalis*, also from woodland areas, were identified in several features.

Woodland edges and clearings
This group was represented by five taxa. It was present in 25% of the samples and the best represented taxon was *Fragaria vesca* (ubiq.: 21,9%). Most of the remains were recovered in UE210 from the storage pit SJ-24.

As a mode of **summary**, it must be highlighted that the plant spectrum at Camp del Colomer was very diverse. Several cereals could have been cultivated, among which naked barley was the better represented taxon. But also two potentially cultivated oil plants were identified: flax and poppy. It is very significant to note that pea was also very frequently encountered in these samples.

The weed spectrum was dominated by *Thlaspi arvense*, which was also very ubiquitous. Plants from woodland and woodland edges were dominated by *Corylus* and *Fragaria*. It is significant to note that many structures had pure finds of one of the woodland taxa and that mixtures were rare. It was observed that UE210 (from the storage pit SJ-24) was especially particular because it had a good representation of many wild taxa from all of the ecological groups.

4.2.4.5. The taphonomic description of the samples
In the following lines, a taphonomic description of the studied assemblage is presented, with a special emphasis on those samples which were more significant for an approach to plant economy at the site, as well as those taxa which yielded a higher amount of remains (cereals, hazelnuts and acorns, mainly).

The degree of fragmentation: general evaluation
In general the degree of fragmentation of the assemblage was relatively high. Nevertheless, fragmentation did not affect all taxa in the same way. Fig. 4.17 shows the proportions of fragments and complete cereal grains and acorns separately. Acorns were much more frequently fragmented. Most of the cereal grains were recovered in feature SJ-01, where no acorns were retrieved. Instead acorns were found in UE232 from pit FS-39, UE243 from pit FS-45 and UE210 from the storage pit SJ-24, where barely any cereal grains were present. It seems likely, then, that the charred remains from both taxa had very different taphonomic histories.

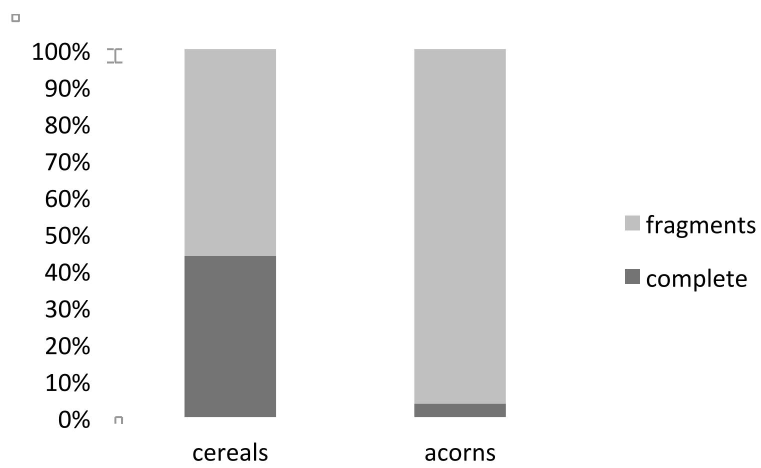


Fig. 4.17. Relative frequencies of fragments and complete cereal grains and acorns (cotyledons) at Camp del Colomer.

The intensity of the fragmentation of hazelnuts and acorns was also compared (Fig. 4.18). It seemed to be heavier in the case of hazelnuts, but both taxa had around 60% of type 1 fragments (small type, see Fig. 3.30). Their taphonomic history could be, then, comparable, even though, as stated above, they were hardly ever found in the same structure.

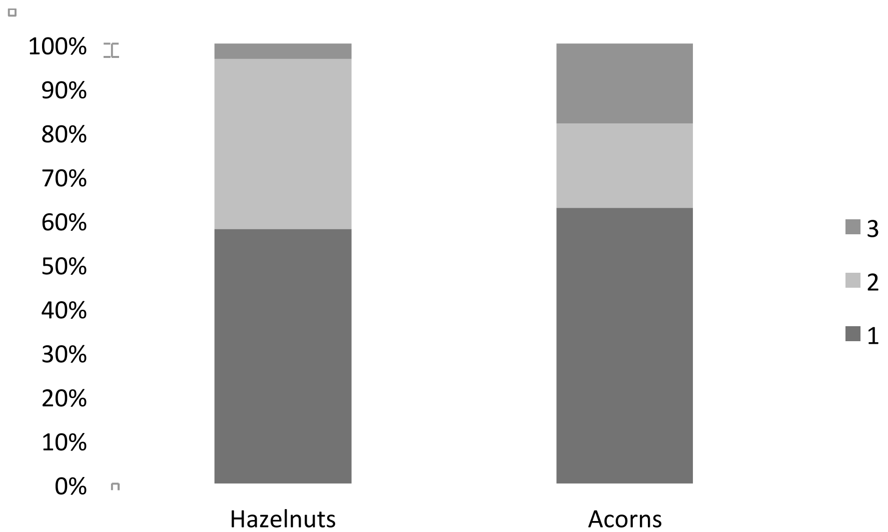


Fig. 4.18. Comparison among the relative frequencies among the different degrees of fragmentation of hazelnuts and acorns in Camp del Colomer.

The vast majority of fragments (89%) presented an irregular fracture and all but one of the fragments of cereal grain were produced after charring.

State of preservation of the surface of the items: general description

The state of preservation of the surface of the seeds and fruits recovered was, in general, good. 68% of the remains did not show (or had very few signs of) degradation or erosion of their surface (Fig. 4.19). When comparing among the best represented taxa, one can observe that acorns show less evidences of surface degradation, while cereal grains and hazelnuts have around 40% of significantly degraded items (4.20).

Fig. 4.19. State of preservation of the surface of the plant macroremains from Camp del Colomer.

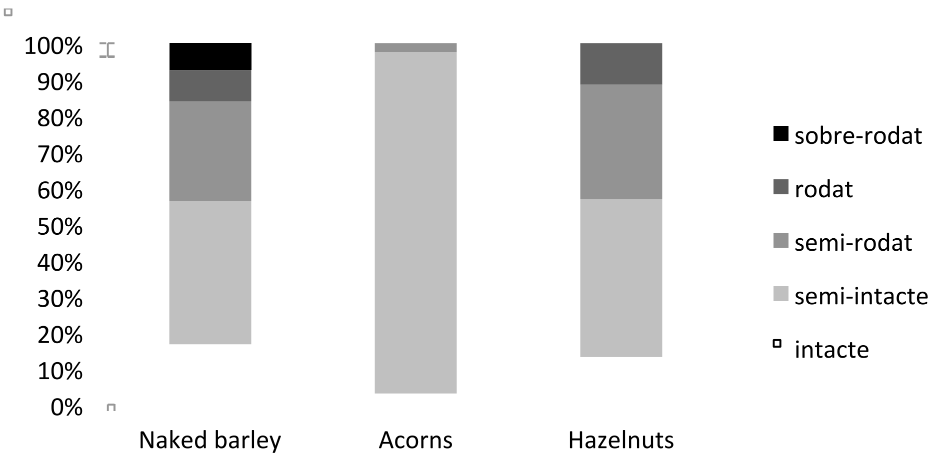


Fig. 4.20. State of preservation of the best represented taxa in Camp del Colomer.

Most of the naked barley grains had lost their embryo (over 91%) and only one grain had visible signs of germination. No insect holes were observed during the analysis.

Effects of charring on grain morphology and surface: naked barley
Charring effects on cereal grains were only possible to evaluate at a quantitative level for naked barley (Fig. 4.21). Around 30% of the grains were popped and 5% had protrusions. Less than 1% had concave flanks. Deformation was rare.

TAXA	**Popped grains**		**Grains with protrusions**		**Grains with concave flanks**		**Deformation produced in a confined space**		**Deformation**	
	N	%	N	%	N	%	N	%	N	%
Hordeum vulgare var. *nudum*	277	29,1	53	5,57	7	0,74	1	0,1	1	0,1

Fig. 4.21. Effects of charring on naked barley grains from Camp del Colomer.

4.2.5. Discussion

4.2.5.1. Was the sampling strategy adequate enough?

The sampling strategy applied at the site was adequate in many ways, especially because it was carried out as systematically as possible, taking samples from all features and, when possible, of several layers per feature, independently of the organic richness observed on the soil matrix. Despite this, the volume of the samples could have been more optimal. The volume of sediment treated per sample at the site is presented in Fig. 4.6. Many samples were of less than 10 litres and the average per sample was 11 litres. This could have had consequences on the archaeobotanical results at different levels. Two of them were observed: the number of items (Fig. 4.7) and the botanical diversity (Fig. 4.8), which were low in the vast majority of samples. The palaeoeconomic implications of both are very important and any sampling strategy should aim to minimize its effect on both variables.

It was observed in Fig. 4.9. that the volume of the samples and the number of remains were rather independent variables. Nevertheless, it was noted how samples above 10 litres were more likely to give better results both concerning the number of items and the number of taxa. A total of 12 samples from Camp del Colomer yielded more than 35 items. Making a hypothetical inference (considering that the samples were randomly taken from larger contexts and that they were representative of the total amount of sediment), if samples of 20 litres of sediment would have been taken, the number of samples with more than

35 items would nearly double (n: 23) (Fig. 4.22). A similar outcome should be expected concerning the botanical diversity, especially considering the good conditions of preservation existing at the site. It would be of extreme interest, then, to take samples of larger volumes (when possible) if new excavations take place in this area in the future. This volume of 20 litres of sediment might be considered high by some archaeologists but it is in fact below what other archaeobotanists have suggested (100 litres) (Alonso et al. 2003) and that is only because the preservation of the plant macroremains at the site is good. This, of course, should not include small concentrations of charred material, which usually present high densities but have a low volume. In this case the whole concentration should always be sampled and analysed.

UE	Feature	Type of feature + stratigraphic location of the UE	Litres	Density of r/l	Nr. of taxa	Total number of items	Potential number of items in a sample of 20 litres of sediment
UE220	FS-36	pit	1	1,00	1	1	20,00
UE215	FS-29	pit – upper layer	2	3,50	1	7	70,00
UE232	FS-39	pit – lower layer	2	11,00	2	22	220,00
UE178	EI-22	pit	3	0,33	1	1	6,67
UE241	FS-41	pit	3	0,33	1	1	6,67
UE228	FS-38	pit	3	1,00	2	3	20,00
UE172	SJ-19	storage pit – intermediate layer	3	1,67	3	5	33,33
UE190	SJ-24	storage pit – intermediate layer	3	1,67	1	5	33,33
UE213	FS-28	pit	3	10,00	3	30	200,00
UE100	SJ-01	storage pit – upper layer	3	21,00	8	63	420,00
UE224	FS-37	pit – upper layer	4	1,00	1	4	20,00
UE146	EI-11	pit – lower layer	4	1,25	2	5	25,00
UE186	SJ-24	storage pit – intermediate layer	4	2,00	4	8	40,00
UE134	FS-09	pit	5	0,20	0	1	4,00
UE151	EI-11	pit – lower layer	5	0,20	1	1	4,00
UE182	SJ-24	storage pit – upper layer	5	3,00	4	15	60,00
UE154	SJ-19	storage pit – upper layer	5	8,00	7	40	160,00
UE130	SJ-07	storage pit – intermediate layer	5,1	23,14	7	118	462,75
UE195	SJ-31	storage pit – lower layer	6	0,17	1	1	3,33
UE144	EI-11	pit – intermediate layer	6	0,33	1	2	6,67
UE222	FS29	pit – lower layer	6	31,67	5	190	633,33
UE225	FS-37	pit – lower layer	7	4,86	1	34	97,14
UE230	FS-39	pit – upper layer	8	0,25	2	2	5,00
UE141	EI-12	pit	8	0,63	4	5	12,50
UE132	SJ-07	storage pit – lower layer	8	1,88	1	15	37,50
UE193	SJ-24	storage pit – intermediate layer	8	3,75	4	30	75,00
UE231	FS-39	pit – intermediate layer	8,5	1,53	3	13	30,59
UE201	FS-34	pit – lower layer	9	0,67	3	6	13,33
UE173	SJ-19	storage pit – intermediate layer	9	2,89	3	26	57,78
UE209	SJ-24	storage pit – intermediate layer	9	3,89	11	35	77,78
UE248	EI-46	pit	10	0,60	4	6	12,00
UE198	FS-34	pit – intermediate layer	11	0,09	0	1	1,82
UE158	SJ-19	storage pit – upper layer	11	2,18	5	24	43,64
UE108	SJ-01	storage pit – intermediate layer	12	20,08	7	241	401,67
UE143	EI-11	pit – upper layer	13	0,08	1	1	1,54
UE114	FS-04	pit	13	0,15	2	2	3,08
UE171	SJ-19	storage pit – intermediate layer	13	2,38	4	31	47,69
UE243	FS-45	pit – upper layer	13	9,54	5	124	190,77
UE245	EI-2	dwelling structure	15	2,87	8	43	57,33
UE117	EI-3	pit	19	0,21	2	4	4,21
UE103	SJ-01	storage pit – intermediate layer	20	33,20	7	664	664,00
UE128	SJ-08	storage pit – upper layer	21	0,10	1	2	1,90
UE211	FS-27	pit – upper layer	21	0,14	2	3	2,86
UE206	FS-26	pit – intermediate layer	22	0,18	1	4	3,64
UE238	EI-40	pit	28	0,82	7	23	16,43
UE199	FS-34	pit – intermediate layer	30	0,03	1	1	0,67
UE127	SJ-07	storage pit – upper layer	43	3,21	14	138	64,19
UE109	SJ-01	storage pit – lower layer	43	20,40	10	877	407,91
UE210	SJ-24	storage pit – intermediate layer	48	11,85	25	569	237,08
UE113	EI-2	dwelling structure	54	0,02	1	1	0,37
		Nr of samples with more than 35 items				**12**	**23**

Fig. 4.22. Samples, volumes of sediment, concentration of remains per sample, total number of taxa, total number of items and potential number of items if samples of 20 litres of volume would have been taken. Samples which yielded more than 35 items are shadowed in grey. For the location of the features see Fig. 4.11.

4.2.5.2. What do the observed densities of remains per sample mean? Which samples could represent single events in the past?

Some authors have highlighted the difficulty of interpreting densities in the archaeobotanical record (Van der Veen 1992, 26). One thing is rather well accepted, though, which is that high densities usually indicate a rapid deposition of the remains. Thus, as observed by other authors (e.g. Kreuz 1990b) a high density in a small volume of sediment is much more likely to represent a single event in the past.

Considering these elements, a preliminary classification of the samples is presented in Fig. 4.23. Those samples with higher density and lower volume were classified as “likely short events”, meaning that they had more chances to represent a single episode. Samples of between 10 and 25 litres and smaller samples with medium densities (below 20 remains per litre of sediment) were grouped as “possibly short events”, since the chances of mixing single episodes were higher or more difficult to evaluate (in the latter case) due to the low number of items. Finally, the larger samples with medium densities of remains per litre were grouped as “possibly multiple events”, meaning that they had many chances to represent multiple depositions rather than single events. This classification is preliminary and must be confirmed by considering the botanical composition of the samples. One assumption was made, which is that any concentration of charred material was isolated during excavation. Otherwise, large samples with medium densities might have also been the result of the excavation of a concentration of charred material together with sediment with a much lower concentration of items. In any case, large samples always have a risk of mixing different episodes.

In short, three samples were classified as “likely short events”: UE222 from the pit FS-29, UE130 from the storage pit SJ-07 and UE100 from the storage pit SJ-01; six samples as “possibly short events”: UE103 from SJ-01, UE108 from SJ-01, UE243 from FS-45, UE232 from FS-39, UE213 from FS-28, and UE154 from SJ-19; and the rest should either be classified as “possibly multiple events” or as “unknown number of events”.

When looking at the composition of those samples (Fig. 4.24), nearly all (except UE154 from the storage pit SJ-19) of the ones that were classified as likely or possibly representing short events show a rather homogeneous composition, dominated either by cereals or one of the wild fruits. Among those possibly representing several episodes, UE109 (from SJ-01) also showed a rather homogeneous composition. In this case one could interpret that this sample could either represent a short episode or the sum of different episodes of similar nature (e.g. discarding refuse from grain consumption). The samples which were rich in hazelnuts presented low volumes (2-7 litres), for which they could be considered as monospecific concentrations resulting from the processing or consumption of these fruits. UE243 (FS-45) and UE232 (FS-39) are acorn-dominated. Pits which contained such concentrations of fruits might have functioned as roasting pits (*sensu* (Mithen et al. 2001). Cereal concentrations were found in UE100, UE103, UE108 and UE109, all coming from fillings of the same silo (SJ-01). Other samples, like UE210 (SJ-24), where a large number of wild plants were identified, could respond to a diverse number of actions, just like UE154 (SJ-19), where different groups of plants were identified. Samples UE127 (from the storage pit SJ-07), UE245 (from the dwelling pit EI-2) and UE209 (from the storage pit SJ-24) did not present high densities but they yielded 35 or more remains. Their composition, though, showed that they probably represented a diverse number of actions.

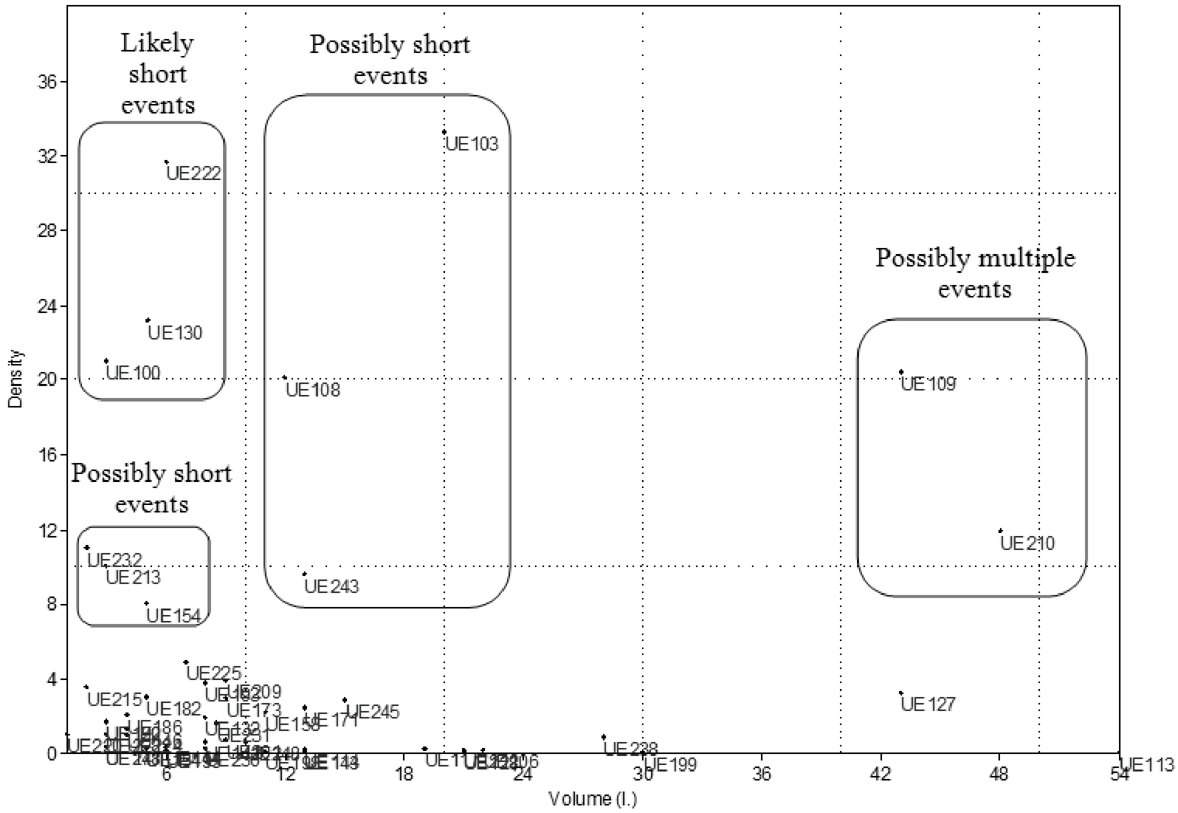


Fig. 4.23. Relation between the volume and the density of remains of the samples from Camp del Colomer. Preliminary identification of samples representing a single event.

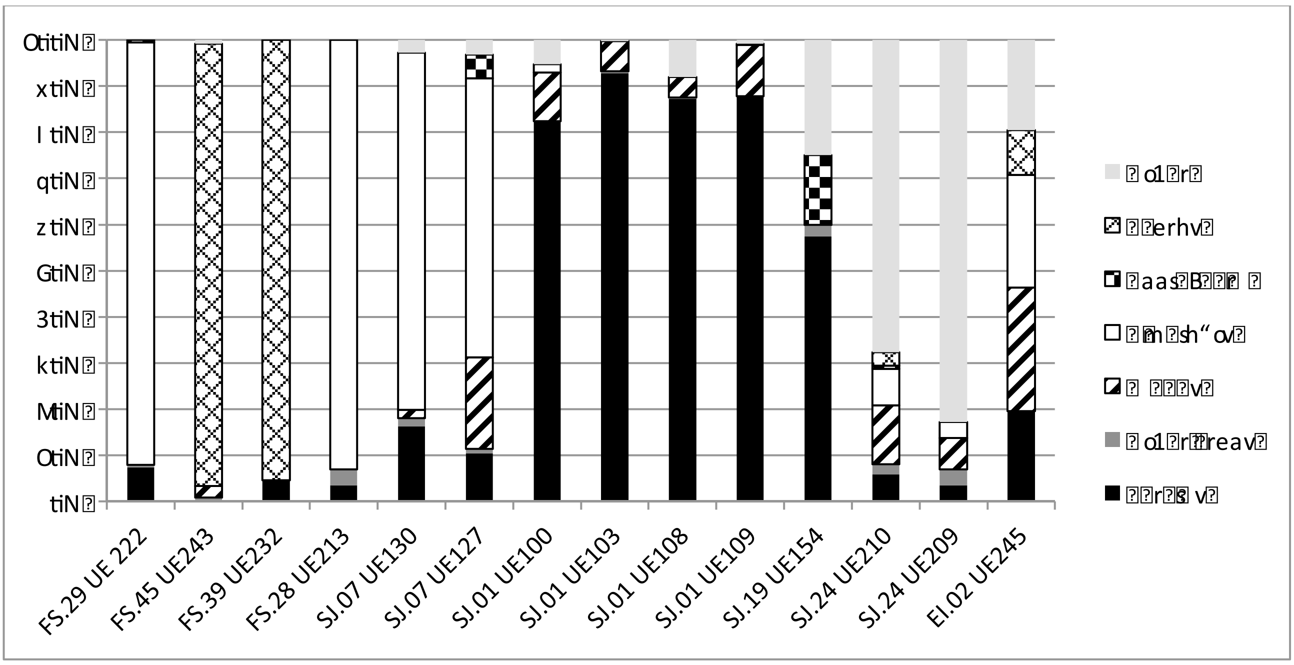


Fig. 4.24. Composition of the samples more than 35 items from Camp del Colomer.

4.2.5.3. Taphonomy: are the assemblages representative of the originally deposited ones? Do we have **in situ** *burnt assemblages? Was their charring history appropriate for carrying out crop husbandry analyses?*

I will focus the taphonomic analysis on those samples which have 35 remains or more and are likely to represent single events. First, the charring conditions will be analysed, and later on, the post-depositional effects will be discussed.

All samples from the storage pit SJ01 (UE100, 103, 108 and 109) were cereal-dominated. For the evaluation of the heating treatment (charring history) I could only consider these grain-rich samples and I had to rely on available experimental data obtained from experiments with naked wheat (see chapter 3.2.10.2).

	Popped seeds	Seeds with protrusions	Seeds with concave flanks	Heating treatment
SJ01-100	18%	6%	6%	250^{0}C LHR
SJ01-103	41%	6%	0,30%	250-300^{0}C LHR
SJ01-108	39%	2%	1%	250-300^{0}C LHR
SJ01-109	20%	4%	1%	250^{0}C LHR

Fig. 4.25. Evaluation of the heating treatment of the cereal-rich samples of Camp del Colomer.

The results obtained seem to support the interpretation that low temperatures and low heating rates were applied to these assemblages (Fig. 4.25). Considering that rachis of free-threshing cereals start to disintegrate with temperatures above 300^{o}C and after 5 hours of exposition (Boardman & Jones 1990), one can conclude that these samples suffered an adequate heating treatment for their preservation (which means that their absence in the samples does not have to do with the heating treatment) and that one can carry out further analyses for the characterization of crop husbandry. On the other hand, the absence of grain aggregates or deformations on the grains produced by heating inside a confined space leads to the conclusion that they got charred in rather open conditions (for instance, a roasting pan).

	Main component	**Fragmen-tation**	**Fragments type 1 (fruits) or 1+2 (cereals)**	**Type of fracture**	**Complemen-tarity**	**Erosion**	**Embryo**	**Density**	***In situ* charring**	**Type of refuse**
UE222	hazelnut	high	high			high		low	likely	Primary?
UE130	hazelnut	high	medium			low		low	likely	Primary?
UE100	cereal grain	medium	low	irregular	low	medium	low	low	no	Secondary
UE103	cereal grain	low	low	irregular	low	medium	low	low	no	Secondary
UE108	cereal grain	low	medium	irregular	low	low	low	low	unlikely	Secondary
UE243	acorn	high	high			low		low	likely	Primary?
UE232	acorn	high	low			low		low	yes	Primary
UE213	hazelnut	high	high			high		low	likely	Primary?
UE109	cereal grain	medium	low	irregular	low	medium	low	low	no	Secondary

Fig. 4.26. Taphonomic evaluation of the samples from Camp del Colomer: charring and deposition.

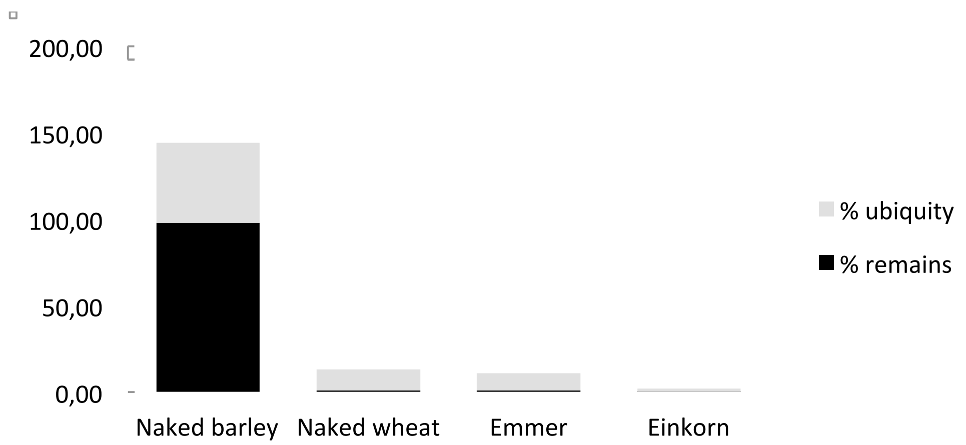
After considering a number of taphonomic variables (Fig. 4.26) it was concluded that the cereal assemblages were probably not burned *in situ* but deposited there as part of the strategies of refuse management at the site. Given the high density of most of these assemblages, each of them is considered to respond to a short event. Quite the opposite, assemblages consisting on wild fruits might represent primary refuse deposits

(Fig. 4.26). The fact that the items were heavily fragmented could be due to trampling effects, even produced after their deposition. The fragmentation could also have been originated during the consumption of those fruits.

Thus, the samples (especially the grain-rich samples) are adequate for further analyses, since they were not severely affected by postdepositional processes.

4.2.5.4. Which were the main cultivars at the site?

As previously stated, seven potential cultivars were identified in Camp del Colomer, four different cereals, two oil plants and one legume. How can we tell which of them were actually cultivated on purpose and if some were of higher economic importance than others?



4.27. Index of relative frequencies of the cultivated cereals recovered in Camp del Colomer.

As mentioned above, naked barley is very well represented at the site. That can also be observed when considering the index of relative abundance (Fig. 4.27). It is very likely, then, that this was the main crop at the site, although one should keep in mind that the excavation only affected a part of the original settlement. It would be of major interest to continue sampling this site if further excavations take place, in order to confirm this statement. The role of the rest of the crops is not so clear. Wheats were considerably badly represented, as well as oil plants. Peas were the second best represented taxon but only 12 seeds were recovered. Considering these results, it is likely, thus, that naked barley was cultivated as a grown as a monocrop at the site.

The presence of peas at the site was rather significant, since they were usually rather badly represented in the record. The high percentage of ubiquity with which it appeared could indicate that it was a relatively important crop at the site. It should be noted at this point that barley depletes soil nutrients rather intensively and that it is usually sown after pea (Jacomet, Brombacher & Dick 1989, table 24: 95). This would open the possibility to the practice of crop rotation at the site, which would support intensive farming practices. The review of ethnographic references carried out by R. Ebersbach demonstrates that there is a correlation between altitude and the use of manure. The higher the location of the plots, the larger the amount of manure used as fertilizer (Ebersbach 2002, Fig. 108: 131). One could propose that, given the available evidence, it seems very likely that intensive farming was practiced at the site. This would be confirmed by the remaining crops that have been identified: flax and opium poppy.

Flax and poppy were equally badly represented in the record but, in this case, there exist a large number of archaeological examples which demonstrate that these plants are severely underrepresented in charred form. For instance, in a compilation of results of seed and fruit analysis from Prehistoric pile-dwelling sites from lake Zurich, less than 1% of the poppy seeds were found in charred form, while the percentage for charred flax seeds was less than 3% (Jacomet, Brombacher & Dick 1989, table 32: 115). Poppy is slightly better represented than flax at Camp del Colomer. Poppy, like barley, needs systematic manuring in order to grow successfully, since it exhausts soil nutrients.

4.2.5.5. Local agriculture or grain trade in Camp del Colomer. Crop processing and ecology of the weed assemblages

As already stated in many archaeobotanical publications, one way of approaching the issue of local cereal production is analysing the stages of crop processing that are represented in the assemblages recovered within a site. Such evaluation can only be carried out on quantitatively significant samples, which are likely to represent single events in the past. These samples are presented in Fig. 4.28. The four samples were rather pure concentrations of naked barley without any chaff remains and a low proportion of weeds (most of them of the small, free, heavy group, which is typical for the last processing stages (Jones 1984)). Even though these samples were not charred *in situ*, they seemed to not have suffered very intense postdepositional effects, for which it was assumed that the final assemblage is representative of the originally discarded one. One fragment of grain produced prior to charring was identified in UE103, which might have originated during threshing, but the evidences are too scanty and do not allow conclusive interpretations.

SAMPLE	Dominant crop	Pure/ Mixed	Chaff + straw	Weed: grain	Processing stage (triplot)	FPreC	Density	*In situ* charring	Heating treatment
SJ01-UE100	ft (nb)	pure	no	0.3	clean product		low	no	250 LHR
SJ01-UE103	ft (nb)	pure	no	0.1	clean product	yes	low	no	250-300 LHR
SJ01-UE108	ft (nb)	pure	no	0.3	clean product		low	unlikely	250-300 LHR
SJ01-UE 109	ft (nb)	pure	no	0.1	clean product		low	no	250 LHR

Fig.4.28. Full taphonomic evaluation of the crop samples likely to represent single-events from Camp del Colomer (ft: free-threshing; nb: naked barley).

Thus, early stages of grain processing (typical of producer sites) were not identified in Camp del Colomer. Consequently, in order to assess the local cultivation of the cereals we could only rely on the ecological requirements of the weed assemblage accompanying the samples which correspond to crop products or crop processing residues. In this case, *Thlaspi arvense* was the more frequently encountered weed taxon. This weed only grows above 800 m a.s.l. (the site is nearly at 1300 m a.s.l.), at present, in our region (de Bolòs et al. 2005). Therefore, it is very likely that the cereals were grown in the close vicinities of the site. Besides this, several archaeological features and findings support the hypothesis of a local cultivation of cereals, since several storage pits and jars were uncovered.

4.2.5.6.The weed assemblage of Camp del Colomer and its implications for crop husbandry practices

Weeds and ruderals make a large ecological group that is formed by plants which have been brought by humans (anthropochores) and local plants which establish themselves as such (apophytes). Consequently, it may be very difficult to distinguish which plants acted as weeds in the past. For an evaluation of the weed spectrum of Neolithic sites, some authors have proposed to consider all plant macroremains (other than wood) recovered from similar samples (e.g. pits) (Kreuz & Schäfer 2011), while others consider that only those coming from samples of pure crops which have been previously ascribed to a crop processing stage can be used (Bogaard 2004b), mainly because crop processing introduces bias in the weed assemblages and one should aim to compare like with like (Bogaard, Jones & Charles 2005). The latter criteria also allow the discarding of weed-rich samples, which could have originated after burning dung or as a result of the intentional gathering and consumption of wild plants.

	Classes (Ellenberg)	Reproduction type	Life span	Seed dimensions	Growth height	Flowering time	Germination period
Chenopodium album	Chenopodietea	seed	summer annual	fine	high	long	spring/ summer
***Polycnemum arvense* s.l.**	Secalietea	(Bogaard et al. 2001) seed	summer annual	fine	low	medium	autumn
Polygonum convolvulus	Secalietea	seed	summer annual	medium	medium	short	spring/ autumn
Reseda luteola	Artemisietea	seed	hemicryptophyte	fine	low	long	autumn
***Solanum* sp.**	Chenopodietea	seed	summer annual	medium	medium		cf. spring/ summer
Thlaspi arvense	Chenopodietea	seed	summer annual	fine	low	short early	spring/ autumn
Urtica dioica	Artemisietea	seed/ vegetative	hemicryptophyte	fine	low	long	spring

Fig. 4.29. Ecological characterization of the weed spectrum from Camp del Colomer (classes were obtained from Ellenberg et al. 1992, seed dimensions and growth height are classified following the criteria from Kreuz & Schäfer 2011 while flowering time follows Bogaard et al. 2001).

The potential weed plants from the samples consisting of pure crops are presented in Fig. 4.29. These are *Chenopodium album, Polycnemum arvense* s.l., *Polygonum convolvulus, Reseda luteola, Solanum* sp., *Thlaspi arvense* and *Urtica dioica.* These plants belong to the Chenopodietea, Secalietea and Artemisietea classes. Chenopodietea are among the best represented considering the number of items and their ubiquity. Most of the taxa reproduce by seeds, although *Urtica dioica* can also reproduce vegetatively. Most of them are also summer annuals. The plants are mainly of short size and have primarily small seeds. A mixture of taxa of short, medium and long flowering time is present. *Thlaspi arvense¸* the best represented taxon, is of short flowering time and early flowering period. The germination period is diverse, with mainly preferably autumn-germinating plants as well as some spring-summer-germinating taxa.

This weed assemblage would be typical of permanent fields (with mostly annual plants and lacking plants from woodland areas), not too intensively managed (with few plants with potentially vegetative reproduction and with several plants of short/medium flowering time) and probably sown in autumn (mainly autumn-germinating plants). It must be reminded here that, according to multiple ethnographic references (see chapter 2.2.1), sowing in areas at a high altitude might take place late in winter, instead of early autumn due to climatic reasons. Unfortunately, it is not possible to give such a precise timing for sowing considering the available data. There are some taxa which are not typical as field weeds like *Reseda luteola* or *Urtica dioica*. Some archaeobotanists have interpreted these finds as possible evidence of the access of herds to the fields, thus depositing their dung and bringing in taxa which are typical of other environments (Kreuz et al. 2005). The low height of most of the weed plants would indicate a low harvesting. This would imply threshing of the grain in bulk, which would have caused the fragmentation of a small proportion of the grain, as evidenced in the analysed assemblage. This type of bulk processing is in accordance with the bulk underground storage structures that were identified at the site.

4.2.5.7. Wild fruit exploitation at Camp del Colomer

Wild fruit exploitation might be difficult to demonstrate for most of the identified taxa in Camp del Colomer (as for many other sites). Nevertheless, a rapid look at the known traditional uses of these potentially gathered plants (Leporatti, Ivancheva 2003, Tardío, Pardo-de-Santayana & Morales 2006, Mears, Hillman 2007, Hadjichambis et al. 2008, Gausachs 2007, Gausachs 2008), allows the observation of the many potential edible and medicinal uses that some of the identified taxa could have had in the past (Fig. 4.30). Some of these plants, like *Reseda luteola*, could have been used as dying plants.

At a general scale, the data obtained from the PFAF database indicates that at least 9 edible plants and 10 species with medicinal use are present in the plant spectrum from Camp del Colomer. The number of taxa with known edible seeds or fruits is somewhat lower. These mainly concern *Corylus avellana, Pyrus malus, Pyrus communis, Quercus* sp., *Fragaria vesca, Rubus fruticosus* and *Sambucus nigra*.

Taxa	Fruits	Flowers	Young shoots	Aerial parts	Roots	Edib. rank.	Medic. rank.
Capsella bursa-pastoris s.l.		eaten raw		medicinal uses, basal leaves stewed		3	2
Chenopodium album				young leaves stewed		3	2
Chenopodium polyspermum type						2	0
Galium aparine subsp. spurium				medicinal use		2	3
Hyoscyamus niger				medicinal use		0	4
Polygonum aviculare				medicinal use		2	3
Polygonum convolvulus						1	0
Reseda luteola						0	1
Solanum nigrum	Eaten raw			eaten boiled; medicinal use		2	2
Thlaspi arvense						2	2
cf. *Artemisia vulgaris*		preservative for making beer		Leafs used as condiment; medicinal use	infusion, with medicinal value	2	3
cf. *Linum catharticum*						0	2
Myosotis cf. scorpioides						0	1
Plantago major subsp. intermedia	medicinal use			Leaves, medicinal use		2	3
Thymus serpyllum subsp. chamaedrys		flowered aerial part as herbal tea, liqueur and stews		Aerial part cooked in soups; infusion, with medicinal value		4	3
Urtica dioica			tender leaves and stems raw or stewed	leaves, medicinal use		5	5
Corylus avellana	eaten, sometimes unripe, often raw, dried or in cakes, stews or as condiment					5	2
Pyrus malus subsp. sylvestris	raw, liqueur					3	2
cf. *Pyrus communis* subsp. *pyraster*	raw, liqueur					2	1
Quercus sp.	fruits roasted, raw, boiled or grinded to flour to make bread		twigs and leves of Q. ilex, to preserve olives	barc and fruits of *Q. petraea* and robur used for medic. Purposes		2-5	2
Veronica cf. officinalis						1	2
Fragaria vesca	eaten raw, jam. Medicinal use		Leaves, medicinal use			3	3
Physalis alkekengi						2	2
Rubus fruticosus agg.	eaten raw or drank as liqueur or other beverages			medicinal uses	medicinal uses	5	3
Sambucus nigra/racemosa	medicinal uses, jam	medicinal uses, jam, herbal tea, liqueur				4	3
cf. *Artemisia campestris*				for preserving raisins		0	2

Fig. 4.30. Ethnobotanically known uses among the wild plants that were identified in the seed and fruit record of Camp del Colomer and edibility and medicinal ranks for each taxon (from www.pfaf.org).

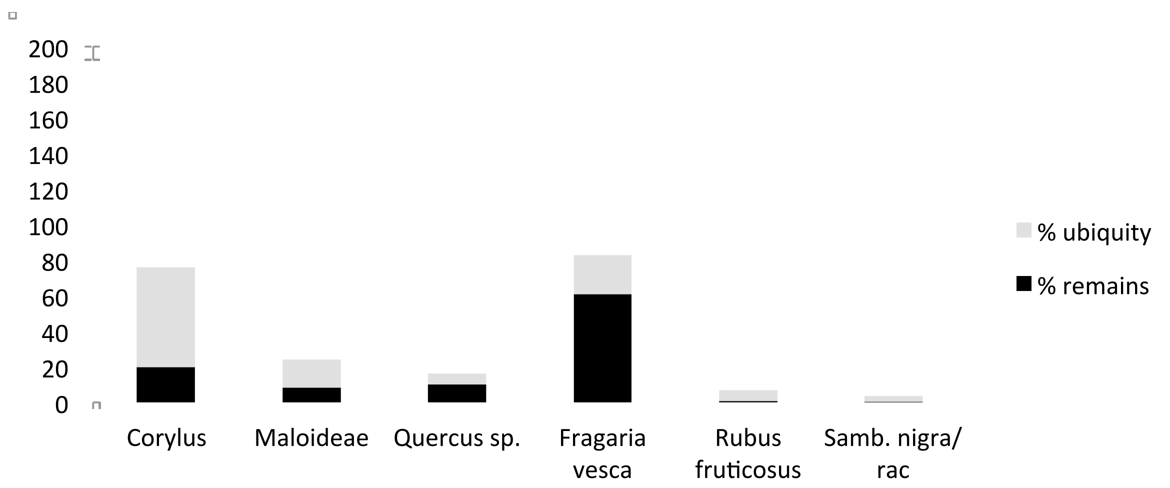


Fig. 4.31. Indexs of relative abundance of the edible wild taxa encountered in Camp del Colomer.

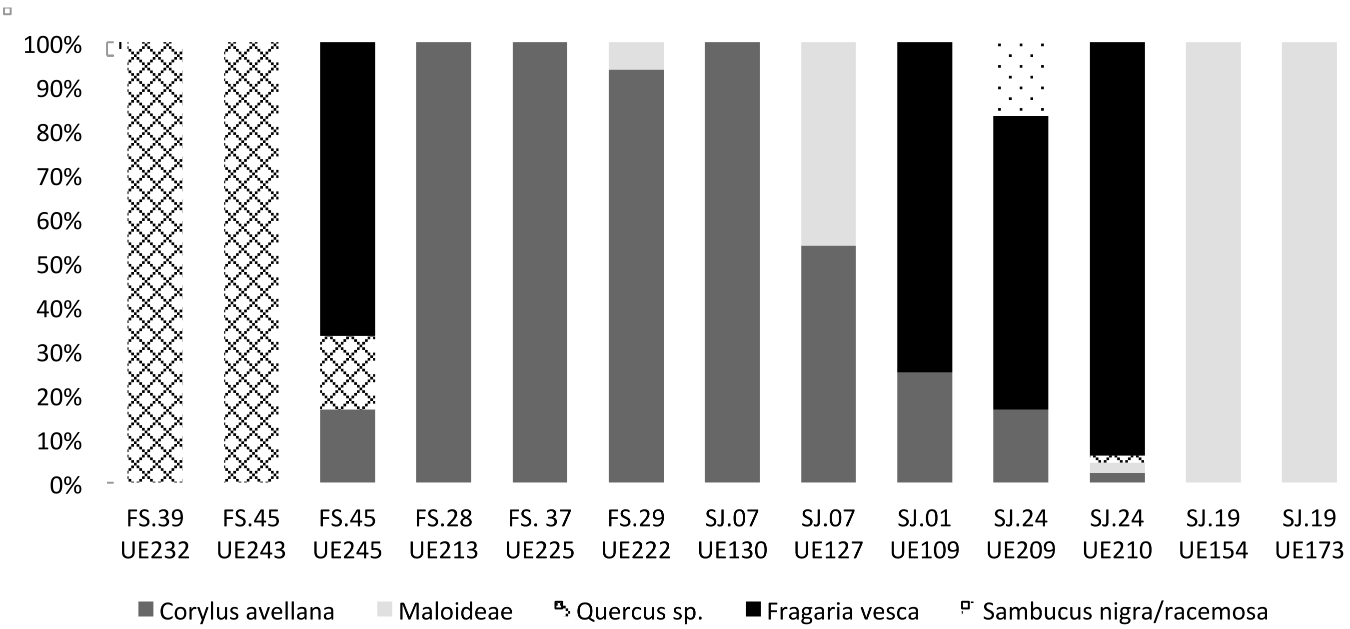


Fig. 4.32. Relative frequencies per sample among the edible wild taxa encountered in Camp del Colomer (all samples with 3 remains or more shown).

The representation of these taxa at the site was not equal, mainly due to taphonomic reasons (they are most likely consumed in different ways, which can affect their chances of preservation by charring) (Fig. 4.31). Nevertheless it is interesting to see that hazelnuts were the most ubiquitous taxon. Their relative frequency (proportion) was relatively low because wild strawberries were probably overrepresented (due to the many seeds that are found in each fruit). Wild strawberries were, in any case, well represented both considering the number of remains and the number of samples where they were recovered. Wild apple/pear and acorn were less well represented. Finds of bramble and elder were very scarce.

The collection period of most of these fruits would be autumn, except for wild strawberry and, possibly, bramble, which are collected in summer. Thus, the identification of these fruits in separate samples seems to support the interpretation that they were independently collected and processed. This fact indicates that wild fruit collection must have been an economically important practice in Camp del Colomer.

One sample was particularly rich in wild plants, most of which were not edible. That is sample UE210 from the storage pit SJ-24. As mentioned above, it contained high quantities of plants from pastures and grasslands, but also weeds and ruderals, together with edible plants like acorns and wild strawberries. This sample is very likely to be of mixed origin. It is a large sample (48 litres of sediment) and it is possible that a diverse number of actions (maybe from different episodes of refuse disposal) are represented in it. The presence of plants from pastures and grasslands might be the result of the use of animal dung as fuel. That is, though, not possible to demonstrate at this stage of research. The large availability of other fuel resources such as wood would make the use of dung unnecessary. If this was the case, it would have been a cultural choice.

As mentioned above, there is a clear distribution of these taxa in different features. This fact is of much palaeoeconomic significance, since it might be suggesting that some of these samples could respond to single events in the past. As can be observed in Fig. 4.32, there is a number of samples characterized by the major representation of hazelnut (mainly those from the pits FS-28, FS-37, FS-29 and SJ-07, two samples where acorn is the only taxon (in pits FS-39 and FS-45), two more where only apple/pear was found (both in the storage pit SJ-19, and four where wild strawberry yielded the majority of remains (in the storage pits SJ-01 and SJ-24 and in the pit FS-45). All of the samples coming from pits but one (UE245 of FS-245) are dominated either by acorns or hazelnuts. All of the samples retrieved from storage pits but one (UE 130 of SJ-07) yielded remains of Maloideae and Fragaria. This, together with previous taphonomic observations, suggests that the samples retrieved from pits are, in general, of different taphonomic origin than those retrieved from storage pits. The former might have originated as primary refuse of the roasting of these fruits inside the pits, while the latter were discarded as residues of consumption (secondary refuse).

4.2.5.8. Evaluation of the distribution of the taxa at a spatial level

For a final evaluation of the economic significance of the analysed samples, it is necessary to carry out a spatial analysis of their distribution.

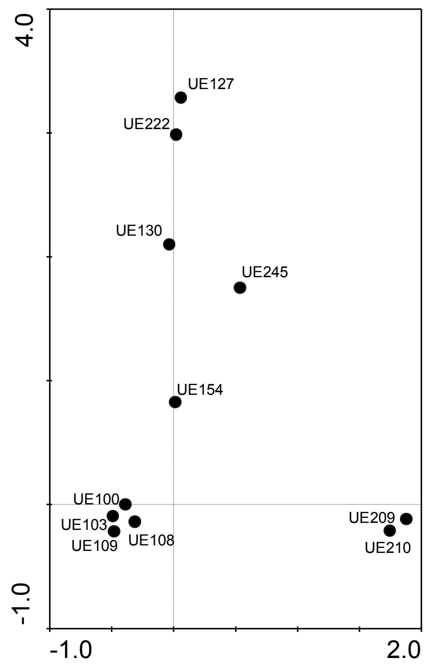


Fig. 4.33. Results of the CA of the samples of Camp del Colomer.

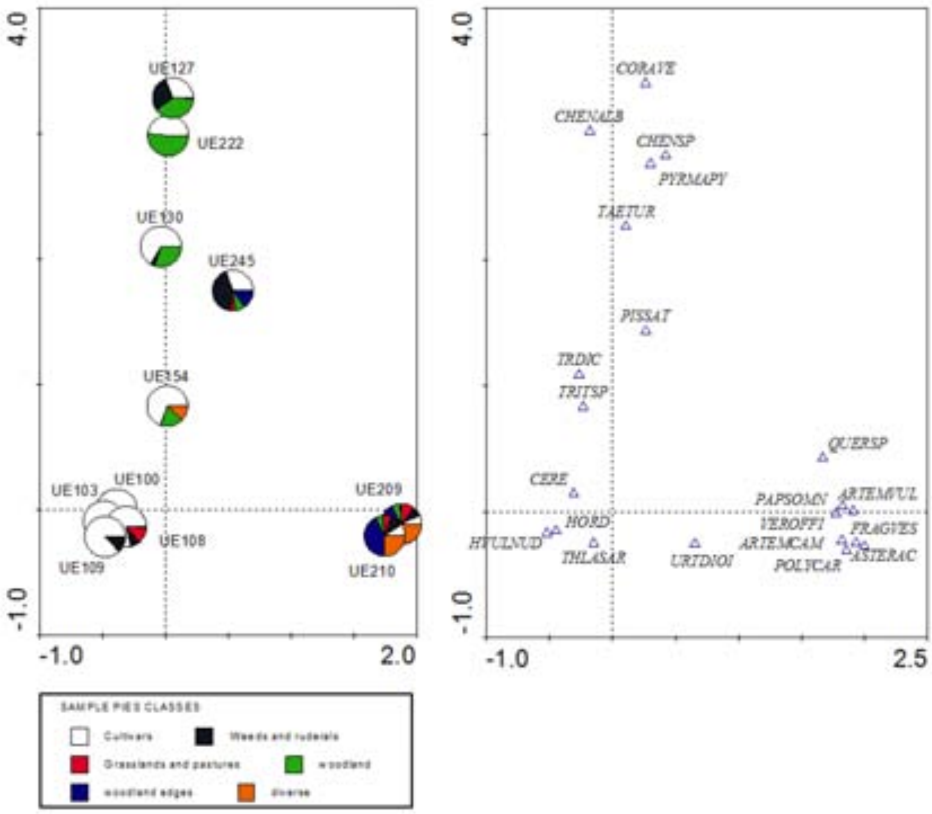


Fig. 4.34.Results of the CA of the samples of Camp del Colomer, after grouping taxa per ecological group (left) and showing the distribution of all the taxa (right). Inertia: Axis 1= 29.1%; axis 2= 26%.

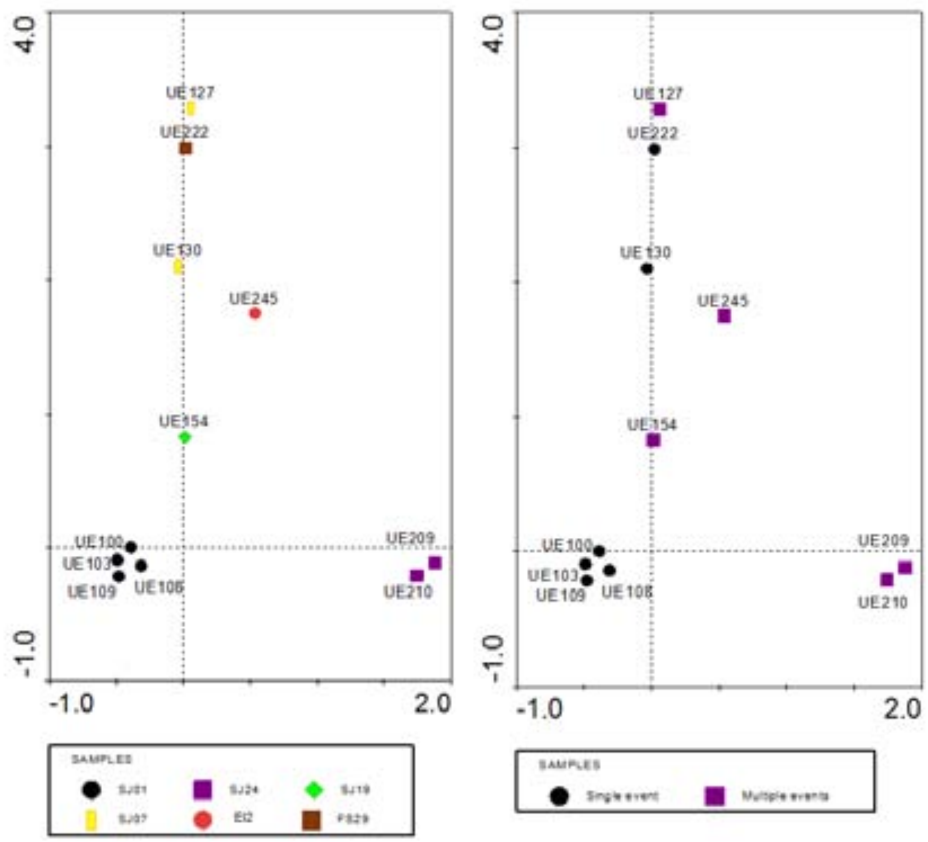


Fig. 4.35. Results of the CA of the samples of Camp del Colomer after grouping the samples per archaeological feature (left) and per taphonomic origin (right).

It was considered of interest to undertake Correspondence Analysis (CA) in order to see how samples grouped when considering all available data and plotting them according to several of the variables considered until now: the botanical composition, the type of feature and the number of events (potentially) represented. Besides, it was considered equally necessary to represent some of the formerly presented results (e.g. grain-rich samples, samples with edible wild plants, etc.) on the site plan in order to see how they are organized spatially.

The CA was carried out on samples with more than 35 identified individuals (n: 12) and taxa that appeared in less than 3 samples were eliminated. Sample UE243 from the pit FS-45 was eliminated after the first plot (not shown) since it was treated as an outlier due to the high proportion of acorns in its contents. The subsequent graph is presented in Fig. 4.33.

When plotting the samples in the same CA in pie charts and grouping the taxa per ecological group some patterns emerged (Fig. 4.34) First of all, the horizontal axis of the graph separates samples which were rich in cultivars from those which were not. The vertical axis opposed those samples which were rich in weeds and woodland taxa from those where cultivars and plants from woodland edges were better represented. When considering the taxa distribution in particular, it was possible to observe that the horizontal axis opposed *H. vulgare* var. *nudum* and *Thlaspi arvense* to a relatively large diversity of taxa where *Papaver somniferum* and *Quercus* sp. were found. The vertical axis, on the other hand, presented *Corylus, Chenopodium, Pyrus, Triticum aestivum/durum/turgidum* and *Pisum* on the positive side and *H. vulgare* var. *nudum*, *Thlaspi arvense* and a diverse variety of wild taxa on the negative side.

These results could be interpreted as supporting the existence of some significant distribution of the taxa. This, at the same time, would mean that refuse from consumption is not randomly distributed among the site. Quite the opposite, it indicates that some management took place. More importantly, it shows that all these resources were managed and consumed independently.

For this to be confirmed, the samples were grouped per archaeological feature and per taphonomic origin, following the results of our own analyses (Fig. 4.35). When observing the samples grouped per feature it seemed clear that, on the one hand, storage pits SJ-01 and SJ-24 were at opposite ends of the horizontal axis while, on the other hand, the storage pit SJ-07, the dwelling structure EI-2, the storage pit SJ-19 and the pit FS-29 were at the positive end of the vertical axis and SJ-01 and SJ-24 were at the negative end. This would indicate that the processes of formation of the stratigraphic units within each structure were very similar. This probably responds to their rapid re-filling of the structure and not to the fact that these were samples from the same activity. For this hypothesis to be confirmed, soil micromorphological analyses should have been carried out. SJ-01 is a good case to put as an example that the different samples, though similar in composition, respond to different actions, since the sampled stratigraphic units usually have other strata in between (see Fig. 4.36). On the other hand, it also indicates that the use that was given to each structure was rather different. It is important to notice at this stage that some refitting among the potsherd fragments found in the features SJ-01 and SJ-24 was possible. This probably means that their filling took place at the same time (and in a short period of time) and that their different botanical composition does not reflect different moments or occupation phases.

Finally, samples were grouped according to their taphonomic origin, distinguishing those identified as “likely to represent one single event” and those “likely to represent several actions in the past”. They seem to be distributed along the horizontal axis. All the samples which are likely to represent one single event in the past are at the negative side of this axis. These usually coincide with the samples with more remains from cultivars, while those samples where wild plants are better represented seem to be more complex in a taphonomic sense. This pattern could be showing that the consumption of cultivars (mainly naked barley) produced a larger amount of refuse which was discarded in some particular structures (in this case mainly the storage pit SJ-01). Conversely, the consumption of wild plants might be much sparser in time, and it might involve lower quantities of refuse.

It is possible that the samples which are rich in naked barley, were produced in a relatively short period of time. The important quantities of barley grains lacking the embryo could be due to the existence of a period of storage. Some insect pests feed from embryos during this process (the presented taphonomic analysis allows the discarding of postdepositional processes such as intense erosion as a cause and the fact that we are dealing with a hull-less grain also allows the omission of the possibility that this was produced during dehusking). Consequently, the analysed samples might be the result of their processing in bulk after storage. At this point the grain could have been roasted before storing it in jars for its piecemeal consumption (such practice was observed ethnographically, see (Ferchiou 1985)) or maybe, as in other ethnographic examples from Tibet, flour was made from roasted grain, a product which is called *Tsamba* (Li et al. 2011). In fact both possibilities are not exclusive.

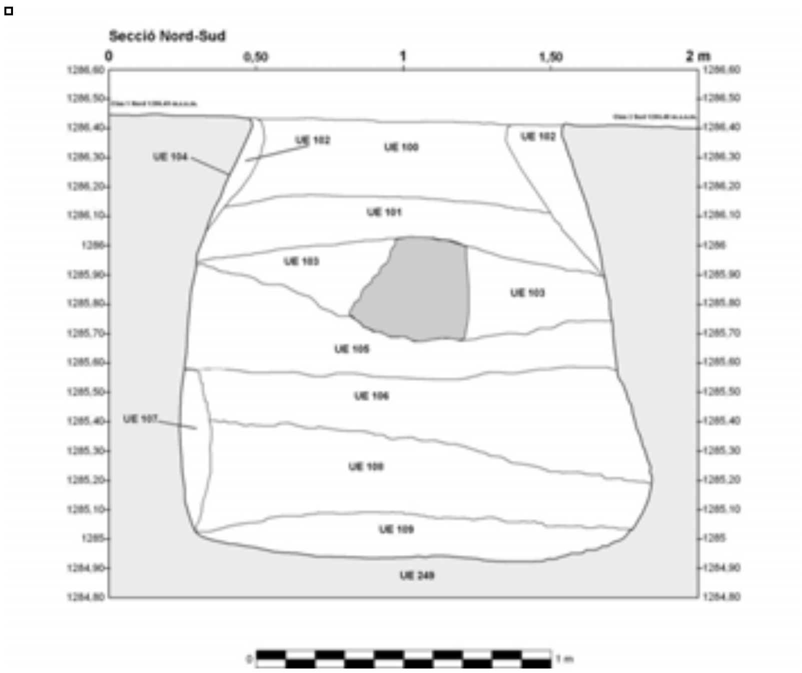


Fig. 4.36. Profile view of feature SJ-01 (storage pit), where the location of UE101, UE103, UE108 and UE109 can be observed (Drawing: Patrimoni Cultural d'Andorra).

The processing of wild plant foods could have taken place at a daily basis, together with the final culinary processing of cereal. This would lead to some of the mixed assemblages that have been observed, which also present lower densities of remains.

Finally, the samples from the storage pit SJ-24 show a different composition. This could respond, as previously stated, to a mixture of crop processing residues, the consumption of wild fruits for different purposes and even the burning of dung or grasses for particular purposes which are unknown to us.

The fact that poppy is mostly linked to feature SJ-24 (and other features not directly or uniquely related to cereal crops) might have two interpretations. One could be that poppy is not a cultivar at Camp del Colomer and the other one could be that poppy went through a completely different process as a crop with respect to barley. The latter interpretation is much more likely, especially considering the importance of this crop in central Europe in the second half of the Vth millennium cal BC (Jacomet 2007), and the taphonomic issues that affect its preservation.

The spatial representation of the analysed samples seems to yield some interesting information (Fig. 4.37). The remains of wild edible fruits are mainly concentrated in pits from the north-western sector. Hazelnuts are found in larger amounts in smaller pits, while acorns were primarily recovered in larger pits. This area must have been intensively used in the past for the processing of wild fruits. These pits could have been used as roasting pits for the processing of both acorns and hazelnuts. Both resources would be processed independently. One further feature with large amounts of hazelnut shells is the storage pit SJ-07, on the eastern side of the site.

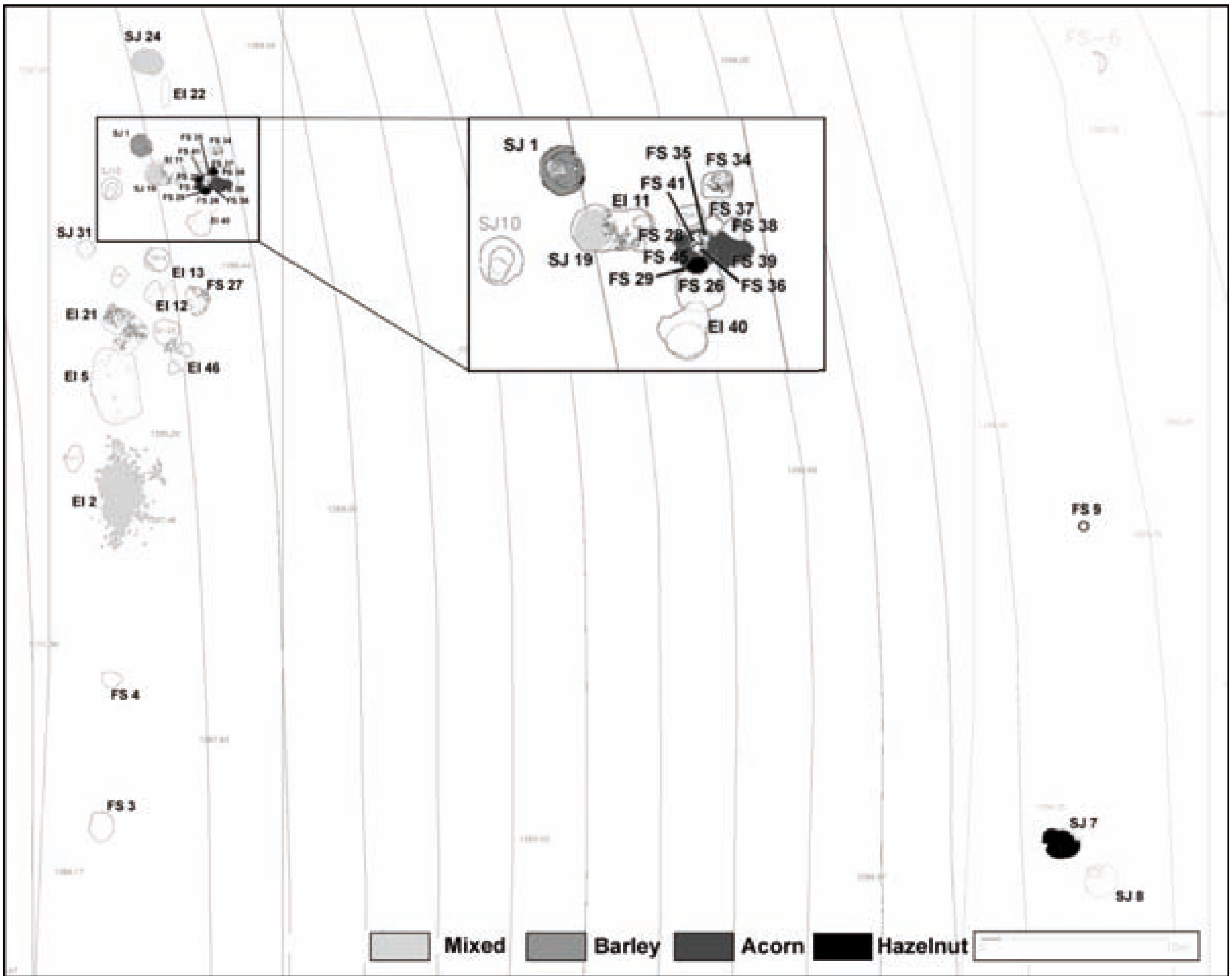


Fig. 4.37. Spatial distribution of the most representative samples from Camp del Colomer according to their principal botanical component (Plan: Patrimoni Cultural d'Andorra) (see Fig. 4.22 for the correspondence between UE and archaeological feature).

On the other hand, the largest amounts of charred grain were found in the storage pit SJ-01, not far from most of the pits related to wild fruits. Finally, two pits were probably filled after several different actions: SJ-24 and SJ-19. It is significant to see that the composition of the dwelling pit EI-02 is of mixed nature. This would indicate that the diversity observed in the storage pits SJ-24 and SJ-19 can potentially be linked to house activities and it reinforces the interpretation of wild strawberry as a consumed wild fruit, since it is also present within the household context. It equally demonstrates how refuse was managed on a daily basis and that dwelling spaces were kept rather clean. This has allowed the detection of a relatively large number of samples originated by a single activity.

4.2.6. Summary and conclusions at a site level

The archaeobotanical analysis of the samples from Camp del Colomer is of major significance. First of all, the site was extensively sampled and several types of structures were included in the analysis (pits, storage pits and dwelling pits). The state of preservation of the material was very good, which allowed the identification of a relatively large botanical spectrum. The density of remains per litre of soil was rather high, which also resulted in the identification of several potential single-refuse deposits.

Naked barley was defined as the main crop at the site, at least in the area that has been excavated. Pea was also interpreted as an important cultivar. Of much significance are the identification of flax and opium poppy, since they are both very rarely found in the north-eastern region of the Iberian Peninsula.

Fields seem to have been permanent, not too intensively managed, and sown in autumn. Barley was probably grown as a monocrop. The harvest would have been low on the straw and the threshing was probably carried out in bulk. It is possible, that animals were used during threshing or that they had access to the fields, considering some of the wild plants that have been found in association with crops (e.g. *Urtica dioica, Reseda luteola*). Grain storage would have taken place in large storage pits. The large concentrations of charred barley grain without embryo in SJ01 were interpreted as a result of the processing (roasting?) in bulk of the grain after their storage in pits and before their storage in jars. Pottery vessels could have been used at this point to facilitate the piecemeal consumption of the grain.

Of particular significance was the identification of several features with relatively monospecific concentration of different edible wild fruits, especially acorns and hazelnuts. These fruits are usually processed before consumption and these structures have been interpreted as potential roasting pits. The concentration of these structures in one area of the site and the stratigraphic relation between them was considered indicative of the repetition of this process over a long period of time, which could have only been carried out by the same household. These interpretations equally support the issue of permanence of the site and the cultivated plots.

4.3. Serra del Mas Bonet

4.3.1. Chronology and phases

There are several occupations in this open-air site; during the Late Early Neolithic (Epicardial, 4900-4600 cal BC), Middle Neolithic (4100-3400 cal BC), Late Neolithic (3400-2700 cal BC) and Early Bronze Age (2200-1500 cal BC) (Rosillo et al. 2012). For further archaeological information on the site see chapter 3.1.3.

4.3.2. Aims of the study

Serra del Mas Bonet offered the possibility of analysing several open-air occupations that took place in the same area during the Vth, IVth and IIIrd millennia cal BC. Some dwelling structures from the Late Neolithic period were identified, which were of much interest for the study of plant food consumption at the site. The identification of specifically symbolic structures with menhirs and horned stelae drew new potential scenarios for our analysis, since such contexts are usually associated with feasting events or other episodes of social coalescence.

4.3.3. Materials and methods

A total number of 132 samples from 103 archaeological features were taken (Fig. III.5). A minimum of 8 litres of sediment (1 bucket full of sediment) were aimed to sample per structure, regardless of the apparent lack of archaeobotanical material during the excavation works. References in the text to features and stratigraphic units follow the nomenclature given during fieldwork: **E** for "feature" and **C** for "stratigraphic unit" or layer. Each sample was considered as a context, since they were taken from different archaeological strata identified during fieldwork by archaeologists. The only exception was in feature 1, substructure 1D (a hearth and some charcoal-rich layers within a large dwelling pit), where some samples were taken from the same context but using a grid square to facilitate the comprehension of the spatial distribution of remains within the dwelling structure. The total volume of sediment processed was 1542,5 litres. Slightly over a half of these samples were possible to ascribe to a particular phase within the Neolithic, the rest were either from the Bronze and Modern Age or impossible to assign to a particular Prehistoric period (Fig. 4.38). For this reason, from now on, unless specified, we will only deal with the 70 samples from 41 structures and 869 litres of sediment that were dated to the Neolithic period with some certainty.

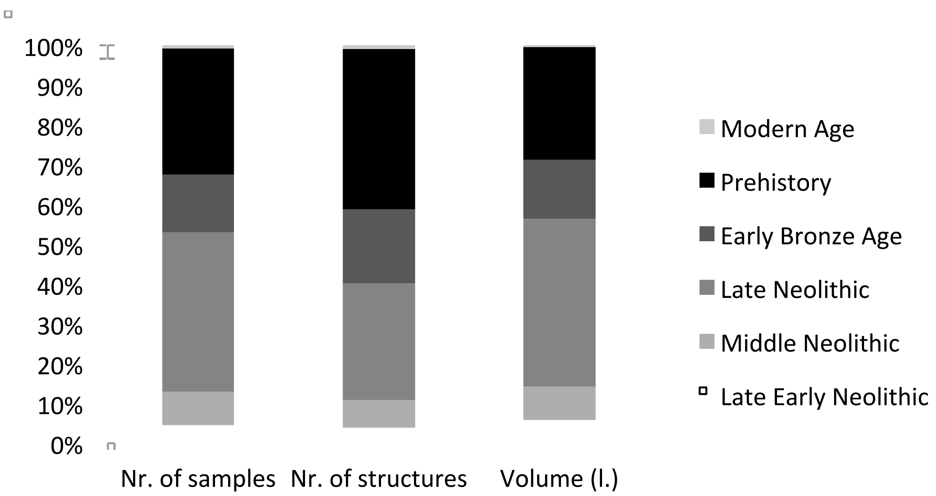


Fig. 4.38. Chronological ascription of the samples, structures and volume of sediment processed from Serra del Mas Bonet.

The average volume of sediment per sample was 12,5 litres, being 42 litres the maximum and 0,5 litres the minimum. Most of the samples were of between 10 and 17 litres of sediment. All of the samples were processed with a flotation machine.

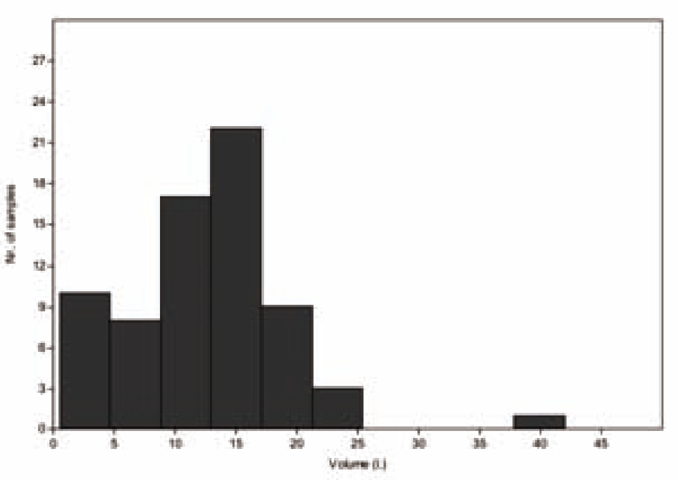


Fig. 4.39. Histogram showing the number of samples according to the volume of sediment of the samples of Serra del Mas Bonet.

All of the sampled contexts from the first two occupation phases of Serra del Mas Bonet were either pits or storage pits. These types of context were also well sampled for the final occupation phase in the Late Neolithic but other contexts were also sampled, like hearths, dwelling contexts, accumulations of charred material and especial contexts were stelae were found (Fig. 4.40). Thus, the Late Neolithic phase of occupation was the best represented at the site, the most extensively sampled and the one which could potentially yield more interesting results.

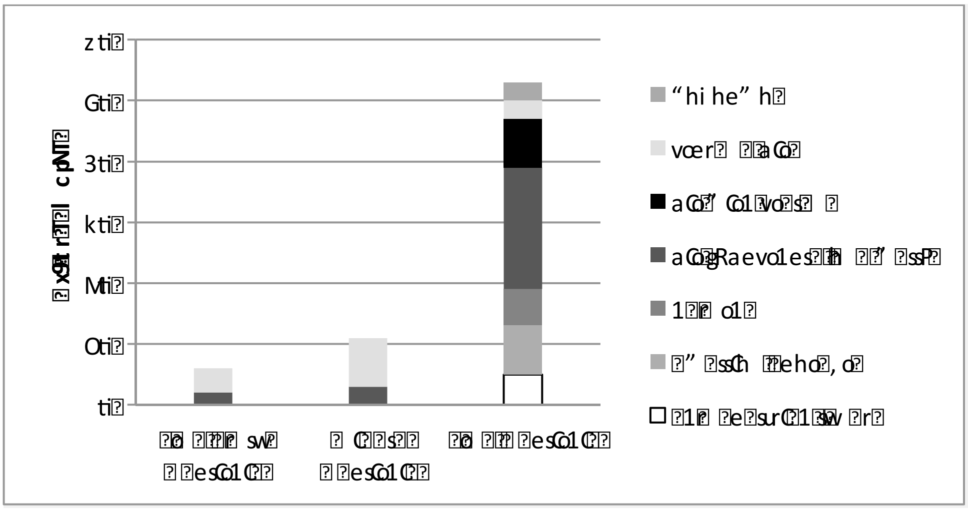


Fig. 4.40. Number of samples per period and type of context in Serra del Mas Bonet.

4.3.4. Results

A total number of 227 charred plant macroremains (other than charcoal) were obtained from the samples taken from the Neolithic occupations at Serra del Mas Bonet. The detailed results presented per sample can be found in Fig. III.6, while the results per settlement phase are presented in Fig. 4.41.

		LEN	MN	LN
Taxa	**Counting unit**	**Nr. of contexts: 3**	**Nr. of contexts: 2**	**Nr. of contexts: 14**
Cultivars				
Hordeum vulgare **(cf. incl.)**	MNI		1	20
Hordeum vulgare **var.** ***nudum***	MNI			2
Hordeum **sp.**	seed/fruit			19
Triticum aestivum/durum/turgidum	MNI		1	
Cerealia	seed/fruit		2	43
Pastures and grasslands				
Medicago **cf.** ***minima***	seed/fruit	1		
Melilotus **sp.**	seed/fruit	1		
Rumex **cf.** ***acetosella***	seed/fruit			1
Woodland areas				
Corylus avellana	pericarp fragment			1
Pinus **sp.**	needle fragment			1
Diverse/Unknown				
Lamiaceae	seed/fruit	30		
Medicago **sp.**	seed/fruit	3		
Papilionaceae	seed/fruit	24		
Poa **sp.**	seed/fruit	3		
Poaceae	seed/fruit	10		16
Polygonum **sp.**	seed/fruit	1		
Polygonaceae	seed/fruit	9		
Vicia/Pisum	total remains			9
Unidentified	total remains	13		13
	Nr. of remains	95	4	128
	Volume (l.)	10	28,5	122
	Density r/l	9,3	0,1	1,0
	N. of taxa	5	2	6

Fig. 4.41. Results of the seed and fruit analysis of Serra del Mas Bonet: identified taxa, counting unit and ecological group (see abbreviations in chapter 3.2.7.). The results were amalgamated per chronological phase (LEN: Late Early Neolithic; MN: Middle Neolithic; LN: Late Neolithic).

Twelve taxa were recovered at the site: three cultivars, *Hordeum vulgare, Hordeum vulgare* var. *nudum* and *Triticum aestivum/durum/turgidum*; three taxa which grow at present in dry grasslands, *Medicago* cf. *minima*, *Melilotus* sp. and *Rumex acetosella;* two taxa from woodland formations, *Corylus avellana* and *Pinus* sp.; and the rest of the taxa were not possible to ascribe to any ecological group, Lamiaceae, *Poa* sp., *Polygonum* sp., *Vicia/Pisum*.

4.3.4.1. The number of items and taxa per context

The number of items per sample was extremely low (Fig. 4.42). In addition to the large number of samples which yielded no plant macroremains (n: 51), seventeen samples produced less than 30 plant macroremains. In short, only two (out of 70) samples produced more than 35 plant macroremains (other than charcoal). These two samples are E-117 C-1 (a storage pit, Late Early Neolithic phase) and E-1, substructure 1D C-5 (a hearth within a dwelling structure, Late Neolithic phase). The number of taxa per sample was equally low (14 samples only yielded one single taxon). The largest botanical diversity was found in sample E-117 C-1, where 5 taxa were identified, all from wild herbaceous plants: *Medicago minima, Melilotus* sp., Lamiaceae, Poaceae and Polygonaceae.

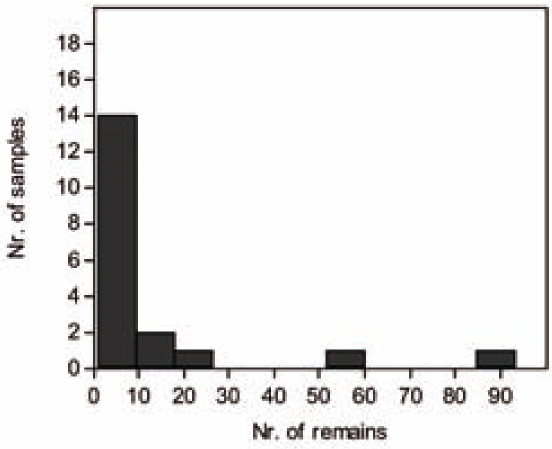


Fig. 4.42. Histogram showing the number of samples according to the number of remains produced in Serra del Mas Bonet.

4.3.4.2.The number of items per type of context

The type of structures that were sampled in Serra del Mas Bonet was rather diverse. They did not contribute in the same way to the archaeobotanical dataset. Most of the plant remains came from storage pits, hearths and waste accumulations. Post holes did not yield any plant macroremains for the Neolithic period, while dwelling structures and other pits produced a low amount of items.

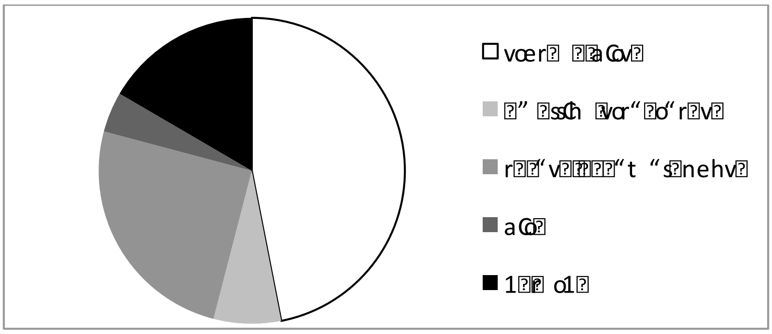


Fig. 4.43. Relative proportions among the number of items obtained from each type of structure in Serra del Mas Bonet.

4.3.4.3. The number of items and taxa per phase

Most of the plant remains are from the Late Early Neolithic (n: 95) and the Late Neolithic (n: 128) phases. Only 4 items were recovered in the samples from the Middle Neolithic. The number of taxa per settlement phase was very low: 5 in the Late Early Neolithic phase, 2 in the Middle Neolithic and 6 in the Late Neolithic.

4.3.4.4.The botanical spectrum per phase

The botanical spectrum of the site was very limited. For the Early Neolithic phase, only wild plants were recovered, mainly herbaceous plants from pastures and grasslands. Cultivars appeared for the first time during the Middle Neolithic phase. Only a few remains were recovered but both hulled barley and naked wheat were identified. In the Late Neolithic phase, a somewhat wider diversity of taxa was found. Naked and hulled barley were identified, along with some taxa from woodland areas (*Pinus* sp. and *Corylus avellana*) and from dry grasslands, or even ruderalized areas (*Rumex acetosella*). At a general scale, the best-represented taxon was hulled barley but the overall number of items was very small.

4.3.5. Discussion

4.3.5.1. Was the sampling strategy adequate enough? Why were the samples so poor in remains?

The sampling strategy applied in Serra del Mas Bonet site was very accurate and was intended to recover charcoal and microfaunal remains, besides seeds and fruits. Nearly all of the archaeological features were sampled, even those of which the chronological ascription was not clear. Only such a sampling strategy allows a real approach to the analysis of presence and absence of archaeobotanical remains within a site. Unfortunately, as already mentioned above, only two of the samples yielded more than 35 seed and fruit remains. No settlement phase reached the desired 384 items, for which the results are not optimal for palaeoeconomic interpretations. Consequently, it feels necessary to wonder whether the sampling strategy was efficient, and why we got such poor results on charred plant macroremains.

Other authors have already highlighted that, in many cases, the more extensive the sampling is the lower the densities of plant remains per feature seem to become (Bogaard & Jones 2007). However, that is no argument to not continue sampling, since absences of materials may be as informative as their presence (Pearsall 1989, Lennstrom & Hastorf 1995, Antolín 2010a). It is interesting to note, though, that, after decades of systematic sampling of Neolithic open-air sites in Europe, some structures seem to consistently lack plant macroremains (seeds and fruits). That would be the case of postholes (e.g. Bogaard & Jones, *op.cit.*). In Serra del Mas Bonet, more than 500 litres of sediment (considering all samples, not only the ones ascribed to the Neolithic period) from these structures were retrieved and they mostly produced unidentifiable macroremains. When thinking on efficiency terms, it is worthwhile noticing the fact that more than 400 litres of soil from structures of unknown function and chronology were processed. Most of the archaeological features that are not dated have a lack of archaeological material. Usually, the absence of such indicators of waste disposal actions means that these structures were not used for discarding refuse. For this reason, one could assume that those structures lacking archaeological material as well as archaeobotanical material (observable during excavation), are very likely to not yield enough plant remains for palaeoeconomic analyses. Consequently, one could randomly sample them just for ascertaining that they are not rich in plant remains and, by doing this, make the whole strategy more efficient.

In conclusion, one should say that the accurate sampling in Serra del Mas Bonet was methodologically interesting but largely inefficient (concerning seed and fruit remains) when considering the amount of information produced. This inefficiency is due to the fact that structures which usually do not produce much archaeobotanical remains were frequently sampled and that many features without much archaeological material (and, for this reason, undated) were also sampled, even when no charred material was visible during excavation.

Concerning the paucity of remains yielded by these samples, one should evaluate whether it was due to the volume of the samples. The minimum volume taken per sample (8 litres) was a bit low (around 20 litres is preferable), but, in any case, only 17 samples were of less than 8 litres of volume, for which one cannot assume that the poor results were derived from the processing of small samples. The lack of archaeobotanical remains at the site must be related to preservation issues or the management of residues within the site.

4.3.5.2. Insights on plant food economy in Serra del Mas Bonet from the Vth to the IIIrd millennium cal BC

The information that can be obtained from the seed and fruit record of Serra del Mas Bonet is very limited. Nevertheless, some aspects of interest can be considered for the three settlement phases that were identified.

The data belonging to the **Late Early Neolithic** period are slightly problematic. First of all, no domestic plants were retrieved, for which it could not be confirmed from an archaeobotanical point of view that agriculture was practiced at the site (even though agriculture seemed to be practiced according to the results of use-wear analyses on lithic tools and the presence of storage pits at the site). Secondly, a relatively large quantity of wild herbaceous plants was recovered, mainly in E-117 C-1 (a storage pit). This assemblage could correspond to several actions, like the burning of local vegetation as part of some cleaning operation, or the burning of animal dung. We lack of any report of the medicinal or alimentary value of the identified taxa. It must be highlighted that these remains were found together with charcoal fragments of *Olea* sp., which is rather unusual for this area in this chronology (Antolín, López-Bultó & Piqué in press). It remains unclear, then, whether these archaeobotanical remains can actually be related to the pottery fragments which allowed the dating of the structure.

For the **Middle Neolithic** the record was very scarce, but two cereal taxa were identified: hulled barley and naked wheat. They were recovered in different archaeological features (the storage pits, E-67 and E-134, respectively). These finds, together with other archaeological evidences, like the presence of sickle blades and storage pits at the site, support the interpretation in favour of the existence of agricultural practices at the site.

The evidences for the **Late Neolithic** phase are slightly more economically significant. Most of the structures which yielded charred plant remains belong to the complex feature E-1, which seems to be a large dwelling pit with several subs-structures (see, for details, Fig. 4.44). The rest of the structures with plant remains (E-17, a pit containing a stela, E-48, a dwelling structure with a hearth, and E-185,a storage pit), though, are distributed along the whole surface of the site. While E-1, E-48 and E-185 seem to be more related to dwelling contexts, E-17 is more related to other areas of the social life of the community, since several singular elements were uncovered, which give to this feature a particular signification.

The complex E-1 is the one which yielded more interesting results (Fig. 4.44; Fig. III.6). The spatial distribution of the plant remains seems to show a concentration of items around the two hearths (E-1O and E-1P). This indicates that these are potential residues of everyday cooking activities. According to these results, these activities would take place inside the domestic space, and only in a particular sector (south) within it.

Most of the identified remains were of hulled barley, though naked barley could also be present at the site. One fragment of (undifferentiated) barley produced prior to charring was identified. This evidence could point towards the existence of some processing (threshing? dehusking?) of the grains, which would indicate that the crop was grown for human consumption. Unfortunately, the meagre data cannot be considered as conclusive. The presence of *Vicia/Pisum* within this context could demonstrate the cultivation of some plant within the legume group. Unfortunately, the state of preservation of the remains did not allow a more precise identification.

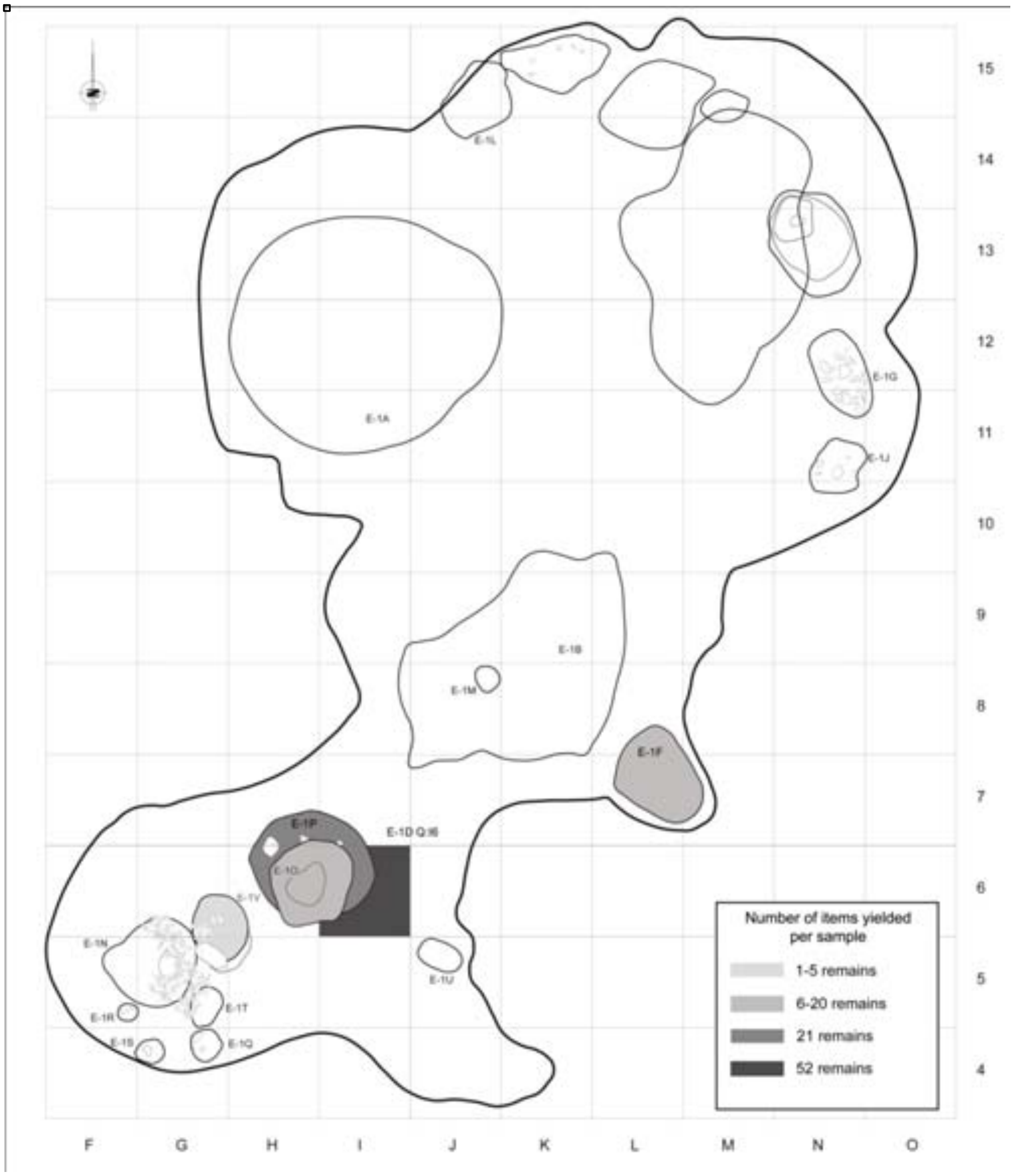


Fig. 4.44. Spatial distribution of the plant macroremains (other than charcoal) recovered in the dwelling structure E-1 (Late Neolithic phase) in Serra del Mas Bonet.

The consumption of wild fruits is also attested in the dwelling complex E-1. One fragment of hazelnut shell was recovered in E-1D. This taxon was not identified in the charcoal record, for which it is most likely that hazels were mainly exploited for their fruits.

One final comment should be added concerning feature E-17 (a storage pit), which was interpreted as a structure with some ritual meaning. Only two charred plant remains were recovered inside the structure, one of which was a fragment of (undifferentiated) barley. This is a very small record compared to the abundant number of faunal remains in the feature. It is difficult to say whether cereal remains could be underrepresented due to taphonomic reasons. In any case, the available evidence does not confirm the role of plant foods in the social activities that could have been related with this feature. One should still consider the possibility that they could have been eaten raw and were not preserved.

4.3.6. Summary and conclusions at a site level

The archaeobotanical study of the samples from Serra del Mas Bonet produced limited results. Despite a very extensive sampling, the archaeobotanical materials retrieved were very scarce and poorly preserved. The most relevant data concerning plant food economy belong to the Late Neolithic phase, where there seems to be some regular consumption of barley in domestic contexts. Of particular social significance is the fact that, considering the meagre available evidence, cooking activities seem to have taken place inside the house.

4.4. La Dou

4.4.1. Chronology and phases

La Dou is an open-air settlement. Several radiocarbon dates were carried out, some of them on charred grains. They expand from *c.* 4900 until 4300 cal BC. G. Alcalde and others consider that this could be explained as the result of several occupations during 350-400 years (Alcalde et al. 2012). For more details on the site, see chapter 3.1.4.

4.4.2. Aims of the study

La Dou was located at a short distance from a palaeolake. It was, for this reason, interesting to approach plant food economy at this site in order to compare it with other Neolithic lakeshore occupations. Besides, a relatively large excavation was carried out, for which data on several potentially different domestic units could have been available for comparison.

4.4.3. Previous archaeobotanical analyses

The first investigations at the site in 2005 were carried out as a rescue excavation. The samples were processed by the archaeological team and the plant macroremains were analysed by R. Buxó (Buxó 2007b). These remains came from Structure 2 (Sector 0). A concentration of fruit stones of *Crataegus monogyna* (MNI: 216) was identified.

4.4.4. Materials and methods

A large number of samples were taken during the several seasons of excavation of La Dou. Fifty-four of these samples were processed for this study (Fig. III.7). Of these, 41 were assigned to the Neolithic period (29 to the Late Early Neolithic and 12 to the Early Middle Neolithic). Ten samples were dated to the Iron Age. For this reason, they were not included in further analyses.

The chronological ascription of the samples was difficult to carry out. Some C14 dates (on charred grain) were obtained, but finds of pottery fragments were scarce, and these were very small and uninformative, for which the chronology of many features was unknown. For this evaluation, nearby contexts were ascribed to the same period, especially when they presented some spatial correlation (similar depths, meaningful spatial disposition, following at all times the observations done by archaeologists). It was also decided to divide the samples into two "settlement phases", one in the Late Early Neolithic, and one in the Early Middle Neolithic. It is, for the moment, impossible to demonstrate whether these settlement phases could actually be the outcome of several occupation phases or just one long period of occupation. In any case, it was considered practical for a palaeoeconomic evaluation of the data to divide the results into two chronological phases.

It must also be noted that there were some further difficulties with the identification of the origin of the samples, since their labelling was frequently too imprecise. This was solved, most of the times, with the help of the archaeologists, but some samples were not possible to identify due to their problematic labelling. These were: “superficial sample NW”, “Layer 3” and “Lower layer”.

Even though, strictly speaking, judgement samples were taken at this site, it must be highlighted that there was a big effort in sampling as many features as possible, making the sampling rather systematic. One of the difficulties of the excavation of La Dou was the absence of clear occupational layers. If anything, only negative structures were visible, especially those which were richer in charred organic material. For this reason, the most frequently sampled types of contexts were charcoal-rich layers and hearths in pits (Fig. 4.45).

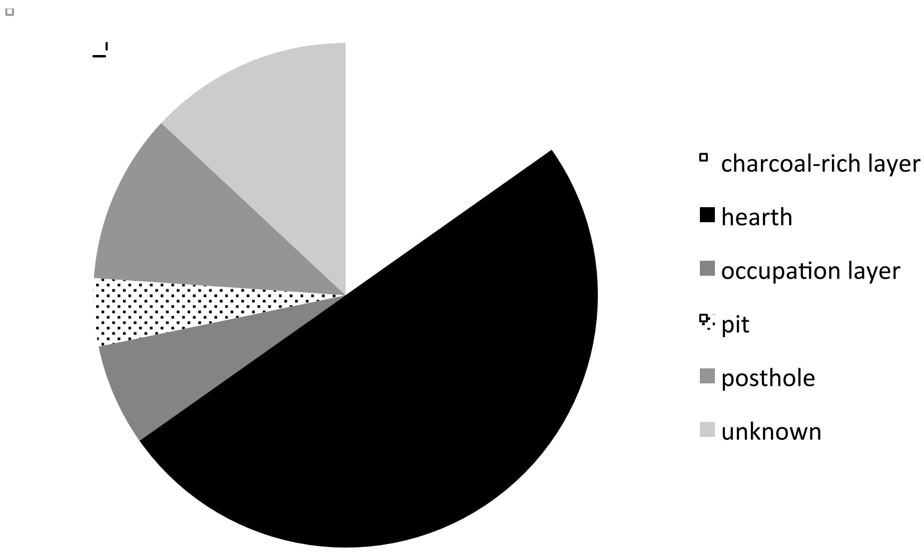


Fig. 4.45. Number of samples per type of context in La Dou.

The average volume of sediment taken per sample was of 14.57 litres. Most of the samples were of around ten litres or less (n: 25), while only around 8 samples were clearly above 20 litres of sediment (Fig. 4.46). All samples were processed with the aid of a flotation machine.

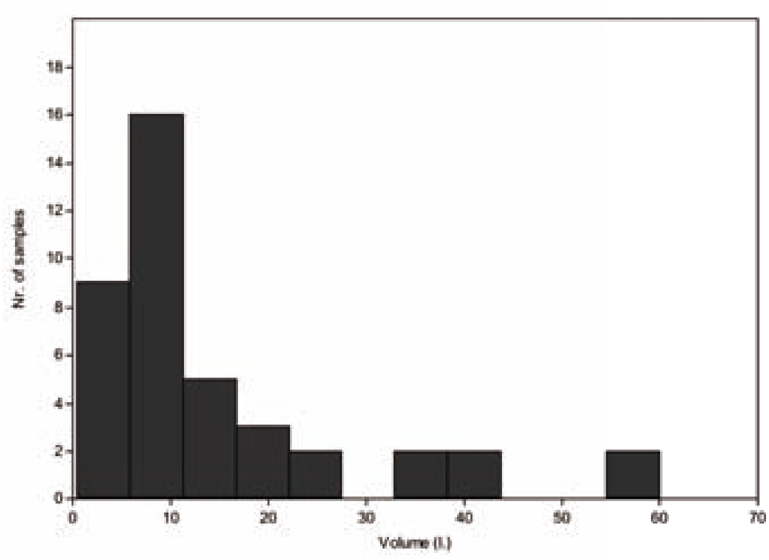


Fig. 4.46. Relation between the number of samples and the volume of sediment processed in La Dou.

4.4.5. Results

A small number of charred plant macroremains, 174, were retrieved from the samples from Neolithic contexts of La Dou site (see Fig. III.8). Fourteen taxa were identified: two cultivars, *Hordeum vulgare* var. *nudum* and *Triticum aestivum/durum/turgidum*; seven taxa that belonged to the weeds and ruderals group, *Avena* sp., *Chenopodium album*, *Galium aparine* subsp. *aparine*, *G. aparine* subsp. *spurium*, *Papaver* sp., *Polycnemum arvense* and *Polygonum convolvulus;* four taxa come from woodland areas, *Cornus sanguinea, Crataegus* sp., *Corylus avellana;* one from lakeshore or riverside woodland formations, *Vitis vinifera* subsp. *sylvestris*; and 1 from woodland edges and clearings, *Rubus fruticosus*.

4.4.5.1.The number of items and taxa per context

Among the few samples which yielded plant remains (17 out of 41), most of them presented a very low amount, between 1 and 5 plant macroremains (n: 13) (see Fig. III.8). Only two samples yielded more than 35 plant remains: "Combustion residues NW", which dates to the Late Early Neolithic, and Layer 1 from Pit 2, which dates to the Early Middle Neolithic, both in sector G (Fig. III.8). A similar pattern was observed when considering the number of taxa per context. Most samples yielded 3 taxa or less, while only three samples allowed the recovery of 4 or 5 taxa (Fig. III.8). It is significant to note that the highest concentration of remains was found in sample Layer 1 Pit 2 (8,33 r/l), dated to the Late Early Neolithic, being in most cases below 0,3 r/l.

For these reasons, the results at a context level will barely be discussed here (see the complete results per context in Fig. III.8). They will only be presented in amalgamated form per chronological phase (Fig. 4.47).

4.4.5.2.The number of items and taxa per chronological phase

The number of items per phase was rather low, especially for the Late Early Neolithic. 53 plant remains were retrieved, 19 of which were not identifiable. On the other hand, 121 plant remains were obtained for the Early Middle Neolithic phase (Fig. 4.47).

		4900-4500 cal BC	4500-4300 cal BC
Taxa	**Counting unit**	**TOTAL LEN**	**TOTAL EMN**
Cultivars			
***Hordeum vulgare* var. *nudum* (cf. incl.)**	**MNI**		2
***Hordeum* sp.**	**seed/fruit**		**1**
***Triticum aestivum/durum/turgidum* (cf. incl.)**	**MNI**		**2**
***Triticum* sp.**	**seed/fruit**		**2**
Cerealia	**seed/fruit**	**4**	**14**
Weeds and ruderals			
***Avena* sp.**	**MNI**	**1**	**2**
Chenopodium album	**seed/fruit**		
***Galium aparine* subsp. *aparine*(cf. incl.)**	**seed/fruit**	**1**	**1**
Galium aparine* cf. subsp. *spurium	**seed/fruit**		**1**
***Papaver* sp.**	**seed/fruit**	**1**	
***Polycnemum arvense* s.l.**	**seed/fruit**	**1**	**1**
Polygonum convolvulus	**seed/fruit**		**1**
Wooldand areas			
Cornus sanguinea	**fruit stone fragment**	**1**	
Corylus avellana	**pericarp fragment**	**5**	**1**
***Crataegus* sp. type**	**fruit stone fragment**		**1**
Lakeshore/riverside vegetation			
***Vitis vinifera* subsp. *sylvestris* (cf. incl.)**	**seed/fruit**	**5**	**1**
Woodland edges and clearings			
***Rubus fruticosus* agg.**	**seed/fruit**	**1**	
Diverse/Unknown			
cf. Cyperaceae	**seed/fruit**		**1**
Papilionaceae	**seed/fruit**		**8**
cf. *Thymus* sp.	**seed/fruit**	**1**	
***Trifolium* sp. (small type)**	**seed/fruit**		**1**
***Vicia* sp. (small)**	**seed/fruit**	**1**	**10**
Vicia/Lathyrus	**seed/fruit**		**2**
Vicieae	**seed/fruit**		**1**
***Sambucus* sp.**	**seed/fruit**	**13**	**41**
Unidentified	**total remains**	**10**	**3**
Unidentifiable	**total remains**	**9**	**4**
Varia	**total remains**		**2**
	Nr. remains	**53**	**121**
	Volume (l.)	73	163
	Density r/l	0,73	0,74
	Nr. taxa	12	14

Fig. 4.47. Results of the seed and fruit analysis of La Dou: identified taxa, counting unit and ecological group (see abbreviations in chapter 3.2.7.). The results were amalgamated per chronological phase (LEN: Late Early Neolithic; EMN: Early Middle Neolithic).

4.4.5.3.The botanical spectrum per phase and type of context

The number of taxa from each phase is not so dissimilar, since 12 taxa were identified for the first one and 14 for the second.

In the Late Early Neolithic, some remains of cultivars were identified, more specifically, of cereals, but it was not possible to tell the type of cereal due to their poor state of preservation. Several ruderals were recovered, like *Avena* sp., *G. aparine* subsp. *aparine, Papaver* sp. and *Polycnemum arvense*. Among the wild fruits from woodland areas, *Cornus sanguinea* and *Corylus avellana* were also found. *Corylus* and *Vitis,* in fact, could have been gathered in the lakeshore woods around the palaeolake that was located close to La Dou site. Finally, some taxa from woodland edges and clearings, like *Rubus fruticosus*, were identified.

The spectrum for the Early Middle Neolithic phase was partly similar. Some identifiable cultivated cereals were recovered, including *H. vulgare* var. *nudum* and *T. aestivum/durum/turgidum*. The spectrum of weeds and ruderals was rather reduced, with some taxa which had been identified in the previous phase (*Avena* sp., *G. aparine* subsp. *aparine* or *Polycnemum arvense*) but also others like *G. aparine* subsp. *spurium* and *Polygonum convolvulus.* Only one fragment of shell of hazelnut, a fragment of fruitstone of *Crataegus* sp. and one pip of wild grape were retrieved. Specially significant was the large number of legumes (*Vicieae* group) that were recovered.

Concerning the general distribution of the taxa per type of context, it is significant to note that cereals and weeds were recovered in hearths, other accumulations of charred remains and occupational layers. Wild fruits were not recovered in occupational layers, only in hearths, charcoal-rich layers and Pit 2 (sector G).

4.4.6. Discussion

4.4.6.1. Was the sampling strategy adequate? What should be considered for future works at the site?

Large efforts were done at the site of La Dou in order to carry out a sampling strategy which was as systematic as possible. Nevertheless, the obtained results were rather poor. This might partly respond to the volume of the samples. The largest number of items was mostly obtained from samples of more than 15 litres and one concentration of material in a sample of 6 litres of volume (Layer 1, Pit 2). Besides, 13 out of 17 samples with charred plant macroremains were either hearths or accumulations of charcoal. Post holes did not produce any plant macroremains other than charcoal. The main reason for the scarcity of plant macroremains was not the sampling strategy. This is due to the poor preservation of charred remains at the site. Nevertheless, it is recommended to take larger samples (20-50 litres), when possible, in future work.

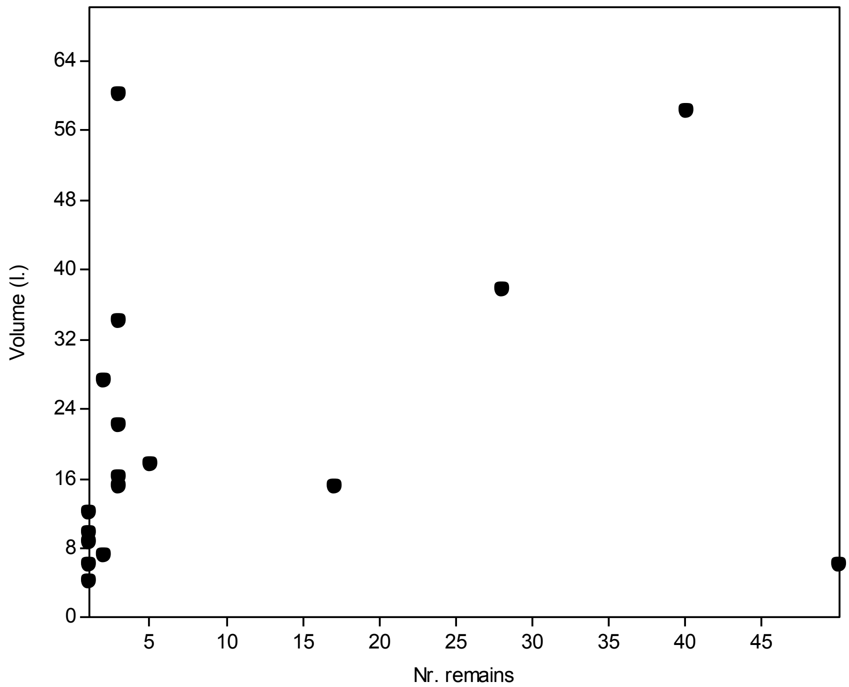


Fig. 4.48. Relation between the volume of the samples and the number of items obtained in La Dou.

4.4.6.2. Insights into plant food economy at the site of La Dou

Despite the meagre results, some interesting points can be proposed in order to approach plant food economy at La Dou site.

First of all, it is important to comment on the appearance of cultivars at the site. These are present in the two chronological phases. Their representation, though, is somewhat better for the second phase. Both naked wheat and barley were rather equally represented by a small number of remains. No further aspects concerning their cultivation can be put forward.

Concerning the distribution of cereals per type of context, it is interesting to see that they were recovered in hearths, in the Late Early Neolithic phase, and in hearths, accumulations of charred material and occupation layers, in the Early Middle Neolithic phase. Therefore, one could conclude that they were likely processed and consumed at the site, and that these remains would be the result of such activities.

Other cultivars might be present at the site, even though it is not possible to ascertain their real economic status at this stage of research. The seed of *Papaver* could belong to the group of cultivars. Unfortunately, its state of preservation did not allow its identification to species level and the number of recovered items does not support such interpretation, for the moment.

Finally, the relatively high number of seeds of the *Vicieae* group (present in 5 of the 10 samples with plant macroremains of the Early Middle Neolithic phase) might correspond either to their systematic collection as wild plants for alimentary purposes, or to weeds from arable land or to their possible cultivation and consumption. Unfortunately, they were not identifiable to genus or species level. Finally, it should be mentioned that the potential weeds would at least indicate permanent fields.

Taxa	Fruits	Flowers	Young shoots	Aerial parts	Roots	Edibility rank.	Medic. Rank.
Chenopodium album				Young leaves stewed		3	2
Galium aparine s.l.				Medicinal use		2	3
Polygonum convolvulus						1	0
Corylus avellana	Eaten, unripe or raw, dried or in cakes, stews or as condiment					5	2
Crataegus monogyna	C. monogyna, fruits eaten raw, also for making liqueur; medicinal value	Medicinal use	C. monogyna, leaves and young shoots eaten raw as snack	Medicinal use (leaves)		C. azarollus: 3; C. monogyna: 4	C. azarollus: 2; C. monogyna 5
Vitis vinifera subsp. *sylvestris*	eaten raw, for making beverages or vinegar		peeled, raw as a snack or prickled in brine			5	2
Rubus fruticosus agg.	eaten raw or drank as liqueur or other beverages			Medicinal uses	Medicinal uses	5	3

Fig. 4.49. Ethnobotanically known uses among the plants that were identified in the seed and fruit record of La Dou and edible and medicinal ranks for each taxon (from www.pfaf.org).

Concerning the role of wild plants in the economy, it was considered interesting to check the known uses of the identified taxa from ethnobotanical records (Leporatti & Ivancheva 2003, Tardío, Pardo-de-Santayana & Morales 2006), as well as the PFAF database, in order to take into account the edibility and medicinal ranks of these taxa (see Fig. 4.49).

Among the edible plants, none of the weeds and ruderals are clearly included, except for *Chenopodium album*. Instead, all of the identified woody taxa can be considered as edible, some of them with important medicinal value, such as *Crataegus monogyna*. It must be reminded that a concentration of more than 200 of these fruits was found in one structure (E-2, from sector 0, probably from the Early Middle Neolithic phase) and analysed by R. Buxó. This concentration could have originated due to the use of branches with fruits as fuel, but it is unlikely (only *Buxus sempervirens* was identified in the charcoal record from this hearth (Mensua & Piqué 2007a)), especially considering the fact that the flesh of the fruits was not preserved. The kernels could have been discarded after the consumption of the fruits. It is significant to note that the assemblage was highly fragmented (only 44 complete stones were recovered), for which they could have been intentionally crushed during some processing. Other potentially edible fruits were found. Unfortunately, the seeds of *Sambucus* sp. were not possible to identify to species level and their economic use is difficult to establish.

Several of the woody taxa appear in both chronological phases, which supports a hypothetical continuity of the exploitation of similar resources and environments. Their repeated appearance, despite the small assemblage recovered, should be interpretable on palaeoeconomic terms. It should be assumed that it is very likely that the consumption of wild fruits at the site was relatively often and economically significant. The presence of taxa like *Vitis* might be indicators of the economic exploitation of lakeshore areas.

4.4.7. Summary and conclusions

The site of La Dou allowed the recovery of some evidences of lakeside settlements in our region of study during the Vth millennium cal BC. Naked cereals were the only cultivars represented on the site. Along with them, a relatively rich weed assemblage was identified, but the taphonomic origin of these taxa is hard to reconstruct and their evaluation is therefore not possible at this stage of research. Finally, a relatively wide variety of wild fruits, some of which were probably obtained in lakeshore woodland formations, was recovered. Especially significant is the assemblage of *Crataegus monogyna* (studied by R. Buxó), probably belonging to the Early Middle Neolithic phase, which could indicate an intensive collection of this taxon, probably for human consumption.

The results of La Dou are, though scanty, very promising, especially considering that the excavations at the site are not finished and that more samples will probably be taken in the future. Larger volumes (between 20 and 50 litres of sediment) are recommended for the improvement of the archaeobotanical record.

4.5. Codella

4.5.1. Chronology and phases

The open-air site of Codella is considered to respond to a single occupation dated between 4780-4490 cal BC (Alcalde et al. 2008). For more information on the site, see chapter 3.1.5.

4.5.2. Aims of the study

The samples from Codella came from one dwelling structure that is thought to be located close to the shore of a palaeolake, like La Dou site (both sites are at a short distance, of less than 3 km from each other), for which comparable possibilities for approaching palaeoeconomy in lakeshore settlements were open. The availability of samples from a dwelling context also enabled the study of household activities and plant food consumption.

4.5.3. Materials and methods

The samples from Codella site were retrieved and processed by the archaeologists themselves (for the complete sample list see Fig. III.9). Unfortunately, the volume of sediment processed was not recorded. However, it is known that samples came from grid squares of 1 m^2, for which one can get an idea of the approximate maximum volume per sample that could have been processed (*c.* 20-30 litres). All samples were taken from a dwelling structure ("Estruct. Habitació"). In this case, then, all samples came from the same archaeological feature and they can be treated as a single context, even though it is very likely that they are the outcome of multiple events in the past.

4.5.4. Results

A total number of 24 plant macroremains were retrieved from these samples, all of them preserved by charring. Eight taxa were identified. The group of the cultivars was represented by one single taxon, *Triticum* sp. Among the weeds and ruderals, *Mercurialis annua* was identified. Two taxa from woodland formations were distinguished: *Cornus sanguinea* and *Corylus avellana*. Finally, four taxa of diverse or unknown ecology were recovered: *Bromus* sp., Rubiaceae, *Vicia* sp. (small type) and cf. *Sambucus* sp. The results per sample are presented in Fig. III.8. No attempt was done to calculate an MNI of any taxon, since these results have no statistical value.

4.5.4.1. The number of items per sample

The obtained number of items per sample was very low, between 1 and 9, and the overall results were very poor (24 remains). The sample which yielded more plant remains is the one from square 143U (see Fig. 4.50).

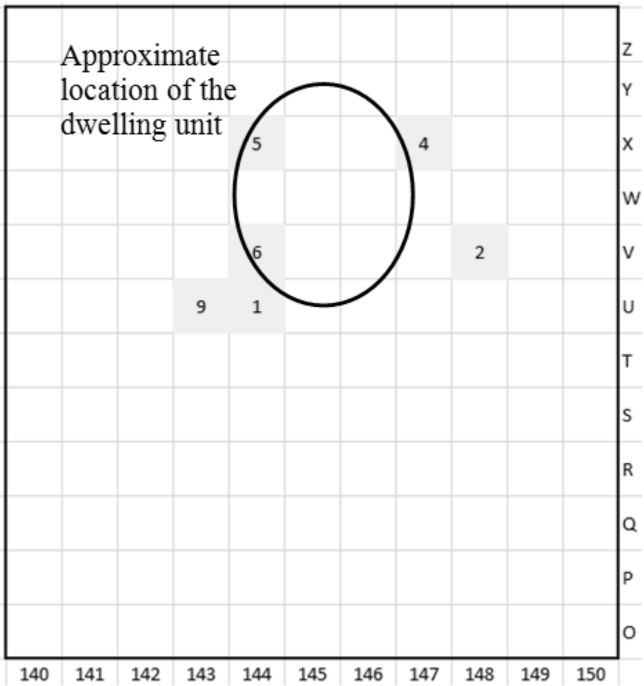


Fig. 4.50. Spatial distribution of the plant macroremains (other than charcoal) in Codella.

4.5.4.2. The botanical spectrum and its spatial distribution

The botanical spectrum recovered at Codella is very limited. Remains from cultivars were recovered in two close-by samples (144U and 144V). Unfortunately, their state of preservation did not allow their identification at a genus or species level. One of the two fragments of cereal grain that were recovered was produced prior to charring. The group of weed and ruderals was badly represented with only one remain of *Mercurialis annua*, though one should consider that the grains of *Bromus* sp. are likely to belong to this group. The remains of wild fruits from woodland areas (n: 3) were recovered in squares 144X and 147X.

4.5.5. Discussion

4.5.5.1. Methodological aspects

Several problems concerning the sampling and processing of the samples were encountered, mainly concerning the processing of the samples in the laboratory, which was carried out by untrained students. It is very likely that a more extensive sampling and a slightly more accurate laboratory processing of the samples would have resulted in significantly better results for the site, which would have been of high interest, given the lack of domestic contexts for this chronology and area. Nevertheless, some interpretations can be attempted.

4.5.5.2. Insights into plant food economy at the site of Codella

The available data from Codella allow a timid approach to plant food economy, especially considering that all these plant remains were recovered within a domestic unit and are very likely to respond to everyday consumption refuse.

The presence of some cereal grains and a fragment of grain produced prior to charring might indicate some processing of the grain for human consumption. Concerning crop husbandry practices, it is interesting to note that the only weed that has been recovered is *Mercurialis annua* which is typical of garden summer plots at present times. Unfortunately no further interpretations can be done at the present state of research.

Concerning crop processing practices and culinary processes, the finding of one fragment of grain produced prior to charring, together with querns which could be related to plant processing practices (Alcalde, Saña & Tornero 2009) could indicate that plant processing and cooking were taking place at the site, probably within the house space. Unfortunately, the archaeobotanical evidences are too scarce to reach any conclusions on this aspect.

Finally, wild fruit exploitation was mildly detected through the finding of hazelnut, the only wild plant of the list which has some nutritional value.

It might be of interest to note that wild fruits only appeared in the northern side of the hut and that cereals were recovered in the south west corner.

4.5.6. Summary and conclusions

The carpological record from Codella is of interest because it allowed the detection of some potential evidences of cereal grain processing within the space of the house, as well as hints of evidence of wild fruit consumption. Unfortunately, the meagre record of charred plant macroremains did not allow the identification of any further interaction with lakeshore or aquatic resources.

4.6. 120 Cave

4.6.1. Chronology and phases

In this work, only one of the phases of occupation of 120 Cave is studied: Layer III. It is thought that grain could have been stored inside the cave in pits and ceramic vessels (Agustí et al. 1987). It has recently been dated towards 4500 cal BC (X. Terrades, pers.com). For further details on the site, see chapter 3.1.6.

4.6.2. Aims of the study

120 Cave site was dug in the early 80s of the XXth century. It yielded some of the first Neolithic plant macroremains of our region. It was for this reason of very high interest to sample one of the storage pits from the site (which was kept for future analyses) in order to check whether the previous results could be considered representative and to increase the number of plant macroremains recovered at the site.

4.6.3. Previous analyses

The plant macroremains from 120 Cave were recovered by sorting the residue obtained mainly after the dry sieving of the sediment (under the supervision of R. Buxó). The sediment from two squares (D16 and H17; see the location in Fig. 4.53) was processed with a flotation machine with sieves of 2 and 0,5 mm but only one seed (*Vicia* sp.) was recovered (Agustí, Rueda & Buxó 1986). Dry-sieving is not considered an optimal method for the recovery of plant macroremains but it allowed the obtention of a relatively large number of items (Fig. 4.51).

	Pit 1	Pit 2	Pit 3	Pit 4	Pit 7	Pit 9	**Total**
Triticum aestivum/durum/turgidum	1	1		1	5	29	**37**
Triticum dicoccum		1				2	**3**
Hordeum vulgare				1	1	14	**16**
Hordeum vulgare var. *nudum*			3	1		6	**10**
Vicia sp.	1						**1**
Total	2	2	3	3	6	51	**67**

Fig. 4.51. Results from the seed and fruit analysis of 120 Cave performed by R. Buxó (Agustí, Rueda & Buxó 1986)

A relatively diversified spectrum of cereals was identified: naked wheat, emmer, hulled and naked barley. Only one structure yielded a considerable number of plant macroremains, pit 9 (n: 51).

4.6.4. Materials and methods

As mentioned in chapter 3.1.6, one of the pits was extracted from the site and transported to the Universitat Autònoma of Barcelona in order to carry out several scientific analyses. From the homogeneous content of this pit (Pit 10), one single sample of 35 litres of sediment was taken. Actually, it was the totality of sediment that was left inside this feature. It was processed with a flotation machine.

4.6.5. Results

Twelve charred plant macroremains (other than charcoal) were retrieved from the sample of 120 Cave. Four different taxa were identified: two cultivars (*Hordeum vulgare* var. *nudum, Triticum aestivum/durum/turgidum*); one potential weed or ruderal plant (*Setaria verticillata/viridis*); and one taxon that was not possible to ascribe to any ecological group (*Vicia* sp.). The total results were presented in Fig. 4.52.

Taxa	Counting unit	Pit 10
Cultivars		
***Hordeum vulgare* var. *nudum* (cf. incl.)**	seed/fruit	**2**
Triticum aestivum/durum/turgidum	seed/fruit	**3**
***Triticum* sp.**	FPostC	**1**
Cerealia	FPostC	**1**
Weeds and ruderals		
Setaria verticillata/viridis	seed/fruit	**1**
Diverse/Unknown		
Poaceae	FPostC	**1**
***Vicia sp.* (small)**	seed/fruit	**1**
***Vicia/Lathyrus* (small)**	seed/fruit	**1**
Varia	bud	**1**
	Total general	**12**
	Volume (l.)	**35**
	Density r/l	**0,34**
	Taxa	**4**

Fig. 4.52. Results of the seed and fruit analysis of 120 Cave: taxa, represented part, ecological group and number of items

The total number of remains and their density (around 0,3 r/l) were very low. Cultivars were the best represented group within the sample but it was interesting to note the presence of some potential weeds. No wild fruits (from woodland areas) were identified during this or previous analyses.

4.6.6. Discussion

4.6.6.1. Can we consider the previous archaeobotanical analyses from 120 Cave as representative? Did the present analysis bring out new information?

It is difficult to discern from the available data whether the previous analyses from 120 Cave are biased or not. The sample that was processed for this work did not present great differences from those of previous works (other than the better representation of small fragments of grain and potential weeds). The spatial representation of the total number of items retrieved per archaeological feature (all available data included) shows that the smaller pits contained few items, while the larger ones seem to have more remains. Besides, most remains are concentrated in the three central pits (Fig. 4.53). Given the particular characteristics of the site (a small cave located in a cliff), it seems unlikely that these materials were residues of everyday food processing. There is a possibility that these remains were just discarded on the floor surface after one short event (or a low number of events) and that they ended up inside the pits by processes of erosion, transport and deposition. Among the few items that were analysed in this work, all cereal grains presented intense surface erosion. Nevertheless, the number of items that were available for analysis was too low and it would be interesting to do a taphonomic analysis of the whole assemblage in the future.

Not all pits yielded charred remains of cereal grain. The sediment of Pit 8 was processed with a flotation machine and it did not yield any plant remain. Pits 5, 6 and 11 did not yield plant remains (Agustí, Rueda & Buxó 1986).

Considering these results it seems that the strategy that was followed in previous work could have been enough for detecting the presence or absence of cultivars in most of the features, and that not all the features contained charred plant macroremains.

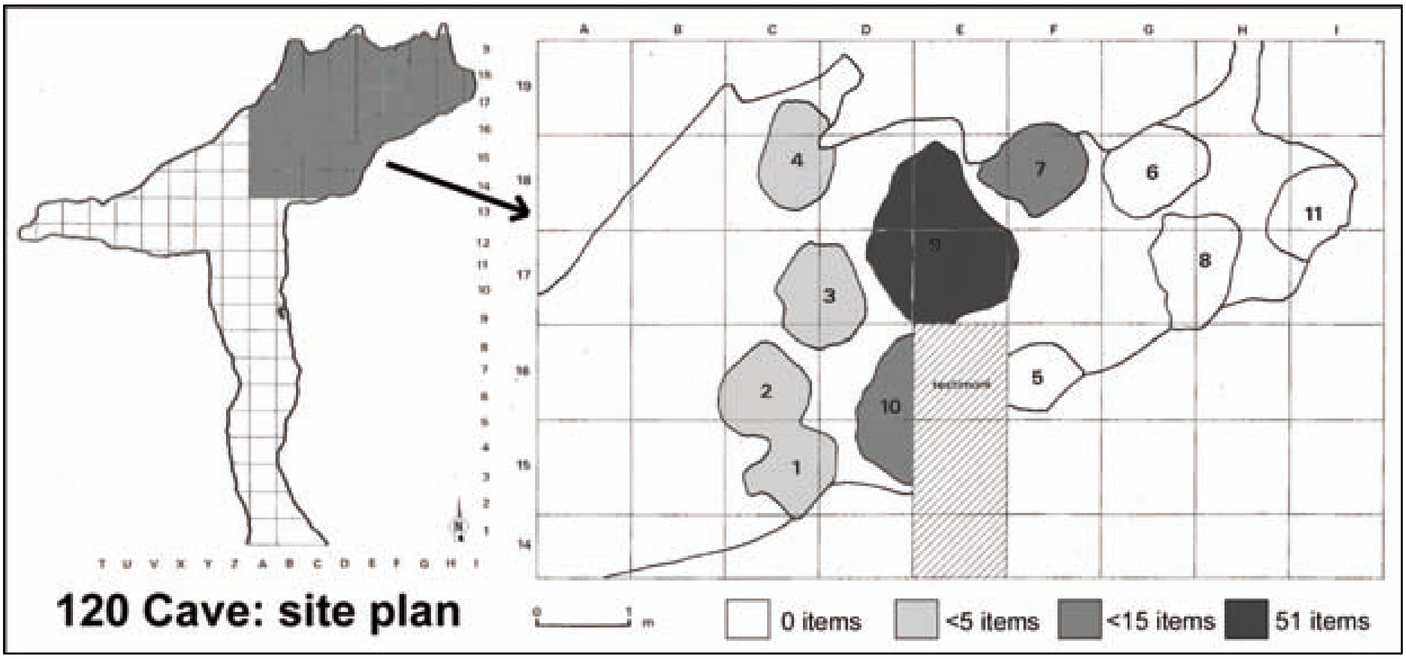


Fig. 4.53. Spatial distribution of seed and fruit remains from 120 Cave.

However, it is not so clear whether it allowed the recovery of all plant remains. It is very likely that only the larger grains were recovered during dry sieving and that most of the fragments and, potentially, chaff remains or smaller weeds were not recovered. It is significant to note that the only other find of *Vicia* that was recovered, came from a sample treated by flotation. The sample that was analysed for this work, then, allowed demonstrating that the available record for the site is only partially representative for the complete grains, and that it is not possible to tell whether a more or less important weed assemblage was lost during the process of recovery in previous investigations.

Nevertheless, it is because of these first archaeobotanical studies in our region that we can now proceed to provide some views on the palaeoeconomic significance of cultivars in 120 Cave site.

4.6.6.2. What can we say about plant food economy from the archaeobotanical assemblage of 120 Cave? What activities could have originated this assemblage?

The available record of plant macroremains at 120 Cave is difficult to interpret because of its particular characteristics as a site. It is a place of very difficult access and it is interpreted as being used as a storage. Then, why do these charred grains appear? Why are there also animal remains at the site? One possibility is that the site was not only used as a storage but also for more everyday-life-activities. Another possibility is that these remains are not contemporary to the use of the pits for storage.

In any case, it seems that the crop diversity was based on free-threshing cereals, especially naked wheat, but with an important proportion of both types of barley (37%) (Fig. 4.54). As free-threshing cereals, it is difficult to argue why naked wheat and barley would appear in charred form in 120 Cave if they were not consumed there.

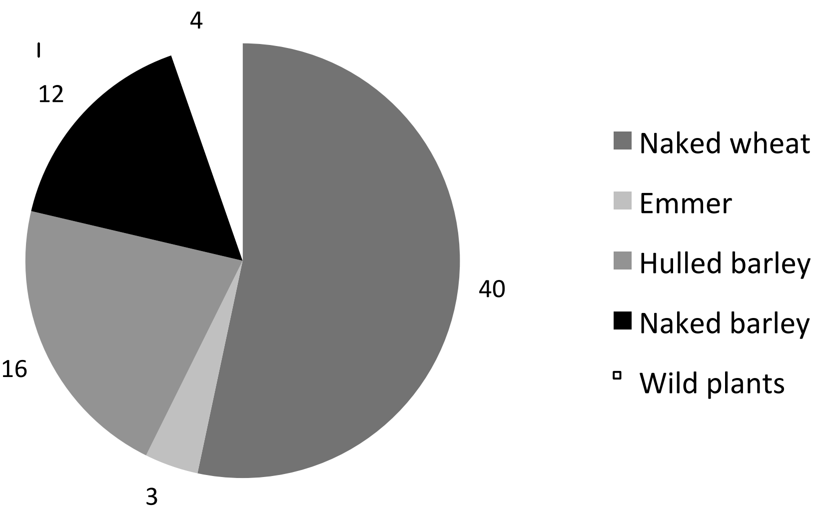


Fig. 4.54. Relative proportion among the different cultivars and wild plants identified in 120 Cave.

4.6.7. Summary and conclusions

The study of a sample from 120 Cave did not yield a large number of items or increase the number of crops at the site. Nevertheless, it was extremely useful to perform a re-evaluation of the significance of those plant macroremains, 25 years after the excavation of the site. In my view, it is not possible to interpret the recovered remains as evidences of the primary use of the pits, as in previous publications, but of evidences of some episode of consumption inside the cave.

4.7. La Draga

4.7.1. Chronology and phases

Two main settlement phases were identified in the open-air site of La Draga. The earliest occupation is a real pile dwelling site. Wooden huts were built right on top of the lake marl. This phase could last from *c.* 5300 to 5200 cal BC (Bogdanovic & Piqué 2012). Immediately after the collapse of the dwelling structures, a rather large accumulation of several layers of clay of terrigenous origin (Balbo & Antolín 2012) covered them and a new settlement was established, mostly using large travertine stones in order to produce an artificial floor. This second phase of occupation could have lasted until 5000 cal BC (see stratigraphy of sector D in Fig. 4.55). For more details on the site, see chapter 3.1.7.

4.7.2. Aims of the study

Archaeobotanical work at La Draga was started in 1990 by the late Vicente López and was continued, from 1997 onwards, by Ramon Buxó and his collaborators. Hundreds of thousands of grains were analysed since then and a lot of information concerning plant economy at the site was available before the start of this project. Nevertheless, the site still offers the possibility of targeting many new scientific questions, especially after the results of the latest excavations in sector D. For this work, two main questions were targeted. The first one concerned stratigraphy, layer formation processes and settlement dynamics. These had never been specifically targeted in previous investigations. Besides, it was also of huge interest for the project to undertake a spatial analysis of the distribution of seed and fruit remains in order to approach the organization of activities within the settlement and the household.

4.7.3. Previous analyses

A synthesis and evaluation of the archaeobotanical studies performed at La Draga between 1990 and 2005 was already published (Antolín & Buxó 2011b). Slightly over 300,000 seed and fruit remains (mainly naked wheat grains) were recovered and identified. Nevertheless, they presented some interpretative problems. Samples from sector A (see Fig. 3.9. for the location) were taken rather systematically all along the excavated surface (Buxó, Rovira & Sauch 2000). They were treated by flotation, since waterlogging conditions did not prevail until present times in this area of the settlement. Unfortunately, it was not possible to distinguish the two settlement phases in this sector and, therefore, it is difficult to correlate the obtained results with the ones from sector D (see Fig. 3.9 for the location). It is likely that most of the samples, especially those coming from hearths and paved floors, belong to settlement phase II. They are, consequently, slightly younger than the surface samples that will be analysed in this work.

This problematic becomes more severe in the samples from sectors B and C (see Fig. 3.9), where waterlogged conditions prevailed until present times but sampling strategies focused on accumulations of charred material. This fact, together with the drying out of the "flots" (after processing the samples) resulted in the loss of much of the uncharred material from the site. Additionally, several sampling and recovery strategies were applied, including judgement and interval sampling, at times using a flotation machine, at times water-screening the samples. Especially in the last field seasons, barely any sampling was carried out. It was out of the goals of this work to review the total sampling strategy and materials recovered during these early phases. It would be important, though, to focus on this issue in future times. A relatively large number of samples remain to be analysed.

The main conclusions from the (somewhat preliminary) evaluation of these first results (Antolín & Buxó 2011b) can be summarized as follows:

- 300,159 seed and fruit remains were analysed and 57 taxa were identified.
- Cultivars are the best represented group among the assemblage (296,944 items). They were found only in charred form.
- The more ubiquitous taxa are naked wheat (*Triticum aestivum/durum/turgidum*), barley (*Hordeum vulgare*), wild grape (*Vitis vinifera* subsp. *sylvestris*), acorns (*Quercus* sp.), sloe fruits (*Prunus spinosa*) and hazelnuts (*Corylus avellana*).
- Naked wheat was identified as tetraploid naked wheat (*Triticum durum/turgidum* type), especially after the study of sample JH84-85 (sector B), where more than 150 rachis fragments were retrieved. An ear fragment was recovered, too.
- It was considered that tetraploid naked wheat was grown as a monocrop and processed in bulk in order to store it, at least partially, in a rather clean state.

4.7.4. Materials and methods

The majority of samples that have been analysed in this work come from sector D of the excavation (see the location in Fig. 3.9). A surface of 58 m^2 was excavated in this sector in 2010, but only 26 m^2 were excavated down to the lake marl level. Our samples were obtained from this relatively small area. Several archaeological layers were observed during the archaeological work, from top to bottom (Palomo et al. 2012; Fig. 4.55):

- Layer 0: modern clays, brought to the area on the 90s of the XXth century;
- Layer I: peat that covers the archaeological layers;
- Layer II: base of the peat layer (I) with scarce archaeological material (including fragments of medieval and modern potsherds);
- Layer III: greyish layer with a high travertinic component.
- Layers IV and V: clayey layers located at the western half of the trench and which are at similar depths as layer VI;
- Layer VI: clayey layer located in the central and eastern sector of the trench. Travertine blocks were also found.
- Layer VII: layer which corresponds to the collapsing of a large number of wooden structures which constituted the earliest settlement phase documented in the area.
- Layer VIII: dark organic sediment below the collapsed wooden structures.
- Layer IX: lake marl.

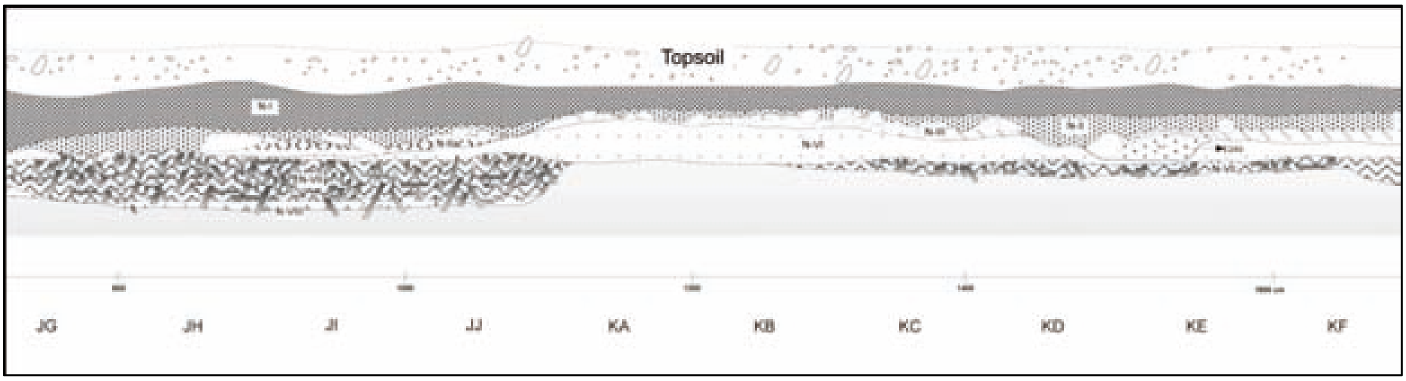


Fig. 4.55. Stratigraphy of the site of La Draga. Sector D – East. For the location of Sector D, see Fig. 3.9, for the location of Sector D East see Fig. 4.56 (Author: Equip Draga).

4.7.4.1. Sampling strategy at the site. 2010 campaign

The sediment sampling and processing techniques applied at La Draga were completely new for the site and previously never applied in the Iberian Peninsula. This was due to the special nature of the site, which has largely remained in waterlogged conditions up to present times. For this reason, the sampling and processing techniques applied for decades in lakeshore sites from central Europe were adopted for our case study, especially following (Jacomet 1985, Jacomet & Brombacher 2005, Vandorpe & Jacomet 2007, Tolar et al. 2010, Jacomet 2013).

What are the particularities of the waterlogged cultural layers preserved in a site like La Draga? On first place, the number of plant remains per litre of sediment is much higher than that of the vast majority of dry sites (except for closed assemblages, like burned down houses with *in situ* burnt storages, which are special cases in archaeology). Therefore it might become unfeasible to take samples of the same size of other sites (*c.* 20 litres). Secondly, a larger diversity of taxa is preserved in such conditions, for which the sampling strategy should also aim to record as much of it as possible. Thirdly, particular types of remains are also preserved in these conditions and need to be considered for the sampling plan (e.g. dung remains, moss, leafs, etc.). Finally, it is extremely difficult to identify stratigraphic units or independent units of analysis during the excavation of the site. Thus, samples must be taken per intervals (frequently enough to allow a spatial analysis) and only after their study one can attempt to amalgamate samples on the basis of their composition, taphonomy and their spatial distribution in order to conform contexts or potentially independent units of analysis.

For this reason, a combined sampling strategy was necessary to carry out. On the one hand, a **systematic (interval) surface sampling** was necessary. This surface sampling was done on three scales. Samples of 0,5-1 litre of sediment were taken per subsquares of 50x50 cm (the grid square of the excavation was of 100x100 cm). Samples of 7-10 litres were taken per square (100x100 cm). Sieves of 2 and 0,35 mm mesh size were used for their processing with the wash-over method (Kenward, Hall & Jones 1980, Hosch & Zibulski 2003, Tolar et al. 2010, Antolín, Buxó & Jacomet in press). Finally, some bulk samples were water-screened with a sieve of 2 mm mesh size, while a 5 mm mesh size was used for the rest. This strategy concerns the 2010 campaign, mainly. From 2011 onwards, the surface samples were equally taken but 100% of the sediment was water-screened and kept for further analyses. Such a complex combination of samples is necessary in order to proceed efficiently through their processing and analysis (for this, small samples are needed as a basis) and to also have represented items of larger size (for this, large samples are needed as a complement). Finally, in order to approach stratigraphy and layer formation at the site, **profile samples** were taken. These samples were extracted from the profiles of the excavation using flower boxes and they were then analysed in the laboratory, where, first of all, a careful identification of the strata was performed. On a second step, each one of the stratigraphic units was sampled and analysed independently.

Each sample got a different code of the type DG10-MS-001 (DG for Draga; 10 for 2010; MS for sediment sample; and a correlative number is given to each sample in order of recovery). Profile samples were labelled as follows: DG10-MP1-M1-5 (MP for profile sample; M for sample within the profile; 1-5 for the cm to which the sample corresponds within the profile, having 0 cm at the base of the profile).

4.7.4.2. Analysed samples in this work

It was impossible to analyse all of the samples that were taken in the 2010 campaign (around 500) for this project. Consequently, it was decided to focus on layer VII and to only give a general picture of the composition and the processes of formation of the rest of the layers. For this reason it was decided to study **all three profile samples** (Fig. 4.56) in order to approach layer formation issues, as well as the stratigraphy of the site. Then a selection of the **surface samples** taken per subsquare, more specifically, the ones from the **NE subsquare** of each grid square (Fig. 4.57), were chosen for an in-depth approach to the spatial distribution of materials within this settlement phase. Besides, some of the **water-screened samples from the different layers** were analysed to get a rough idea of their archaeobotanical content (Fig. 4.58). No judgement samples or large surface samples taken per square were evaluated. Finally, **10 samples from the 1998-2004 phase** of excavation were also included in the analysis (Fig. 4.59). These samples were taken from the pile-dwelling phase, that is to say, the equivalent to what is called layer VII in sector D. It was considered interesting to perform a semi-quantitative evaluation of their contents in order to compare them with the results from sector D.

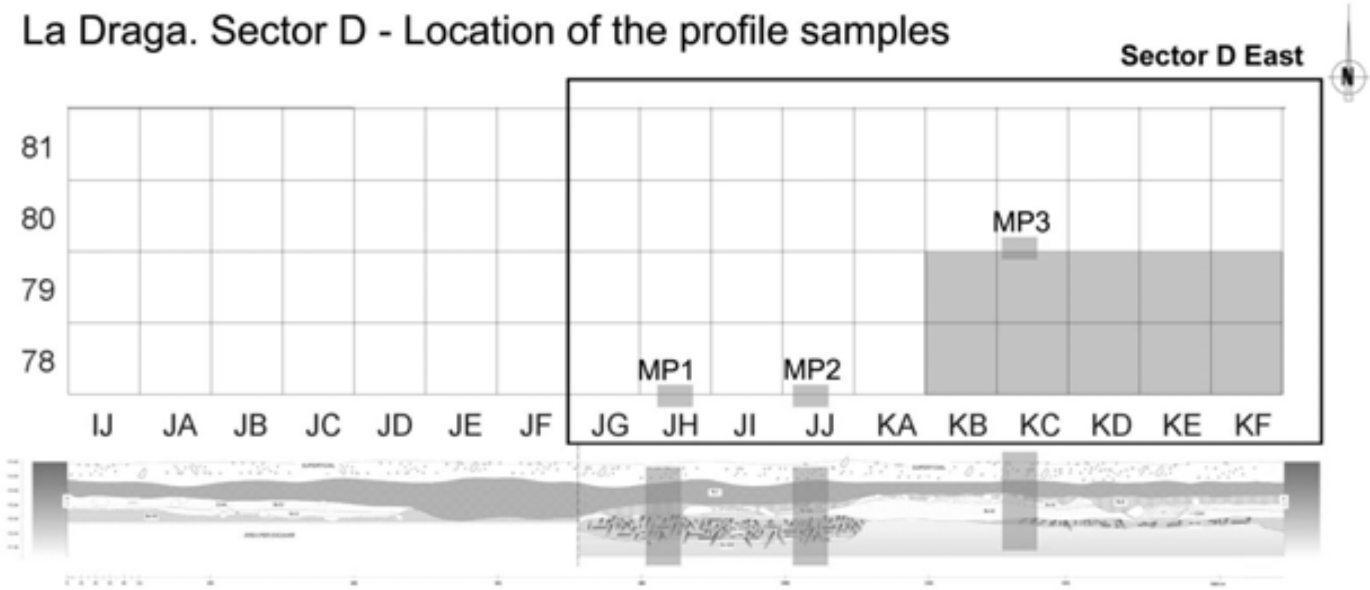


Fig. 4.56. Analysed profile samples from sector D at La Draga and indication of the location of Sector D (East).

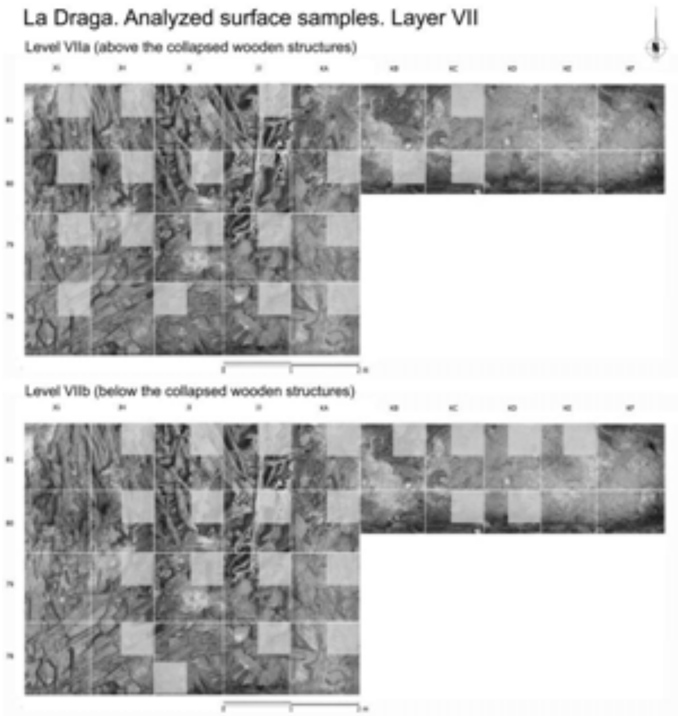


Fig. 4.57. Analysed systematic surface samples taken per subsquare from La Draga (sector D) (adapted from the site plan provided by Equip Draga).

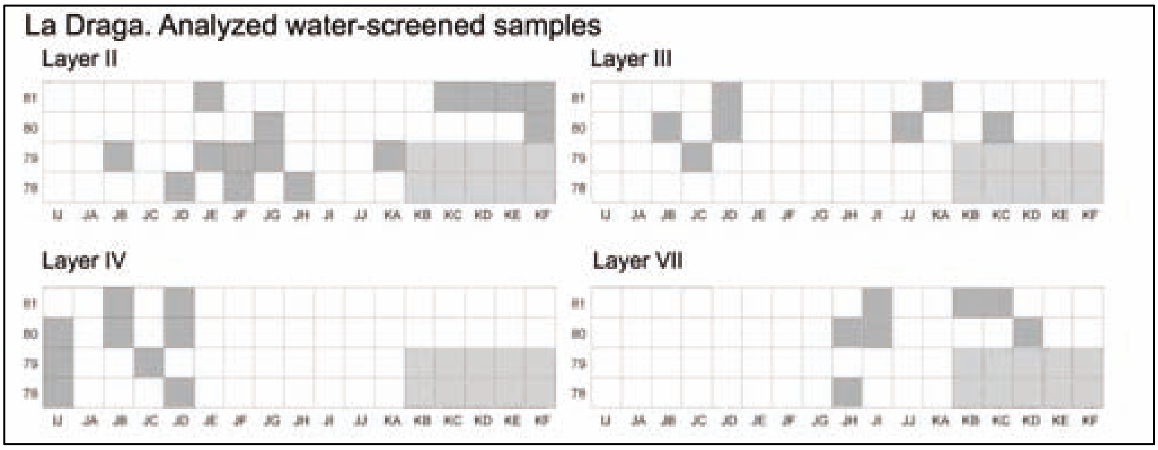


Fig. 4.58. Analysed water-screened samples from La Draga (sector D). For the location of the sector see Fig. 3.9.

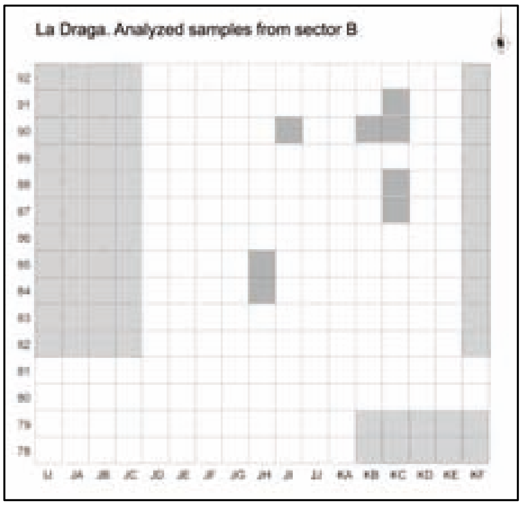


Fig. 4.59. Analysed samples from sector B from La Draga.For the location of the sector see Fig. 3.9.

As a result, a total sum of 121 samples were analysed (see the complete list in Fig. III.11). The total volume of sediment of the studied (with a fully quantitative methodology) systematic and profile samples was around 45 litres.

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*Fig. 4.60. Summarizing table of number of samples, the total volume, the average volume and the processing technique of each type of sample taken at La Draga and analysed in this work (*only a small part of the residues were analysed since only a qualitative approach was intended).*

The processed volume of sediment per sample is diverse in each of the categories presented in Fig. 4.60. The samples processed in the period between 1998 and 2004 were usually large (9,5 in average; 6 litres minimum and 15 maximum). The samples obtained from the profiles and the systematic surface samples were much smaller (0,52 and 0,74 in average, respectively). Most of the samples extracted from the profiles are of around 0,3 l, even though some samples are around 0,8 litres (Fig. 4. 61). The volumes of these samples are highly dependent on the size of the profiles that are extracted and of the thickness of the layers that can be identified in them. The systematic surface samples seem to be of around 0,7-1 litre in most cases (Fig. 4.62). Finally, concerning the water-screened samples from the 2010 campaign, different average volumes per square were obtained for layers II, III and IV, in comparison with layer VII. For the first three layers, 10 litres per square were processed in most occasions. For layer VII it was decided to sieve 100% of some squares, due to the higher interest and better chances of preservation of organic material. Thus, volumes of between 5 and 155 litres were processed, although only a small part of the larger samples was investigated, since only a qualitative approach was intended.

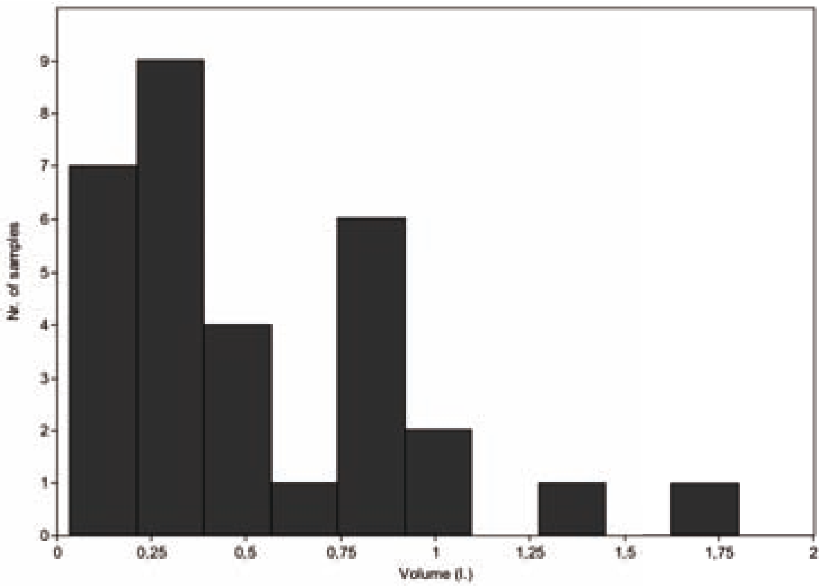

Fig. 4.61. Histogram showing the volume per sample of the samples extracted from the profiles of La Draga.

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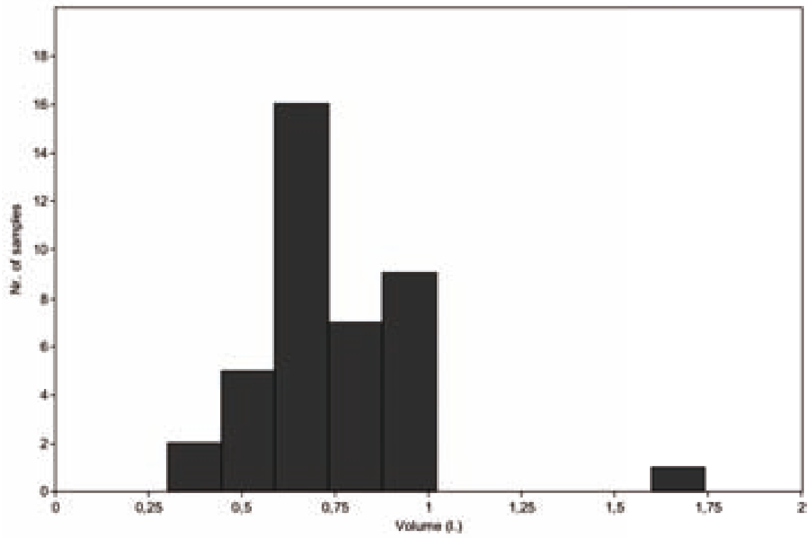


Fig. 4.62. Histogram showing the volume per sample of the systematic surface samples analysed from La Draga.

4.7.4.3. Subsampling

Subsampling is usually practiced in sites with waterlogged preservation because they are too rich in remains to analyse each sample in its entirety. It can be carried out in several moments between the collection of the sample and its analysis. None of the samples that we have analysed for this work were subsampled before processing, only after processing. In most cases the 0,35 mm fraction was subsampled, and only in two occasions this was done with the 2 mm fraction. The grid method was used for subsampling, which is considerated a systematic and representative method (van der Veen & Fieller 1982)

Since there were no previous records of the optimal volume for a subsample of the 0,35 mm fraction from this site and it was not the aim of this work to establish such value, I relied on the reference data obtained in the lakeshore sites from central Europe (see, for instance, Jacomet & Brombacher 2005). Consequently, 10 ml subsamples of the 0,35 mm fraction were taken as long as the total volume of the fraction was above 25 ml (Fig. 4.63).

Using a fixed volume to establish the subsampling strategy implies that sometimes the obtained results will be multiplied by very high factors to calculate the total number of items per sample. In our case, in most occasions the multiplying factor was between 5 and 12 (Fig. 4.64).

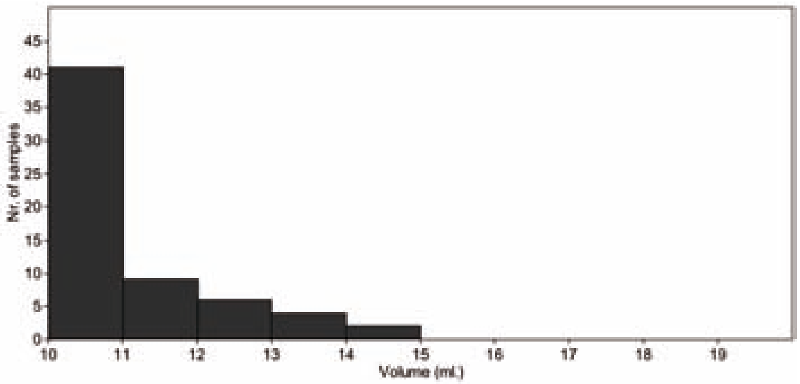


Fig. 4.63. Volume of the analysed subsamples of the 0,35 mm fraction from La Draga (only systematic surface samples considered).

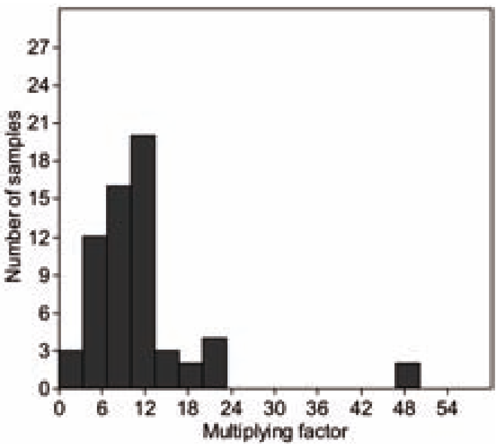


Fig. 4.64. Multiplying factors used in the analysed subsamples of the 0,35 mm fraction from La Draga (only systematic surface samples considered).

Concerning the 2 mm fraction of the systematic surface samples, this was only subsampled in two occasions: in samples JG80 NE and JH80 NE. Both samples were highly rich in charred remains, for which it was decided to sort them completely and then subsample the grains that were classified as naked wheat in order to save time in their taphonomic description. This allowed a faster evaluation of the sample without losing information concerning minor crops.

The samples from the 1998-2004 phases were treated slightly differently when conducting subsampling. Subsamples of around 20 ml were taken for the 0,35 mm fraction and, in some occasions, subsamples from the 1 and 2 mm fractions were also taken. Sample JH84-85 was analysed early in 2010, before any other samples from La Draga, and the subsampling technique was also different, 5% of the volume of each of the fractions was analysed.

4.7.4.4. Sorting of the samples and description of their composition

All fractions from samples treated with the wash-over technique were sorted under a binocular microscope, always keeping them in water. Charred remains were dried only after sorting. Some choices were made concerning what was pulled out from the sorting fraction. All fully quantified materials except the Oogonia of Characeae were sorted, this includes bone remains (macro and microfauna, including fish bones, scales, etc.), identifiable malacological and entomological remains, flint, pottery, dung remains and charred amorphous tissues of plant origin.

The rest of the materials (wood chips, roots, moss fragments, leaf fragments, etc.) were semi-quantitatively described as explained in chapter 3.2.11.1. In this same chapter one can find the classifications used to group these components. It was considered significant for the taphonomic evaluation of the samples to differentiate those materials which were more likely to be of local origin (related to the lake/lakeshore environment) from those which were more likely to be of anthropogenic origin (from anywhere outside the lake and lakeshore area).

4.7.4.5. Quantification and semi-quantification

As explained in chapter 3.2.6., some of the samples from La Draga were not fully quantified. This concerned the water-screened samples when no sieve of 0,35 mm mesh size was used. Semiquantification allows a relatively fast evaluation of the composition of a sample and it is especially useful when the number of items counted is particularly meaningless and when the sample is only interesting in order to detect new taxa or types of remains or strikingly different trends in the general composition of the sample.

4.7.4.6. Presentation of the data and analytical procedures

The data are presented in **tables** with absolute total numbers as well as the density values per litre of sediment. Both data have been used for the palaeoeconomic evaluation of the record.

The results of the profile samples were presented in **stratigraphic diagrams**, using the free software C2 (version 1.6.7.1; Juggins 2007). The evaluation, though, was carried out at a layer scale, not at a profile scale (see below for further discussion). It was considered of interest to calculate the **organic content** of the samples obtained from the profiles, as an index to compare strata. For this, the volume of the 2 mm and the 0,35 mm organic fractions were added and the proportion of the total obtained with respect of the original volume of the sample was calculated. This percentage was not calculated for layers II and IX, since the inorganic component within the organic fractions was too high and the results, especially for the 0,35 mm fraction, did not bring up reliable information.

For the **spatial evaluation** of the results, pie charts were represented in their corresponding square of the site plan. It is worth noting here that pie charts are plotted occupying the whole square for practical reasons (better visibility) even though their origin is just a subquadrant of that square.

The results will be presented according to the type of sampling strategy, that is to say, first the profile samples, then the systematic surface samples, then the water-screened surface samples and, finally, the samples from previous phases of excavation. This scheme was chosen in order to facilitate the comprehension of the information yielded by each type of sample. Consequently, the discussion of each type of sampling strategy will deal with the aspects related to their initial goals. The general discussion concerning the palaeoeconomy at the site is only conducted after the presentation of all the results, since interpretations are obtained through the combination of all the data.

4.7.5. The profile samples

4.7.5.1. Methods: extraction and specific laboratory procedures

As previously stated, three profile columns were analysed for this work. The three of them were taken from the only profile that was available after the excavation of the site in November 2010: the southern profile of sector D (Fig. 4.56). The location of this sector within the site can be observed in Fig. 3.9.

In all cases, the length of the columns (31 cm for profile sample (MP) 1, and 45 cm for MP2 and MP3) was sufficient to record the complete stratigraphy, from the lake marl until layer II. Plastic flower boxes were used for their recovery and storage. They were tightly wrapped in plastic film and kept in a dark and cool room for a few days until they were processed in the laboratory.

The methodology used followed the one practiced in different laboratories of the Circum-Alpine region, like the IPNA (Universität Basel) or the Fachbereich Feuchtbodenarchäologie in the Landesamt für Denkmalpflege in Hemmenhofen. First of all, the surface of the samples was cleaned for a first observation of the stratigraphy. The best location was chosen for the extraction of a sample for soil micromorphology analysis. In this case, only profile samples 2 and 3 were sampled for this purpose. Then the whole profile was carefully sampled from bottom to top. It was excavated following visible stratigraphical boundaries of the layers. The composition of the layers was also considered in order to define sub-layers that were not possible to detect during fieldwork. Each stratigraphic unit was given a sample number, as described above (chapter 4.7.4.1), according to its location in the profile. A short description of the type of soil and its contents was performed (Fig. 4.65, 4.66 and 4.67). Each sample was individually stored with water in a zip-lock plastic bag.

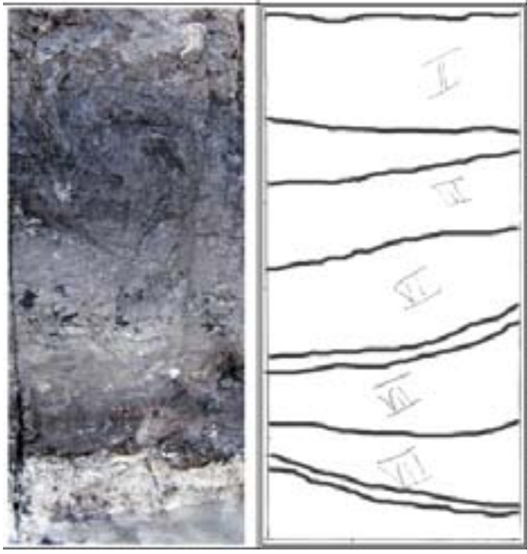
DG10-MP1	Sketch	Sample	Corresponding archaeological layer	Description	Volume (ml)	2 mm org Volume (ml)	0.35 mm org Volume (ml)	Anorg. Volume (ml)
		M 25-31	II	peat layer with few malacological remains	1800	200	500	5
		M 22-25	II	peat layer very rich in malacological remains	700	50	170	5
		M 17-21	III	light grey clay layer with small bits of travertine, many charcoal, malacological and some faunal remains	1000	60	120	60
		M 12-16	VI	light grey clay layer with some malacological remains	840	50	100	10
		M 10-11	VIIa	separation layer with some bark and wood chips	300	70	45	2
		M 8-10	VIIa	dark coloured clay layer. Small malacological remains, twigs, roots, etc.	900	170	240	3
		M 6-7	VIIb	plenty of organic material (twigs and branches), malacological remains. Not very clay rich.	400	130	90	0,5
		M 6	VIIb	contact area with the lake marl	270	14	50	5
		M 1-5	IX	lake marl	280	20	65	25

Fig. 4.65. Profile sample 1, Sector D: Picture, sketch of the stratigraphy, samples, archaeological layers, description of the samples, volume of the samples and fractions obtained after sieving.

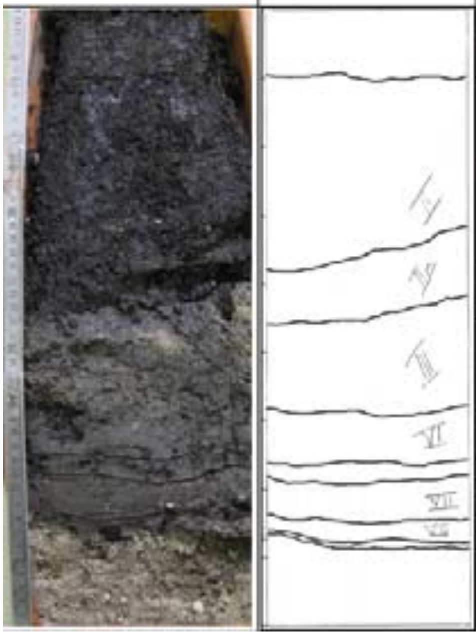
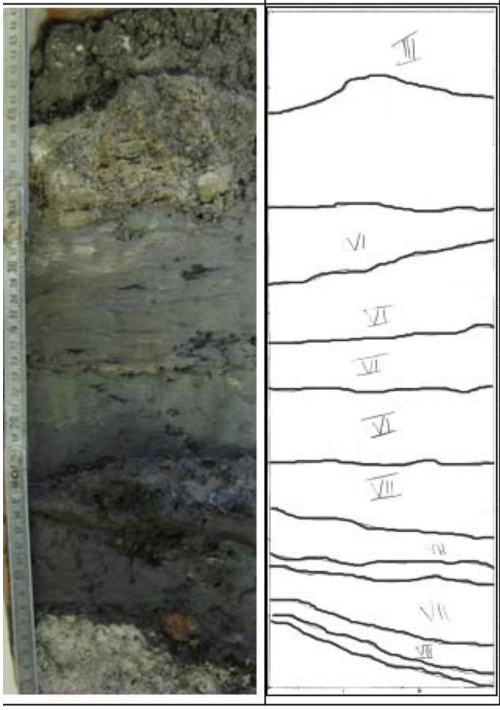
DG10-MP2	Sketch	Sample	Corresponding archaeological layer	Description	Volume (ml)	2 mm org Volume (ml)	0.35 mm org Volume (ml)	Anorg. Volume (ml)
		M 41-45	Top soil	Light grey colour, with many malacological remains (Mitilus sp.)	640	80	260	3
		M 27-40	II	Dark grey/black peat layer	1380	140	500	3
		M 23-26	IIa	black peat layer with great abundance of charred plant material, faunal remains and malacofauna	320	100	120	8
		M 17-22	III	travertine		0	0	100%
		M 13-16	VI	light grey clay layer with some bits of charcoal	400	50	50	8
		M 11-12	VIIa	charcoal layer with small and big pieces, light grey clay	240	70	50	8
		M 8-11	VIIa	light grey clay layer with malacofauna and wood chips	150	35	20	1
		M 7-8	VIIb	organic layer with a clay component	140	70	26	4
		M 7bis	VIIb	contact layer with the lake marl	35	10	7	2
		M 1-7	IX	lake marl	200	7	34	50

Fig. 4.66. Profile sample 2, Sector D: Picture, sketch of the stratigraphy, samples, archaeological layers, description of the samples, volume of the samples and fractions obtained after sieving.

DG10-MP3	Sketch



Sample	Corresponding archaeological layer	Description	Volume (ml)	2 mm org Volume (ml)	0.35 mm org Volume (ml)	Anorg. Volume (ml)
M 38-45	III	light grey with malacofauna and little charcoal pieces	760	30	120	95
M 33-37	III	travertine and light grey soil with little charcoal	300	14	22	130
M 27-32	VI	Light grey clay layer with whitish lenses	800	44	55	4
M 26	VI	Small layer of charcoal	220	5	16	31
M 24-26	VI	Light grey clay layer	500	48	50	10
M 21-23	VI	Light grey clay layer with many charcoal fragments	460	40	50	8
M 16-20	VI	Light grey clay layer with light brown lenses	900	35	85	7
M 13-15	VIIa	3rd layer of organic material with big wooden pieces, light grey lenses in the dark grey layer	1000	360	115	12
M 9-12	VIIa	clay layer with sparse organic material	800	100	110	6
M 9	VIIa	2nd layer of organic material with some twigs and wood	200	50	45	1
M 7-8	VIIb	clay layer	180	40	50	1
M 6-7	VIIb	organic layer with many twigs and small branches	440	200	100	4
M 5	VIIb	Contact with the lake marl	150	20	50	17
M 1-5	IX	lake marl	230	14	40	100

Fig. 4.67. Profile sample 3, Sector D: Picture, sketch of the stratigraphy, samples, archaeological layers, description of the samples, volume of the samples and fractions obtained after sieving.

4.7.5.2. Results

4.7.5.2.1. What layers and levels could we observe?

A first description of the profiles is available in Figs. 4.65, 4.66 and 4.67. In the following lines, a global evaluation is presented, only considering the observations made during the sampling of the profiles. The description of the identified layers was carried out from bottom to top of the profile samples. The stratigraphy of the site, already identified during fieldwork, can be observed in the drawing of the general profile (Fig. 4.55). The layer numbers that were used in this text are the same than those observed archaeologically. Three categories of sedimentological units are used, from general to concrete: layer, level and sub-level. Layers follow the archaeological units, levels are smaller units which seem to be sedimentologically or compositionally distinguishable within layers (for instance, different colour and different organic composition); sub-levels distinguish smaller units within levels or layers (for instance, a deposit of small and sparse branches within a homogeneous clayey layer)

Nine levels were observed in MP1 and MP2, while 14 were distinguished in MP3.

All profiles had around 5 cm of lake marl at the base (**layer IX**). This resulted in samples of volumes of around 250 ml with a very low organic content (7-20 ml in the 2 mm fraction). Layer IX is much thicker but our interest was centred in the transition between the lake marl and the first cultural layer.

Between the lake marl and the lowest cultural layer, a **contact layer** (of around 1 cm of thickness) was isolated, in order to avoid contaminations as much as possible. The samples obtained were of variable volumes, from 35 (MP2) to 270 (MP1) ml. The organic content was very low (10-20 ml in the 2 mm fraction).

Layer VII was divided into two levels: **VIIa and VIIb**. This nomenclature is not used in the archaeological evaluations of the site but it is useful from a stratigraphic and archaeobotanical point of view. VIIb is the sedimentary episode that is found below and between the wooden structures and it is visibly richer in organic material, usually darker in colour. Level VIIa is the uppermost level of collapsed structures, mostly presenting a lighter grey colour. Several samples were individualized within those sedimentary episodes, some being richer in wood chips and twigs, other with a clear clayey component. Since the excavation took place from bottom to top, the distinction considered between levels VIIb and VIIa was: 1) a clear reduction in the organic component of the layer; and 2) a slight change in colour (towards a lighter greyish) of the sediment. Both profiles MP1 and MP2 had a single sample identified as VIIb, with a high organic component (55-68% of the total volume of the sample), and two VIIa samples with a lower organic component (38-50%). MP3 allowed the detection of two sub-levels within level VIIb, also with a higher organic content (50-68%), and three from level VIIa (with an organic content between 26,3 and 47,5%). Level VIIb was usually 2-4 cm thick, while VIIa was 4-6 cm. The organic component was primarily in waterlogged state in all the samples except DG10-MP2-M11-12 (level VIIa), where a charcoal layer was identified. In all profiles the total volume processed for sublayer VIIa is about three times that of level VIIb.

On top of layer VII, a compact layer of light grey clay was identified in all the profiles. It is **layer VI**. It appeared with variable thicknesses, from 5 to 17 cm. It was identified as one single layer in MP1 and MP2, but 5 sub-levels were distinguished in MP3. The organic component of this layer was very low (9-25%), despite the relatively large volumes that were processed (from 400 ml to nearly 3 litres). In MP3, two clear sub-levels of charcoal were identified in between other sub-levels or light grey clay. No waterlogged preservation of organic material was observed.

On top of layer VI, **layer III** was identified in all three profiles. Volumes around 1 litre were processed in MP1 and MP3, but no sediment (only pure travertine stone) was recovered in MP2. The layer was described as consisting of light grey clay and it contained charcoal, faunal and malacofaunal remains. The organic content was very low (*c*. 15%) and in charred state. This was the uppermost layer that was identified in MP3, but other layers were observed in MP1 and MP2.

Layer IIa was only identified in MP2. This layer is of dark brown colour and it was already identified during fieldwork. Its organic component (320 ml) was very high (69,8%) but it was mainly in charred state. It was about 4 cm of thickness and very rich in malacological remains.

Layer II is of dark brown colour and it was described as peat, following the observations during the archaeological work. Nevertheless, A. Balbo concluded in his analysis of soil micromorphology (Balbo & Antolín 2012) that it is moder, e.g. peat that has reached a high level of decay. It had 12-14 cm of thickness and it was nearly impossible to sieve it, due to its extremely compacted nature. Volumes of over 1 litre were processed.

Finally, some centimetres of topsoil were also identified in MP2, but these were not analysed, since this layer was originated around 20 years ago.

As a **summary**, layers from IX to III were identified in all profile samples. Layer IIa only in MP2 and layer II in MP1 and MP2. Plant material was clearly preserved in waterlogged state in layer VII, but not in the rest of the layers above it. Two levels were possible to detect within layer VII, which seem to have different richness in organic content. Two main dwelling phases could have been detected: layer VII (a and b) and layer III/IIa. The charcoal levels within layer VI (MP3) could respond to particular episodes, but this remains to be evaluated. The significance of this sampling for the understanding of the stratigraphy of the site will be discussed further on.

4.7.5.2.2. Components of the layers (other than seeds and fruits): aquatic and lakeshore organisms/ materials Vs. elements/organisms from outside the lakeshore

A number of components of the samples (other than seeds and fruits) were described either quantitatively or semi-quantitatively in order to gain a better understanding of the studied assemblages (see chapter 3.2.11.1 for further methodological details). The total results per sample are presented in Fig. III.12. Quantified and semiquantified materials/elements of both lake/lakeshore origin and from other origins outside the lakeshore were recovered and they were compared separately (this classification is based on the numerous available studies of profile samples from the circumalpine region).

Concerning the **materials from outside the lakeshore**, all animal/fish bones, dung remains and stone flakes were quantified (Fig. 4.68). The general picture is that those layers which were identified as cultural layers or settlement phases have higher concentrations (nr. of remains per litre of sediment) of these materials, at least above 40 r/l in average. Animal (mammal) bone remains were recovered in all layers except layer IX but the highest concentrations were found in layers III and IIa, where also more burnt and calcined bones were recovered. Fish bones were recovered in all layers. The highest concentrations were found in layer IX, level VIIa and layer II. Fish scales were only recovered in levels VIIa and VIIb. Dung was exclusively recovered in level VIIb, and flint and quartz only in layer III. Dung remains of La Draga are not yet analysed (M. Kühn and J. Revelles, in progress) but ruminant and mice dung seem to be present.

These trends are not so clearly constant when looking at the results per profile. Some sub-levels from levels VIIb and VIIa in MP1 and MP3, have low concentrations of these materials from outside the lakeshore, while very high concentrations are achieved only in some particular sub-levels like MP1-M17-21 (III), MP2-M8-11 (VIIa) and MP3-M6-7 (VIIb). The high concentration of fish bones obtained for layers II and IX is due to the distortion produced by the high densities of two sub-levels from the profile MP1: M22-25 and M1-5. Dung was also only identified in a single sample: MP3-M6-7. It must be emphasized, then, that single episodes may affect the overall results of each layer and that a larger number of samples are needed to get more reliable average results.

The semi-quantified remains from outside the lakeshore area also bring out interesting information. The general graph where the average results per layer are presented (Fig. 4.69) shows three main trends. At the basis of the stratigraphy, layer IX has very low contents of this type of remains. Levels VIIa and VIIb have a much more rich diversity and quantity, especially in waterlogged materials, while in the upper layers, from VI to II, charcoal is the best represented element and waterlogged material gradually disappears.

A closer look to the results per profile confirms these general trends. In MP1 the results seem to be poorer with respect to those from other profiles. The diversity of elements is poorer, and so are the observed contents of the samples. Nevertheless, the differences between the three trends mentioned above remain clear, with charcoal as the main component of the upper layers, a larger diversity in levels VIIa and VIIb and a large reduction of remains in layer IX. MP2 shows very similar tendencies but the diversity and quantity of remains in levels VIIa and VIIb is much larger. It seems clear that charcoal is better represented in the upper samples from level VIIa. Leaf fragments and buds are better represented in M8-11 and M-7-8. MP3 offers a similar pattern but two samples from level VIIb show much richer results and very diverse in terms of types of remains. In layer VI, two charcoal-rich samples (M21-23 and M26) are coherent with the observations done before sieving, during the processing of the samples in the laboratory. The three sublevels identified in VIIa are very homogeneous in composition. In level VIIb, two samples show a very rich content of this type of remains and they are quite poor in charcoal.

It was considered significant to have a final look at the raw semi-quantified description of these items (Fig. III.12) in order to include their size (as a variable) into the general discussion. Wood chips were larger towards the base of level VIIb in MP1 and MP3, but not in MP2, where they were larger in the uppermost sub-level of VIIa. In all profiles, wood chips were abundant at this point of the stratigraphy. Charcoal remains are not only more abundant in the upper layers VI to II but they are also usually larger. Bark remains were larger at the base of VIIb in MP1 and MP3, but not in MP2, where they were similarly well represented in other samples of level VIIa and layer VI.

The **travertine** component of the samples was not included in these graphs because it is of mineral nature and its taphonomic history is not comparable to other organic remains. It is worth mentioning, though, that it was highly present in layer IX (in all profiles), where it appeared in a very disaggregated form, as travertinic sand. Otherwise, the largest concentrations of travertine were in layer III and the immediate samples taken above and below it. Some travertine fragments were recovered in one of the clayey sub-levels from level VIIa in MP3.

Insect remains are equally interesting at this point. Their origin could be diverse but their distribution patterns within the profiles are very clear (Fig. III.12). They concentrate in levels VIIa and b. Concentrations are much higher in MP2, but also at the base of level VIIb in MP3, especially in M6-7, where dung was also found.

Materials/organisms from aquatic or lakeshore origin were also very well represented in some of our samples. The results per layer for the quantified remains (Fig. 4.70) show very high overall concentrations in level VIIb and layer IIa (also layer II). In all layers, malacofaunal remains are the best-represented items and only in levels VIIa and b, statoblasts of *Cristatella* are well represented. Layer VI has a very low presence of these items.

The results per profile and sample show interesting patterns. All samples from layers VI and III show low concentration values for this sort of remains, while the lowest samples of layer II are rich (MP1 and MP2). In MP2 and MP3 there is a progressive decrease from levels VIIb to VIIa and, in the three profiles, the uppermost sample of level VIIa has very low concentrations of lake/lakeshore elements. The highest concentrations of statoblasts of *Cristatella* were recovered in level VIIb of MP3. The concentrations of lakeshore/aquatic elements observed in layer IX are very variable (from c. 300 to 2200 r/l).

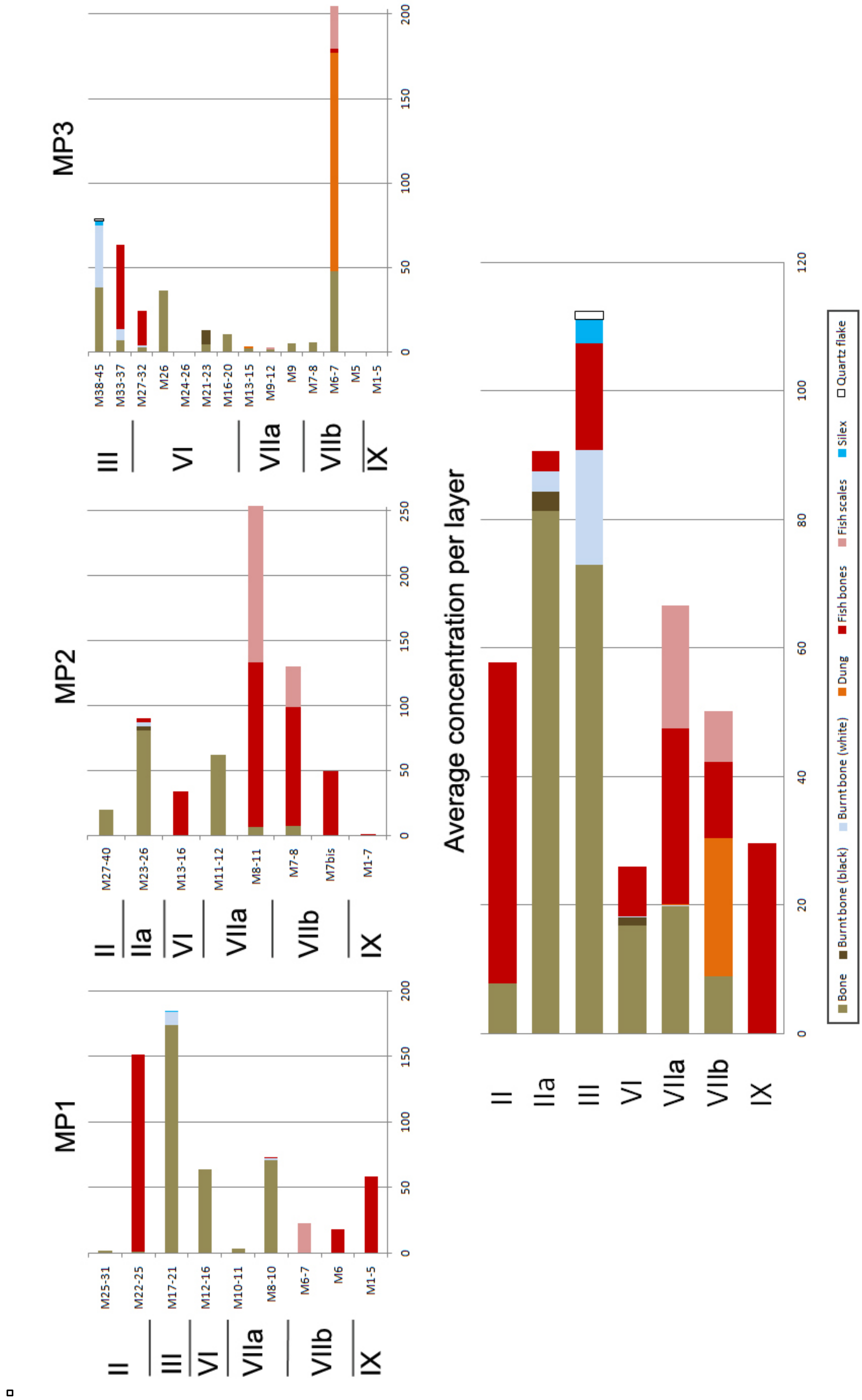


Fig. 4.68. Concentration per litre of the fully quantified elements of anthropogenic origin or from outside the lakeshore area presented per sample, per profile and the average concentration per layer (considering all the samples from the three profiles).

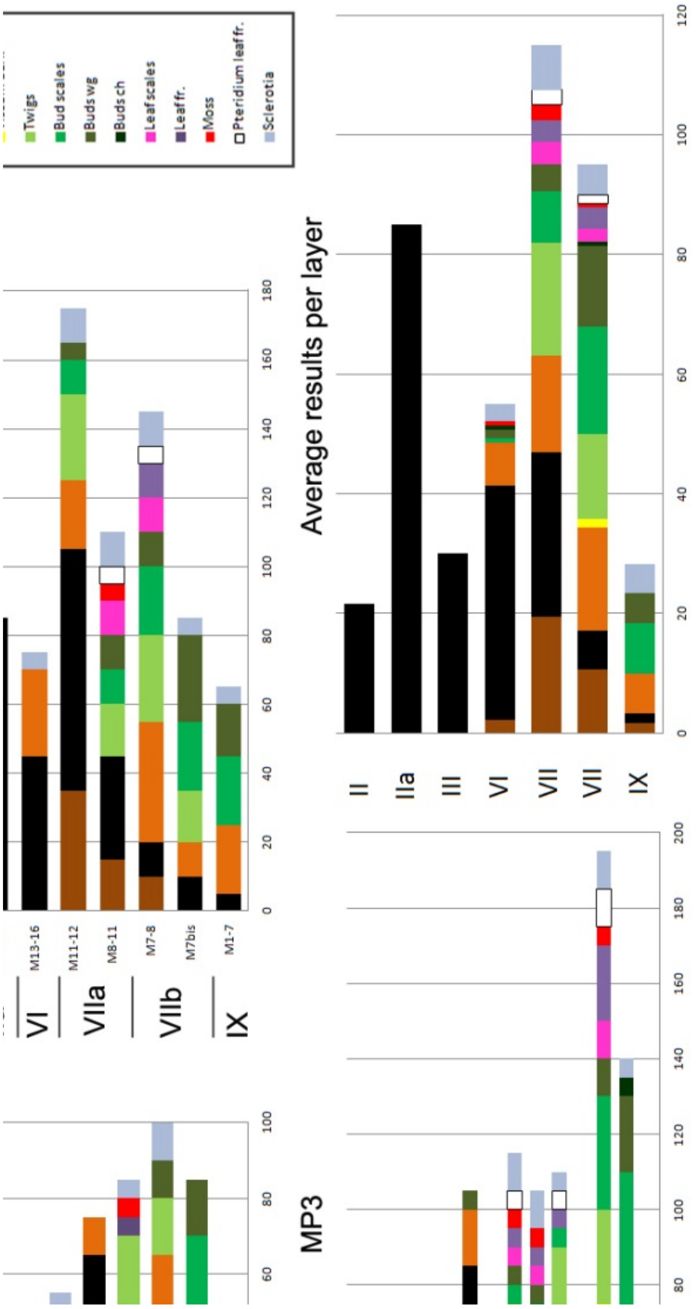


Fig. 4.69. Results of the semi-quantified elements from anthropogenic origin or from outside the lakeshore area presented per sample, per profile and the average concentration per layer (considering all the samples from the three profiles).

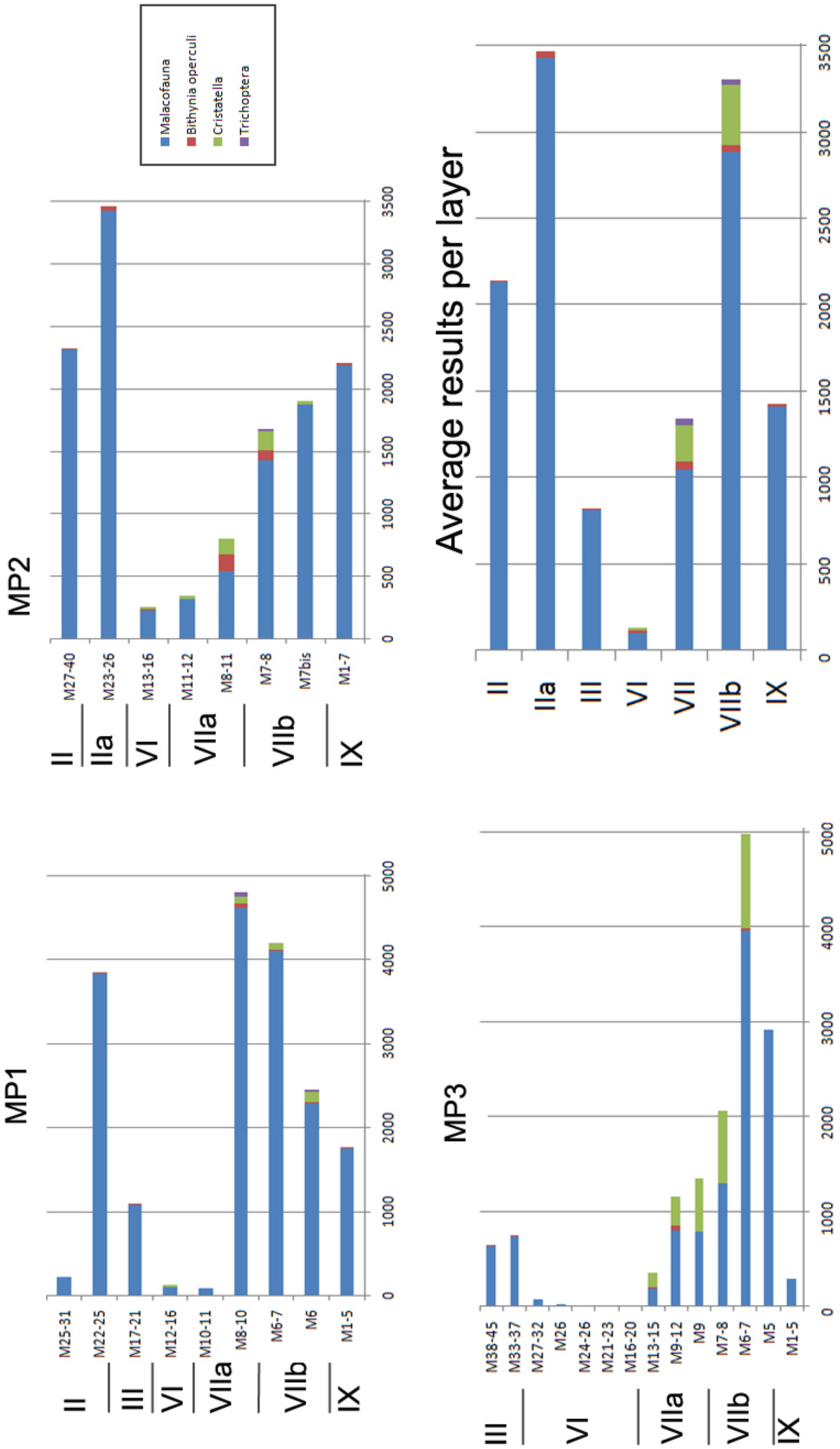


Fig. 4.70. Concentration per litre of sediment of the quantified elements from the lakeshore/lake area presented per sample, per profile and the average concentration per layer (considering all the samples from the three profiles).

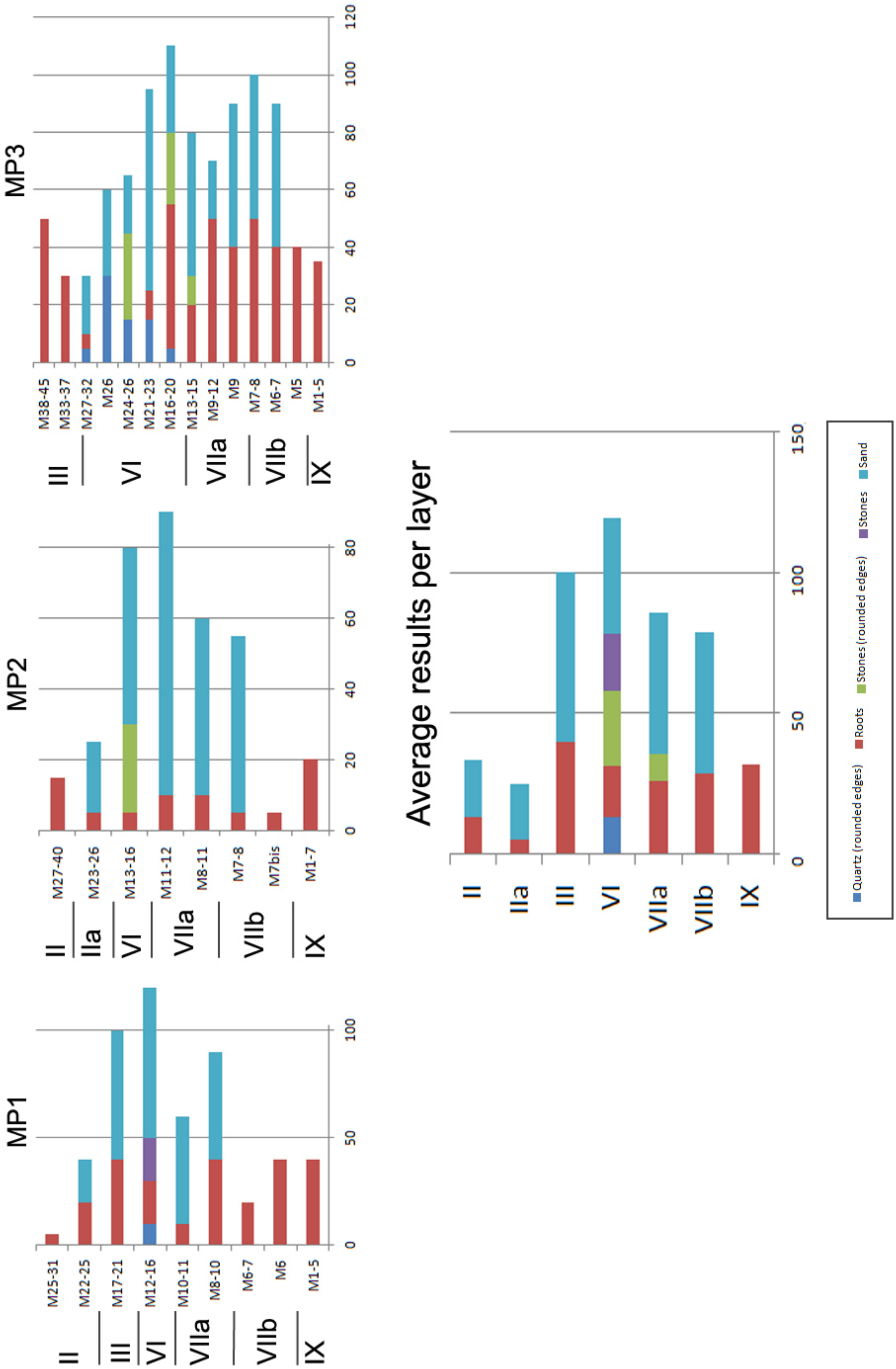


Fig. 4.71. Results of the semi-quantified elements from the lakeshore/lake area presented per sample, per profile and the average concentration per layer (considering all the samples from the three profiles).

Finally, the results obtained from the semiquantified elements from lake or lakeshore environments allow the singularization of some further differences between layers (Fig. 4.71). The clearest difference is the one from layer VI, where all the stones (with and without rounded edges) and quartz fragments (with rounded edges) were recovered. The adscription of stones to lake or lakeshore environments is not clear and further investigations should be carried out on this topic.

As a **summary** of the results presented above, it was observed that the basal layer IX is rather poor in remains, except for some fish bones and malacofauna. Level VIIb, as well as level VIIa, are characterized by the waterlogged preservation of all sorts of organic materials in large quantities. Fish scales were only found in these two levels. The charred component of level VIIb seems to be significantly lower than the one observed in level VIIa. The concentration of of the quantified materials of lakeshore or lake origin is much higher, in general terms, in level VIIb. The opposite is observed when considering the concentration of materials from outside the lakeshore (although the differences are not so sharp). Layer VI has few evidences of material of anthropogenic origin, although the concentration of bone remains is not neglectable and there are particular sub-layers with significant presence of charcoal. Layer III, which was identified as the start of the second settlement phase, shows an important presence of faunal remains, stone flakes and charcoal. Large travertine stones were found in some of the profiles. Its results are rather similar to those from layer IIa, where more charcoal and malacofauna was observed, but less evidences of lake influence. Layer II shows lower evidences of anthropic influence, despite the large presence of fish bones in one of the samples.

4.7.5.2.3. Seed and fruit remains: overall results per layer and the preservation type (charred Vs. waterlogged)

A total number of 1240 seed and fruit remains were recovered after the sorting of the three profiles. Most layers yielded a low number of items, below 200, but layer VII produced over 500 remains, especially level VIIa. The different taphonomic histories of the observed layers could have affected the preservation of seed and fruit remains very significantly. In five of the seven analysed layers (layers II, VI, VIIa and VIIb), 99-100% of the material was preserved in subfossil state. Charred material only appeared with a significant proportion (85%) in layer IIa and with a much smaller percentage (20%) in layer III (Fig. 4.72). The density of charred seeds and fruits is also low in most layers, except for layers III and IIa, where average densities of 70-110 remains per litre of sediment were observed. It is significant to note that level VIIa presents a higher average density of charred remains (17,2 r/l), in comparison with VIIb (1 r/l). On the other hand, the higher average densities of waterlogged material are found in level VIIa and b, followed by layer II. Layers IX and VI present the lowermost densities of seeds and fruits (125-200 r/l).

	Nr. of samples	Total volume of sediment	rNR	eNR	Average density r/l	% ch	% wg	Average density ch	Average density wg
Layer II	2	3,18	60	1274	410,1	0,4	99,6	2,15	407,98
Layer IIa	1	0,32	40	40	125	85	15	106,25	18,75
Layer III	3	2,06	179	827	307,6	20	80	70,95	236,64
Layer VI	5	2,82	110	446	125,8	5,16	94,84	10	114,8
Level VIIa	7	3,35	533	2592	627,7	1,1	98,9	17,19	610,5
Level VIIb	7	1,615	270	850	526,3	0,12	99,88	1,02	528,6
Layer IX	3	0,71	48	141	205,5	0	100	0	205,5

Fig. 4.72. Results of the seed and fruit analysis of the profile samples amalgamated per layer. Proportion of charred and waterlogged remains (ch: charred; wg: waterlogged; rNR: real number of analysed remains; eNR: estimated number of remains; r/l: remains/litre of sediment).

4.7.5.2.4. The volume of the samples and the obtained seed and fruit population

As already mentioned above, most of the samples that were individualized from the profiles were of around 0,3 litres of sediment, and a smaller number of samples were of approximately 0,8 litres. Were these volumes enough for a proper evaluation of the layers? Were the subsamples taken from the 0,35 mm fraction large enough? How diverse is the botanical diversity observed in each layer and does it have any relation with the most frequent type of preservation (waterlogging or charring)? The results per fraction, sample and profile are presented in Fig. 4.73, 4.74 and 4.75.

None of the samples produced the targeted number of items per fraction (*c.* 400). All fractions yielded less than 100 remains and only in 9 cases the number of items was above 50 (Fig. 4.76). Seven samples would yield more than 400 items in the 0,35 mm fraction if this had been sorted in its entirety: two from layer II (MP1-M22-25 and MP1-M25-31), one from layer III (MP1-M17-21), three from level VIIa (MP1-M8-10 and MP3-M9-12) and one from level VIIb (MP3-M6-7).

The botanical diversity obtained in each sample was equally low. Less than 10 taxa were identified in most of the samples (Fig. 4.77). Only the ones from levels VIIa and VIIb produced more than 10 taxa. The 0,35 mm fraction from these samples are, consequently, more likely to yield a larger number of taxa if more subsamples are sorted. The samples from layers II and III show a low taxonomic diversity and this diversity would probably not increase significantly if more subsamples were analysed.

MP1											
Sample	Layer	Vol. (ml)	Fract.	Fract. vol. (ml)	Analyz. vol. (ml)	rNR	eNR	Density (r/l)	Taxa	Target reached?	Worth extra sorting?
M25-31	II	1800	0,35	500	10	13	552	306,67	3	No	No
M22-25	II	700	2	50	50	5	5 (4)	812,86	4	No	No
			0,35	170	10	36	564				
M17-21	III	1000	2	60	60	62	62 (58)	677	6	No	No
			0,35	120	12	66 (9)	615 (81)				
M12-16	VI	840	2	50	50	4	4 (3)	264,29	6	No	No
			0,35	100	11	31	218 (2)				
M10-11	VIIa	300	2	70	70	4	(4)	186,67	10	No	Might increase the nr. of taxa
			0,35	45	10	20	52				
M8-10	VIIa	900	2	170	170	23	23 (3)	1014,44	15	No	Might increase the nr. of taxa
			0,35	240	12	55	890 (2)				
M6-7	VIIb	400	2	130	130	3	3	25	6	No	No
			0,35	90	10	7	7				
M6	VIIb	270	0,35	50	10	22	74	274,07	6	No	No
M1-5	IX	280	0,35	65	10	13	57	203,57	3	No	No

Fig. 4.73. MP1: samples, processed volume, analysed fractions with seed and fruit remains, volume of the fractions and the final analysed volume, real number of obtained remains (rNR) (the number of charred remains is presented in parentheses), estimated total of remains per fraction (eNR), density of remains per litre and number of identified taxa.

MP2											
Sample	Layer	Vol. (ml)	Fract.	Fract. vol. (ml)	Analyz. vol. (ml)	rNR	eNR	Density (r/l)	Taxa	Target reached?	Worth extra sorting?
M27-40	II	1380	2	140	140	3	3	110,87	4	No	No
			0,35	500	10	3	150				
M23-26	IIa	320	2	100	100	36	36 (33)	125	2	No	No
			0,35	120	10	4	4 (1)				
M13-16	VI	400	2	50	50	14	14 (14)	145	9	No	No
			0,35	50	11	15	44 (1)				
M11-12	VIIa	240	0,35	50	10	32	120 (7)	500	8	No	No
M8-11	VIIa	150	2	35	35	15	15 (2)	660	20	No	-
			0,35	20	20	84	84 (7)				
M7-8	VIIb	140	2	70	70	6	6 (1)	478,57	13	No	Might increase nr. of taxa
			0,35	26	11	36	61				
M7bis	VIIb	35	0,35	7	7	27	27	771,43	8	No	-
M1-7	IX	200	2	7	7	1	1	365	2	No	No
			0,35	34	10	22	72				

Fig. 4.74. MP2: samples, processed volume, analysed fractions with seed and fruit remains, volume of the fractions and the final analysed volume, number of obtained remains (rNR) (the number of charred remains is presented in parentheses), estimated total of remains per fraction (eNR), density of remains per litre and number of identified taxa.

MP3											
Sample	Layer	Vol. (ml)	Fract.	Fract. vol. (ml)	Analyz. vol. (ml)	rNR	eNR	Density (r/l)	Taxa	Target reached?	Worth extra sorting?
M38-45	III	760	2	30	30	16	16 (7)	165,79	3	No	No
			0,35	120	10	11	110 (1)				
M33-37	III	300	2	14	14	9	9 (8)	80	2	No	-
			0,35	22	22	15	15 (11)				
M26	VI	220	0,35	16	16	2	2	9,1	2	No	-
M21-23	VI	460	2	40	40	21	21 (3)	47,83	4	No	-
			0,35	50	10	1	1				
M16-20	VI	900	2	35	35	5	5	157,77	4	No	No
			0,35	85	10	17	137				
M13-15	VIIa	1000	2	360	360	45	45 (1)	609	10	No	Might increase the nr. of taxa
			0,35	115	10	60	564				
M9-12	VIIa	800	2	100	100	85	85 (1)	850	13	No	Might increase the nr. of taxa
			0,35	110	10	65	595				
M9	VIIa	200	2	50	50	8	8	575	6	No	No
			0,35	45	10	37	107 (2)				
M7-8	VIIb	180	2	40	40	17	17	566,66	5	No	No
			0,35	50	10	21	85				
M6-7	VIIb	440	2	200	200	56	56	1140,91	10	No	Might increase the nr. of taxa
			0,35	100	10	59	446				
M5	VIIb	150	2	20	20	1	1 (1)	453,33	4	No	No
			0,35	50	10	15	67				
M1-5	IX	150	2	14	14	2	2	47,83	2	No	-
			0,35	40	40	10	10				

Fig. 4.75. MP3: samples, processed volume, analysed fractions with seed and fruit remains, volume of the fractions and the final analysed volume, number of obtained remains (rNR) (the number of charred remains is presented in parentheses), estimated total of remains per fraction (eNR), density of remains per litre and number of identified taxa.

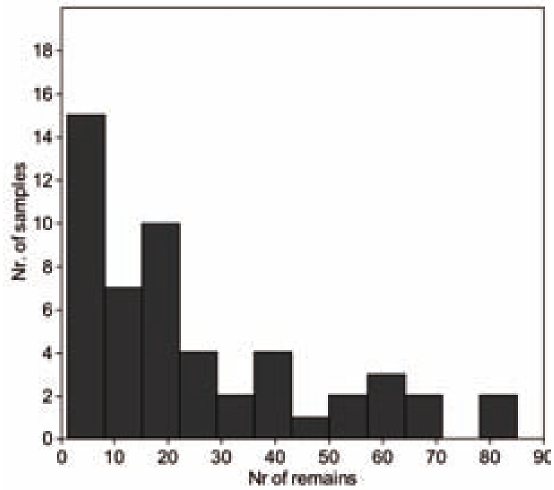


Fig. 4.76. Histogram showing the number of fraction residues from samples of profile columns according to the number of remains they yielded.

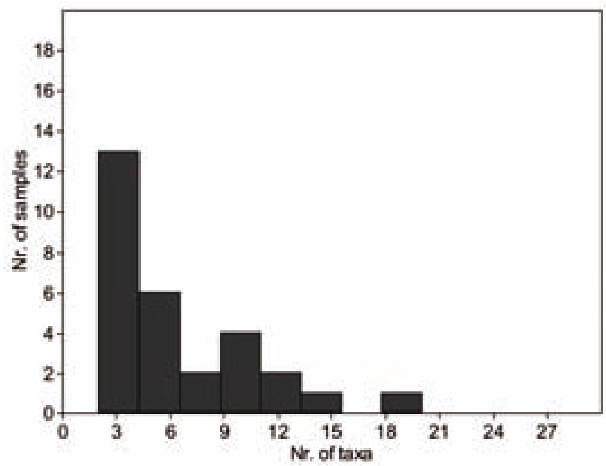


Fig. 4.77. Histogram showing the number of samples from profile columns according to the number of taxa they yielded.

The layers which yielded a larger taxonomic diversity (VIIa and VIIb) are those with waterlogged preservation. The higher densities of remains were also found in these layers. Concentrations above 1000 r/l were found in two samples (MP1-M8-10 and MP3-M6-7). For this reason, it might be worth sorting at least another subsample of the 0,35 mm fraction from the samples of levels VIIa and VIIb which are more likely to yield new taxa (see Fig. 4.73, 4.74 and 4.75).

4.7.5.2.5. Number and densities of seed and fruit remains per layer

The volume of sediment processed per profile and layer is rather variable (Fig. 4.78). This could make it difficult to establish comparisons between profiles. The samples from layer IX are quite similar in size (around 0,2 litres of sediment). Layers II and IIa were only found in two profiles, for which comparisons will be very limited. Concerning the rest of the layers, the samples from MP2 are much smaller than the ones from MP1 and MP3. As a result, the data obtained from MP1 and MP3 are more likely to be comparable than those from MP2.

More than 400 remains would have been obtained in all layers except layer IIa and IX if the totality of the 0,35 mm fraction would have been sorted (Fig. 4.78). This would make the results per layer more reliable on quantitative terms. The samples from MP2 would produce less remains in most of the layers, probably due to the lower volumes of the samples. Other interpretations (e.g. the composition of the samples from this profile is different from the other two profiles) should not be discarded.

	VOLUME OF SAMPLES				ESTIMATED NR. OF REMAINS				AVERAGE CONCENTRATION				NUMBER OF TAXA			
	MP1	MP2	MP3	Σ	MP1	MP2	MP3	Σ	MP1	MP2	MP3	Average	MP1	MP2	MP3	Σ
Layer II	2,5	1,38	-	**3,18**	1121	153	-	**1274**	559,765	110,9	-	**410,1**	4	1	-	**5**
Layer IIa	-	0,32	-	**0,32**	-	40	-	**40**	-	125	-	**125**	-	2	-	**2**
Layer III	1	*	1,06	**2,06**	677	-	150	**827**	677	-	122,895	**307,6**	6	-	3	**7**
Layer VI	0,84	0,4	1,58	**2,82**	222	58	166	**446**	264,3	145	71,566	**125,8**	6	9	7	**11**
Layer VIIa	1,2	0,39	2	**3,59**	969	219	1404	**2592**	600,555	580	677,583	**627,9**	17	21	19	**38**
Layer VIIb	0,67	0,175	0,77	**1,615**	84	94	672	**850**	149,535	625,001	719,545	**523.9**	12	15	15	**26**
Layer IX	0,28	0,2	0,23	**0,71**	57	73	11	**141**	203,6	365	47,8	**205,5**	3	2	2	**5**

*Fig. 4.78.Number of samples, remains and taxa, and average concentration (r/l) per profile and layer (*the sample from MP2 corresponding to layer III was 100% inorganic).*

The average concentration of items per layer is rather high (above 300 r/l) for layers III, II, VIIa and VIIb. Nevertheless, the concentrations are not so high in all profiles. They tend to be higher in MP1 for layers II, III, VI and IX; while in MP3, levels VIIa and VIIb have a higher concentration of items.

The number of taxa is clearly different between layers. Levels VIIa and VIIb present the largest botanical diversity. The rest of the layers, especially layers IIa, II and IX, produced a very low number of taxa. The distribution of the number of taxa per profile is rather regular in all profiles, for which it seems that the volume of the samples and the number of analysed items might have not affected dramatically the botanical composition of the layer. Consequently, qualitative comparisons between layers from MP2 and the other two profiles might be possible.

4.7.5.2.6. What information can one expect to obtain from each archaeological layer and from each sample? Are both charred and waterlogged remains significant enough at a quantitative level?

The obtained data at a sample level are too scarce to be considered quantitatively significant. Consequently, it is difficult to state differences between samples from the same layer. Alternatively, the botanical diversity seems to be similarly represented in all profiles, for which qualitative comparisons between samples of the same layer but from different profiles might be informative at a spatial level (if used with caution).

However, the obtained results at a layer scale are much more quantitatively significant (except for layers II, IIa and IX), for which the comparison between layers should allow the proposal of the first diachronical trends at the site. These data must also be used and interpreted with caution, since the number of analysed items is low in many cases and we will be working with estimations.

All quantitative evaluations are only valid for waterlogged material, since charred remains were too sparse. Larger surface samples will be needed for a proper evaluation of the charred record.

In the next lines, a **quantitative and qualitative evaluation at a layer scale** will be presented, mainly attending to the representation of the different ecological groups in each layer, and the better represented taxa within each group.

4.7.5.2.7. Results per layer: total of remains and concentration of items per litre of sediment

In the forthcoming lines, the results obtained for the seed and fruit record will be presented per layer and sample in order to get a short look at the detailed results and notice particular differences between profiles or samples which may affect the amalgamated results that will be presented in the subsequent chapter 4.7.2.8.

The total estimated number of items and the concentration of items per profile is presented in Fig. III.13. The taxa were classified into ecological groups, as described in chapter 3.2.7. As a result, 6 taxa were classified as cultivars (**C**: *Hordeum* sp., *Triticum durum/turgidum* type, *Triticum aestivum* type*, Triticum dicoccum, Triticum monococcum* and *Papaver somniferum*); twelve taxa were included either in the group of weeds and ruderals (**WER:** *Capsella bursa-pastoris, Bromus* cf. *arvensis*, *Chenopodium album*, cf. *Neslia paniculata*, *Portulaca oleracea, Silene gallica, Sonchus oleraceus/asper, Urtica dioica, Verbena officinalis*) or into the pastures and grasslands group (**PG:** *Epilobium* sp.[5], *Leucanthemum vulgare,* cf. *Pulicaria dysenterica*,); three taxa were put to the woodland group (**WO:** *Clematis vitalba, Pyrus malus* subsp. *silvestris, Quercus* sp.); four taxa to the woodland edges and clearings group (**WEC:** *Fragaria vesca, Physalis alkekengi, Rubus fruticosus* and *Sambucus* cf. *nigra*); ten taxa to the group of lakeshore plants (**LS:** *Alisma plantago-aquatica, Carex hirta* type, *Cladium mariscus, Eupatorium cannabinum, Juncus* sp., *Lycopus europaeus,* cf. *Phragmites* sp., *Ranunculus sceleratus*, *Typha* sp., *Vitis vinifera* subsp. *sylvestris*); two taxa to the water plants group (**WP:** *Najas marina,* Characeae); and ten to the unknown or diverse group (**DIV:** *Apium* sp., *Cerastium* sp., *Cyperus* sp., cf. *Dactylis glomerata*, cf. *Linum* sp., *Mentha* sp., Papilionaceae, *Prunus* sp., *Scirpus* sp., *Solanum* sp.).

Layer IX

The results of the seed and fruit record from this layer show a clear predominance of Oogonia of Characeae (Fig. 4.79). Four more taxa were identified but only as single finds.

An important proportion of the oogonia do not present the typical lime concretion that is formed around them. This is considered to indicate poor conditions of preservation. These data would indicate that this deposit was formed in underwater conditions. A more careful identification of the Oogonia could give information concerning the depth of the water in which these algae were growing.

			Sample	DG10-MP1-M1-5		DG10-MP2-M1-7		DG10-MP3-M1-5		TOTAL	
Ecol. group	Taxa	Represented part	Preservation	eNR	Concentr.	eNR	Concentr.	eNR	Concentr.	eNR	Average concentr.
C	*Papaver somniferum*	Total CU	5			1	5			1	1,67
WEC	*Rubus fruticosus* agg.	Total CU	5					1	4,35	1	1,45
LS	*Cladium mariscus*	Total CU	5	1	3,57					1	1,19
WP	Characeae	Oogonia with outer layer	5	1	3,57	55	275			56	92,87
WP	Characeae	Oogonia without outer layer	5	54	192,86	17	85	10	43	81	106,95
DIV	*Mentha* sp.	seed/fruit	5	1	3,57					1	1,19
			Total remains	57	203,57	73	365	11	47,83	141	205,47
			Sample volume (l.)	0,28	0,28	0,2	0,2	0,23	0,23	0,71	0,71
			Nr. of taxa	3	3	2	2	2	2	5	5

Fig. 4.79. Synthesis of results of the samples from layer IX taken from the profile samples of La Draga (CU: counted units; for the ranking values used to describe the preservation type see Fig. 3.27; eNR: estimated number of remains).

[5] It is probably *Epilobium tetragonum, E.hirsutum* or *E. parviflorum*.

Level VIIb

As already mentioned, this level corresponds to the first settlement phase at La Draga. The first evidences of the presence of cultivars (barley, tetraploid naked wheat and einkorn) were detected in our analysis (Fig. 4.80), together with the appearance of several taxa which are not local (wild apples or acorns) and were probably transported to this area by humans. Nevertheless, a closer look at the results obtained per sample allows the observation that some sharp differences exist between them. These aspects will be developed in the next lines.

Cultivars are well represented. Among the cereals, free-threshing wheat is the best represented taxon. Both charred grain and waterlogged chaff remains (more abundant than grain) were recovered. Most of the chaff remains were recovered in MP3. Some scanty chaff remains of barley and einkorn were also identified. Nevertheless, he better represented cultivar was opium poppy. Waterlogged seeds were recovered in MP2 and MP3, but mostly in the latter, with concentration values of 50 r/l in MP2 and between 433 and 954 r/l in MP3.

Seeds from weeds and ruderals, as well as pastures and grasslands were mostly present in MP1 and MP2 and nearly absent in MP3. These were mostly single finds in waterlogged state, for which it is really difficult to tell their origin. On the other hand, most of the woodland taxa, including four clearly edible taxa (*Fragaria vesca, Rubus fruticosus, Pyrus malus* subsp. *sylvestris, Quercus* sp.) were only identified in MP2 and MP3 and in waterlogged state.

Besides cultivars, the other important ecological group (in quantitative terms) are lakeshore and aquatic plants. A rather large diversity is observed, but primarily concentrated in MP1 and MP2. MP3 has barely any find from these two groups. These sharp differences do not seem to be due to taphonomic reasons but to real spatial differences, which should be confirmed after the analyses of the systematic surface samples. There seems to be more lakeshore vegetation in profiles MP1 and MP2. But the presence of organisms living in water in MP3 can also be attested through the finding of statoblasts of *Cristatella* sp. The different composition of the samples of MP3 might respond to activity areas within the site. The concentration of chaff observed in this profile might relate, for instance, to the finding of dung in the sample DG10-MP3-M6-7. This could also be confirmed in the near future through the analysis of the composition of the dung pellets that were found.

				DG10-MP1-M6		DG10-MP1-M6-7		DG10-MP2-M7bis		DG10-MP2-M7-8		DG10-MP3-M5		DG10-MP3-M6-7		DG10-MP3-M7-8		TOTAL	
EG	**Taxa**	**Represented part**	**Pr.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Aver. conc.**
C	*Hordeum* sp.	chaff (node=1)	5													1	5,56	1	0,8
C	*Triticum aest./dur./turg*	grain (MNI)	1							1	7,1							1	1
C	*Triticum dur./turg.* type	chaff (node=1)	3+5											9	20,5			9	2
C	*Triticum monococcum*	spikelet fork (SF=2)	5											2	4.54			2	0,64
C	*Triticum* sp.	chaff	5											32	72, 3			32	10,4
C	Cerealia	grain pericarp	5											4	9, 1			4	1,3
C	Cerealia	chaff	5											3	6,8			3	1
C	*Papaver somniferum*	Total CU	5							7	50	65	433, 3	420	954,5	95	527, 8	587	280,8
WER	*Bromus* cf. *arvensis*	pericarp fragment	5							1	7,1							1	1
WER	cf. *Neslia paniculata*	fragment	5					1	28,6									1	4,1
WER	*Portulaca oleracea*	seed/fruit	5			1	2,5	1	28,6									2	4,4
WER	*Urtica dioica*	seed/fruit	5	1	3,7													1	0,5
WER	*Verbena officinalis*	Total CU	5							2	14,3							2	2
PG	*Leucanthemum vulgare*	seed/fruit	5											1	2, 3			1	0,3
WO	*Clematis vitalba*	seed/fruit	5											1	2, 3			1	0,3
WO	*Pyrus malus* subsp. *sylv.*	Total CU	5											2	4,5			2	0,6
WO	*Quercus* sp.	Total CU	5							2	14,3			1	2,3			3	2,4
WEC	*Fragaria vesca*	seed/fruit	5							1	7,1							1	1
WEC	*Rubus fruticosus* agg.	Total CU								1	7,1							1	1
LS	*Alisma plantago-aquatica*	seed/fruit	5			1	2,5											1	0,4
LS	*Carex hirta* type	seed/fruit	5																
LS	*Cladium mariscus*	Total CU	5	2	7,4	1	2,5	7	200	17	121, 4					1	5,6	28	48,1
LS	*Eupatorium cannabinum*	Total CU	5			1	2,5			1	7,1							2	1,4
LS	*Juncus* sp.	seed/fruit	5	1	3,7							1	6,7					2	1,5
LS	*Typha* sp.	seed/fruit	5							1	7,1							1	1
LS	*Vitis vinifera* subsp. *sylv.*	Total CU	5							1	7,1							1	1
WP	Characeae	Oogonia with outer layer	5	2	7,4			6	171,4	3	21,4			1	2,3			12	28,9
WP	Characeae	Oogonia without outer layer	5	50	185,2	2	5	4	114,3	19	135, 7							75	62,9
DIV	cf. *Apium* sp.	seed/fruit	5			1	2,5											1	0,4
DIV	Cyperaceae	seed/fruit	5	15	55,6	3	7,5			1	7,1							19	10
DIV	*Cyperus* sp.	seed/fruit	5											2	4,5			2	0,6
DIV	*Mentha* sp.	seed/fruit	5													1	5,6	1	0,8
DIV	*Papaver* sp.	seed/fruit	5					4	114,3	2	14,3							6	18,4
DIV	Papilionaceae	seed/fruit	1									1	6,7					1	0,9
DIV	Poaceae	total remains	5	1	3,7			1	28,6					1	2,3			3	4,9
DIV	*Rubus* sp.	Total CU	5					1	28,6	1	7,1	1	6,7	1	2,3	1	5,6	5	7,2
DIV	Umbelliferae	Total CU	5	1	3,7			1	28,6	1	7,1							3	5,6
	Unidentified	total remains	5					1	28,6	5	35,7			7	15,9			13	11,5
	Varia	total remains	5	1	3,7									2	4,5	3	16,7	6	3,6
		Total remains		74	274,1	10	25	27	771,4	67	478,6	68	453, 3	502	1140.9 1	102	566, 7	850	526.3
		Sample volume (l.)		0,27	0,27	0,4	0,4	0,035	0,035	0,14	0,14	0,15	0,15	0,44	0,44	0,18	0,18	1,615	1,615
		Nr. of taxa		6	6	6	6	8	8	13	13	4	4	10	10	5	5	26	26

Fig. 4.80. Synthesis of results of the samples from level VIIb taken from the profile samples of La Draga (CU: counted units; for the ranking values used to describe the preservation type see Fig. 3.27; eNR: estimated number of remains).

				DG10-MP1-M8-10		DG10-MP1-M10-11		DG10-MP2-M8-11		DG10-MP2-M11-12		DG10-MP3-M9		DG10-MP3-M9-12		DG10-MP3-M13-15		TOTAL	
EG	Taxa	Represented part	Pres.	eNR	Conc.	eNR	Conc.	eNR	Conc.	eNR	Conc.	eNR	Conc.	eNR	Conc.	eNR	Conc.	eNR	Aver. Conc.
C	*Hordeum* sp.	chaff (node=1)	5											4	5	1	1	5	0,9
C	*Triticum dur./turg.*	chaff (node=1)	1					1	6,7									1	1,0
C	*Triticum dur./turg.*	chaff (node=1)	3+5									2	10	61	76,3	7	7	70	13,3
C	*Triticum aestivum*	chaff (node=1)	5													3	3	3	0,4
C	*T. aest./dur./turg.*	grain (MNI)	1	1	1,1	3	10	2	13,3					1	1,3	1	1	8	3,8
C	*T. aest./dur./turg.*	chaff (node=1)	1							1	4,2							1	0,6
C	*T. aest./dur./turg.*	chaff (node=1)	5													1	1	1	0,1
C	*Triticum dicoccum*	glume base (GB=1)	5											3	3,8	1	1	4	0,7
C	*Triticum monococcum*	glume base (GB=1)	5											3	3,75			3	0,53
C	Glume wheat	chaff (nr)	5									1	5					1	0,7
C	*Triticum* sp.	grain	1	1	1,1	1	3,3											2	0,6
C	*Triticum* sp.	chaff	1					1	6,7									1	1
C	*Triticum* sp.	chaff	5									3	10	54	66,3	1	1	56	11,0
C	*Cerealia*	grain	1					4	26,7	2	8,3							6	5
C	*Cerealia*	grain pericarp	5	1	1,1											1	1	2	0,3
C	*Cerealia*	chaff	5									2	10					2	1,4
C	*Papaver somniferum*	Total CU	5					8	53,3	50	208,3	99	495	516	645	569	569	1242	281,2
WER	*Bromus cf. arvensis*	pericarp fragment	5					1	6,7									1	1,0
WER	*Capsella bursa-pastoris*	seed/fruit	5									1	5					1	0,7
WER	*Chenopodium album*	seed/fruit	5													1	1	1	0,1
WER	*Silene gallica*	seed/fruit	5													1	1	1	0,1
WER	*Sonchus oleraceus/asper*	seed/fruit	5									1	5					1	0,7
WER	*Urtica dioica*	seed/fruit	5	63	70,0	1	3,3											64	10,5
WER	*Verbena officinalis*	Total CU	5					7	46,7	25	104,2			1	1,3			33	21,7
PG	*Epilobium sp.*	seed/fruit	5					2	13,3									2	1,9
PG	*cf. Pulicaria dysenterica*	seed/fruit	5	1	1,1													1	0,2
WO	*Clematis vitalba*	seed/fruit	5											1	1,3			1	0,2
WO	*Quercus sp.*	Total CU	5					1	6,7					7	8,8	9	9	17	3,5
WEC	*Rubus fruticosus agg.*	Total CU		1	1,1	1	3,3	1	6,7									3	1,6
LS	*Alisma plantago-aquatica*	seed/fruit	5	81	90,0	27	90,0	3	20	1	4,2							112	29,2
LS	*Carex hirta type*	seed/fruit	5					1	6,7									1	1,0
LS	*Cladium mariscus*	Total CU	5	121	121			5	33,3							2	2	128	24,3
LS	*Eupatorium cannabinum*	Total CU	5					2	13,3									2	1,9
LS	*Juncus sp.*	seed/fruit	5			1	3,3	1	6,7									2	1,4
LS	*Lycopus europaeus*	seed/fruit	5	1	1,1			7	46,7	20	83,3							28	18,7
LS	*cf. Phragmites sp.*	pericarp	5					1	6,7									1	1,0
LS	*Ranunculus sceleratus*	Total CU	5	2	2,2	2	6,7	4	26,7	1	4,2							9	5,7
LS	*Typha sp.*	seed/fruit	5					2	13,3									2	1,9
WP	*Najas marina*	fragment	5					1	6,7									1	1,0
WP	Characeae	Oogonia with outer layer	5					7	47									7	6,7
WP	Characeae	Oogonia without outer layer	5	283	314,4			22	147	15	63					1	1	321	75,1
DIV	*Apium* sp.	seed/fruit	5	120	133,3													120	19,0
DIV	*Carex* sp. tricarpellate	fragment	5	1	1,1													1	0,2
DIV	Caryophyllaceae	fragment	5									1	5			1	1	2	0,9
DIV	*Cerastium* sp.	seed/fruit	5											1	1,3			1	0,2
DIV	Cerealia/Poaceae	rachis frag.	5											2	2,5			2	0,4
DIV	Cyperaceae	seed/fruit	5	81	90,0													81	12,9
DIV	*Cyperus* sp.	seed/fruit	5											1	1,3			1	0,2
DIV	cf. *Dactylis glomerata*	pericarp fragment	5					1	6,7									1	1,0
DIV	cf. *Linum* sp.	fragment	5	1	1,1													1	0,2
DIV	*Mentha* sp.	seed/fruit	5	80	88,9	1	3,3	1	6,7									82	14,1
DIV	*Papaver* sp.	seed/fruit	5					4	26,7									4	3,8
DIV	*Papaver/Nasturtium*	underdeveloped grain	5			1	3,3											1	0,5
DIV	Poaceae	total remains	5	1	1,1							1	5					2	0,9
DIV	*Prunus* sp.	seed/fruit	5											1	1,3			1	0,2
DIV	*Ranunculus* sp.	seed/fruit	5											1	1,3			1	0,2
DIV	*Rubus* sp.	Total CU	5	2	2,2	1	3,3	1	6,7	1	4,2			2	2,5			7	2,7
DIV	*Sambucus* sp.	Total CU	5	2	2,2													2	0,3
DIV	*Scirpus* sp.	Total CU	5	60	66,7	15	13,3											75	11,4
DIV	Umbelliferae	Total CU	5	1	1,1	1	3,3											2	0,6
	Unidentified	total remains	1+5	1	1,1			6	40					5	6,3	3	3	15	7,2
	Varia	total remains	1+5	4	4,4	1	3,3	1	6,7					3	3,8	1	1	10	2,7
		Total remains		913	1014,4	56	186,7	99	660	120	500	115	575	680	850	609	609	2592	627,7
		Sample volume (l.)		0,9	0,9	0,3	0,3	0,15	0,15	0,24	0,24	0,2	0,2	0,8	0,8	1	1	3,59	3,59
		Nr. of taxa		15	15	10	10	20	20	8	8	6	6	13	13	10	10	38	38

Fig. 4.81. Synthesis of results of the samples from level VIIa taken from the profile samples of La Draga (CU: counted units; for the ranking values used to describe the preservation type see Fig. 3.27; eNR: estimated number of remains).

Level VIIa

Cultivars are equally well represented in level VIIa. Some differences can be observed though. On the one hand, besides the already identified cultivars, emmer was recovered in two samples of MP3. On the other hand, the presence of charred grains and chaff remains is more significant in all profiles. These mainly belong to naked wheat. Chaff remains continue to be better represented in MP3. Concerning poppy, it does not appear in MP1, just like in level VIIb, but it was recovered in MP2 and MP3 (the concentration values were higher in this profile).

Urtica dioica and *Verbena officinalis* are well represented among the weeds and ruderals groups, but the former only appears in MP1 while the latter was primarily recovered in MP2.Waterlogged remains of acorns were identified in MP2 and MP3.

Water plants, once again, concentrate in MP1 and MP2, giving a similar spatial pattern to the one observed previously.

Layer VI

Layer VI is considered to be some sort of natural layer in between the two settlement phases that were documented in La Draga (Palomo et al. 2012). Despite this, charred grains and chaff of naked wheat were recovered in all profiles, sometimes with similar or larger concentrations than in level VIIa (Fig. 4.82). Waterlogged cereal remains were not found. This time the largest concentrations were obtained in MP2, while it is very interesting to note that the charred remains from MP3 are from the sample M21-23, which was characterized as a charcoal layer already during the sampling of the profile. On the other hand, poppy was identified in samples of MP2 and MP3.

				DG10-MP1-M12-16		DG10-MP2-M13-16		DG10-MP3-M16-20		DG10-MP3-M21-23		DG10-MP3-26		TOTAL	
EG	**Taxa**	**Represented part**	**Pres.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Aver. Conc.**
C	*Triticum aest./dur./turg.*	grain (MNI)	1	3	3,6	5	12,5			3	6,5			11	4,5
C	*Triticum aest./dur./turg.*	chaff (node=1)	1			7	17,5							7	3,5
C	*Triticum dur./turg.* type	chaff (node=1)	1			6	15							6	3
C	*Triticum* sp.	grain	1			2	5							2	1
C	Cerealia	grain	1	2	2,4									2	0,5
C	*Papaver somniferum*	Total CU	5			14	35	136	151,1	17	37,0			167	44,4
WEC	*Physalis alkekengi*	fragment	5			1	2,5							1	0,5
LS	*Alisma plantago-aquatica*	seed/fruit	5			1	2,5							1	0,5
LS	*Cladium mariscus*	Total CU	5			1	2,5	1	1,1					2	0,7
LS	*Eupatorium cannabinum*	Total CU	5	1	1,2	1	2,5					1	4,5	3	1,6
WP	Characeae	Oogonia with outer layer	5	2	2,4									2	0,5
WP	Characeae	Oogonia without outer layer	5	183	217,9	23	57			1	2,2			207	55,4
DIV	Cyperaceae	seed/fruit	5	28	33,3									28	33,3
DIV	*Papaver* sp.	seed/fruit	5					2	2,2			1	4,5	3	1,4
DIV	*Rubus* sp.	Total CU	5	1	1,2	1	2,5	2	2,2	1	2,2			5	1,6
DIV	*Sambucus* sp.	Total CU	5			1	2,5							1	0,5
DIV	*Scirpus* sp.	Total CU	5	1	1,2									1	0,2
DIV	*Solanum* sp.	seed/fruit	5					1	1,1					1	0,2
DIV	*Solanum/Physalis*	fragment	5	1	1,2									1	0,2
		Total remains		222	264,3	58	145	142	157,8	22	47,8	2	9,1	446	125,8
		Sample volume (l.)		0,84	0,84	0,4	0,4	0,9	0,9	0,46	0,46	0,22	0,22	2,82	2,82
		Nr. of taxa		6	6	9	9	4	4	4	4	2	2	11	11

Fig. 4.82. Synthesis of results of the samples from layer VI taken from the profile samples of La Draga (CU: counted units; for the ranking values used to describe the preservation type see Fig. 3.2; eNR: estimated number of remains 7).

Lakeshore and water plants are badly represented, but they were mainly recovered in MP1 and MP2. In general, waterlogged remains are mostly lacking.

Layer III

The results obtained from layer III also show that waterlogged remains (other than Oogonia of Characeae) were only very rarely recovered. Charred cereal remains were found in all layers, with particularly high numbers in MP1. Water plants show high concentration values in MP1 and MP3.

				DG10-MP1-M17-21		DG10-MP3-M33-37		DG10-MP3-M38-45		TOTAL	
EG	Taxa	Represented part	Preservation (1:charred to 5:uncharred)	eNR	Conc.	eNR	Conc.	eNR	Conc.	eNR	Aver. Conc.
C	*Hordeum* sp. (incl. cf.)	FPostC	1					1	1,32	1	0,44
C	*Triticum aest/dur/turg*	grain (MNI)	1	17	17	3	10	1	1,316	21	9,439
C	*Triticum* sp.	grain	1	21	21	5	16,67			26	12,56
C	Cerealia	grain	1	101	101	9	30	6	7,895	116	46,3
WEC	*Sambucus* cf. *nigra*	seed/fruit	5	1	1					1	0,333
LS	*Cladium mariscus*	Total CU	5	1	1					1	0,333
LS	*Eupatorium cannabinum*	Total CU	5	1	1					1	0,333
WP	Characeae	Oogonia with outer layer	5	30	30	4	13	117	153,9	160	69,6
WP	Characeae	Oogonia without outer layer	5	502	502	1	3,3	1	1,316	504	168,9
DIV	*Sambucus* sp.	Total CU	5	2	2					2	0,667
DIV	*Solanum* sp.	seed/fruit	5	1	1					1	0,333
			Total remains	677	677	24	80	126	165,8	827	307,6
			Sample volume (l.)	1	1	0,3	0,3	0,76	0,76	2,06	2,06
			Nr. of taxa	6	6	2	2	3	3	7	7

Fig. 4.83. Synthesis of results of the samples from layer III taken from the profile samples of La Draga (CU: counted units; for the ranking values used to describe the preservation type see Fig. 3.27; eNR: estimated number of remains).

Layer IIa

As already mentioned, layer IIa probably belongs to the same settlement phase as layer III, but it seems to be more recent when considering the stratigraphical location of both layers. It was only identified in MP2, for which the results that we are presenting are very preliminary. Mainly charred cereal remains were recovered, primarily naked wheat. Chaff remains of tetraploid naked wheat were also identified. Besides, some waterlogged seeds of *Sambucus* were also recovered. This taxon is well known for its capacity for surviving in oxic environments, for which good waterlogging conditions are not necessary for its preservation.

				DG10-MP2-M23-26	
Ecological group	Taxa	Represented part	Preservation (1:charred to 5:uncharred)	eNR	Concentr.
C	*Triticum aestivum/durum/turgidum*	grain (MNI)	1	13	40,625
C	*Triticum durum/turgidum*	chaff (node=1)	1	3	9,375
C	*Triticum* sp.	grain	1	13	40,625
C	Cerealia	grain	1	5	15,625
WEC	*Sambucus* cf. *nigra*	seed/fruit	5	1	3,125
DIV	*Sambucus* sp.	total CU	5	5	15,625
			Total remains	40	125
			Sample volume (l.)	0,32	0,32
			Nr. of taxa	2	2

Fig. 4.84. Synthesis of results of the samples from layer IIa taken from the profile samples of La Draga (CU: counted units; for the ranking values used to describe the preservation type see Fig. 3.27; eNR: estimated number of remains).

Layer II

Finally, layer II was identified in MP1 and MP2. It is not interpreted as an archaeological deposit, but charred grains were also recovered in both profiles. Besides, relatively large concentrations of lakeshore and waterplants were identified. The concentration of *Eupatorium cannabinum* is particularly high in MP2, while oogonia of Characeae are better represented in MP1.*Eupatorium cannabinum* is typical of riverside woodland edges, for which it might be indicating some sort of ecological change in the area. I will not go into further discussion concerning this issue. Further analyses should be carried out, including pollen analyses, in order to get a better insight into what happened in the area after the abandonment of the settlement.

				DG10-MP1-M22-25		DG10-MP1-M25-31		DG10-MP2-M27-40		TOTAL	
EG	**Taxa**	**Represented part**	**Pres.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Conc.**	**eNR**	**Aver. Conc.**
C	*Triticum aest./dur./turg.*	grain (MNI)	1	3	4,3			1	0,7	4	1,7
C	*Triticum* sp.	grain	1	1	1,4					1	0,5
LS	*Alisma plantago-aquatica*	seed/fruit	5	1	1,4					1	0,5
LS	*Cladium mariscus*	Total CU	1?					1	0,7	1	0,2
LS	*Eupatorium cannabinum*	Total CU	5	3	4,3	1	0,6	150	108,7	154	37,8
WP	Characeae	Oogonia with outer layer	5			550		1	0,7	551	0,2
WP	Characeae	Oogonia without outer layer	5	561	801,4					561	267,1
DIV	Cyperaceae	seed/fruit	5			1	0,6			1	0,2
		Total remains		569	812,9	552	306,7	153	110,9	1274	410,1
		Sample volume (l.)		0,7	0,7	1,8	1,8	1,38	1,38	3,18	3,18
		Nr. of taxa		4	4	3	3	4	4	5	5

Fig. 4.85. Synthesis of results of the samples from layer II taken from the profile samples of La Draga (CU: counted units; for the ranking values used to describe the preservation type see Fig. 3.27; eNR: estimated number of remains).

4.7.5.2.8. Quantitative evaluation of the results per layer: taxa and ecological groups represented

The distribution of the taxa and the different ecological groups along the stratigraphy is not even. In order to evaluate this issue we will compare the number of taxa per ecological group (Fig. 4.86) and the relative proportions among the estimated total number of items identified for each group (all samples from the same layer from all profiles have been amalgamated in Fig. 4.87). At a final stage, the average density of items per litre of sediment will be presented per taxon and layer in stratigraphic diagrams.

In general terms, levels VIIa and VIIb have a clearly larger botanical diversity (above 25 taxa), as already mentioned above. Concerning the taxa from lakeshore and aquatic environments, they are present in all layers except layer IIa. The largest botanical diversity within these groups is observed in levels VIIb and VIIa (Fig. 4.86). When looking at the relative proportion of the number of remains within each group per layer, a different trend is observed. Layers IX, III and II show very high percentages of aquatic plants, while levels VIIb and VIIa have a much lower proportion (Fig. 4.87). Concerning the diversity of cultivars, it is equally larger in levels VIIa and VIIb, but they are present in all the analysed layers. If we consider the relative proportions of this group, it becomes clear that cultivars are very well represented in levels VIIb, VIIa and IIa, but not so well represented in layers VI and III. There are barely any remains of cultivars in layers IX and II. Plants from the groups of weeds and ruderals, pastures and grasslands and woodland areas are only present in levels VIIa and VIIb. The botanical diversity of these groups is relatively large, but they are not very well represented at a quantitative level, especially in relation to the rest of the ecological groups.

Finally, plants from woodland edges and clearings are present in all layers (except layer II) but in a very low proportion.

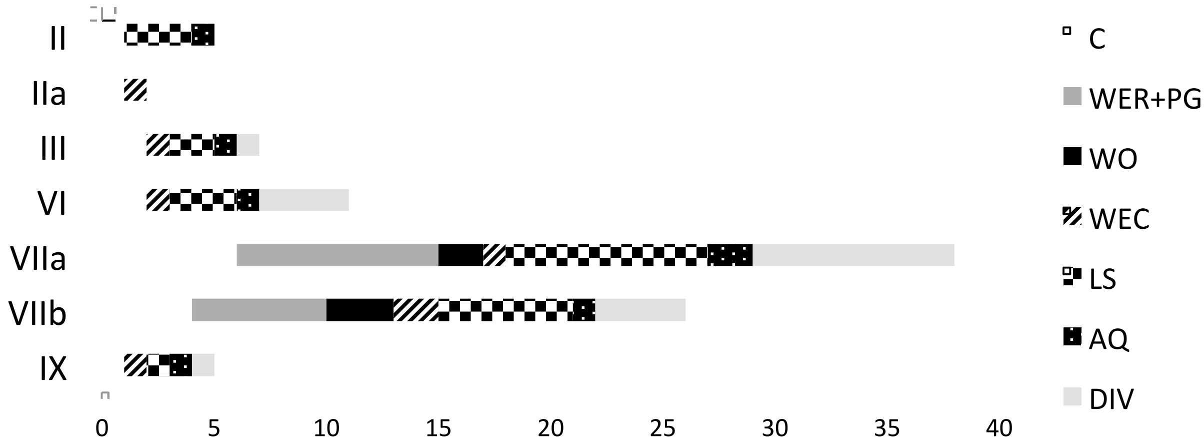


Fig. 4.86. Number of taxa per ecological group in each layer analysed in the profile samples.

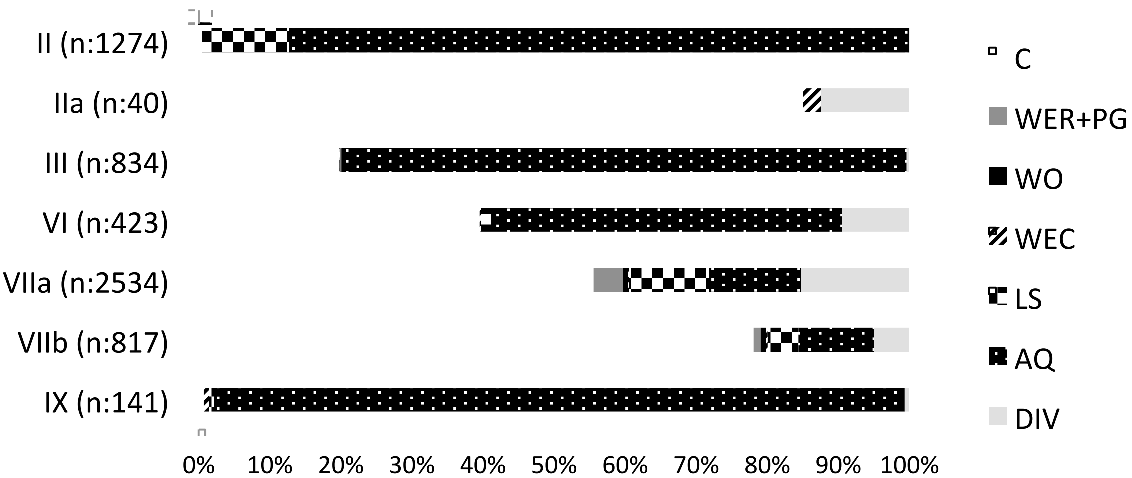


Fig. 4.87. Relative proportions among the estimated total number of items per ecological group in each layer analysed in the profile samples.

In the following paragraphs, a more detailed evaluation per ecological group will be presented, considering, first, the results per sample and profile and, after that, the average concentration of remains per litre of sediment. A synthetic stratigraphic diagram showing the amalgamated results per layer (with an average concentration of remains per litre of sediment obtained from the results of all samples) is presented in Fig. III.14.

Aquatic and lakeshore plants

As already stated above, all seeds and fruits of aquatic and lakeshore plants were in waterlogged state. Their distribution along the stratigraphy shows clear changes (Fig. 4.88). Aquatic plants are much better represented in layers IX, III and II, where lakeshore plants are rarely present. Concentrations of 200-300 r/l are observed. Among the aquatic plants, Characeae are the most frequently encountered. The highest concentrations appear in layers IX and VII.

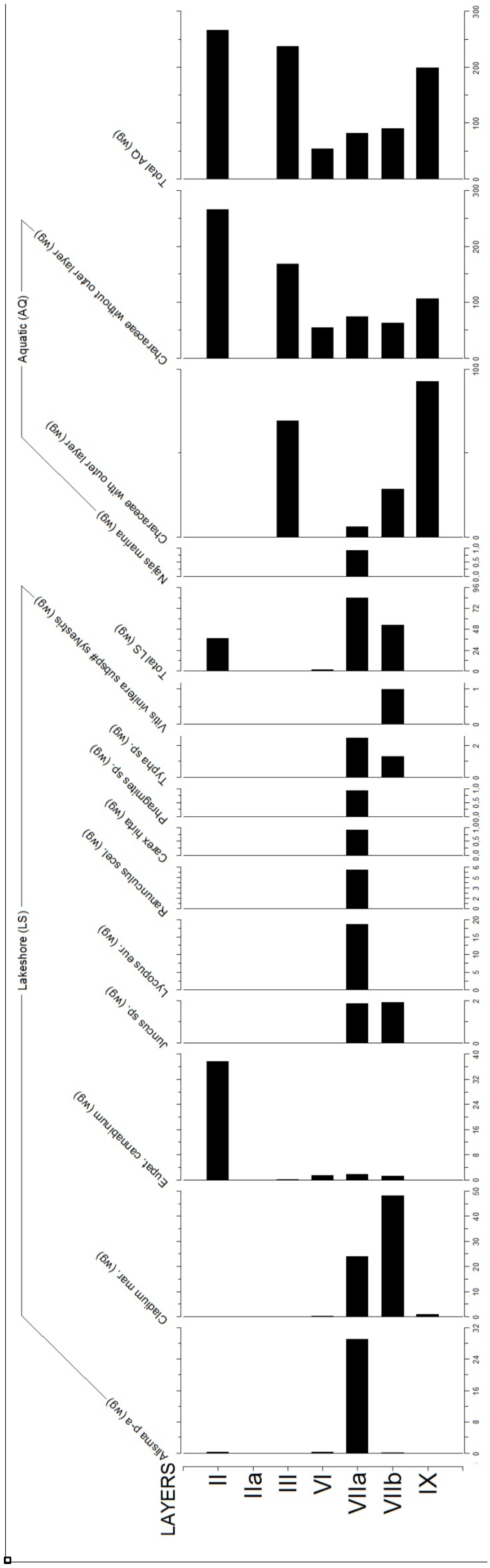


Fig. 4.88. Stratigraphic diagram showing the average concentration of seeds and fruits of lakeshore and aquatic plants per litre of sediment from all the samples from each layer analysed in the profile samples.

In levels VIIa and VIIb lakeshore and aquatic taxa are more evenly represented (Fig. 4.88). There is a greater botanical diversity within the lakeshore group in these levels. In level VIIb, a high concentration of seeds of *Cladium mariscus* is observed. In level VIIa, *Alisma plantago-aquatica, Lycopus europaeus, Ranunculus sceleratus,* and *Phragmites* sp. are much better represented. In layer II there is a clear shift. *Eupatorium cannabinum* is the best represented taxon. In layer IIa no aquatic or lakeshore taxa were identified.

Plants of diverse or unknown ecology

Most of the seed and fruit remains identified within this group are preserved in waterlogged state. Only one seed of an unidentified legume was found in level VIIb. Most of the taxa within this group were found in levels VIIa and VIIb (Fig. 4.89). Most of them are most probably of local origin, especially *Apium*, Cyperaceae, *Mentha* sp. or *Scirpus* sp. In layer VI, Cyperaceae (probably of local origin) are also present in a relatively high density. In layer IIa, *Sambucus* sp. is the only represented taxon within this group.

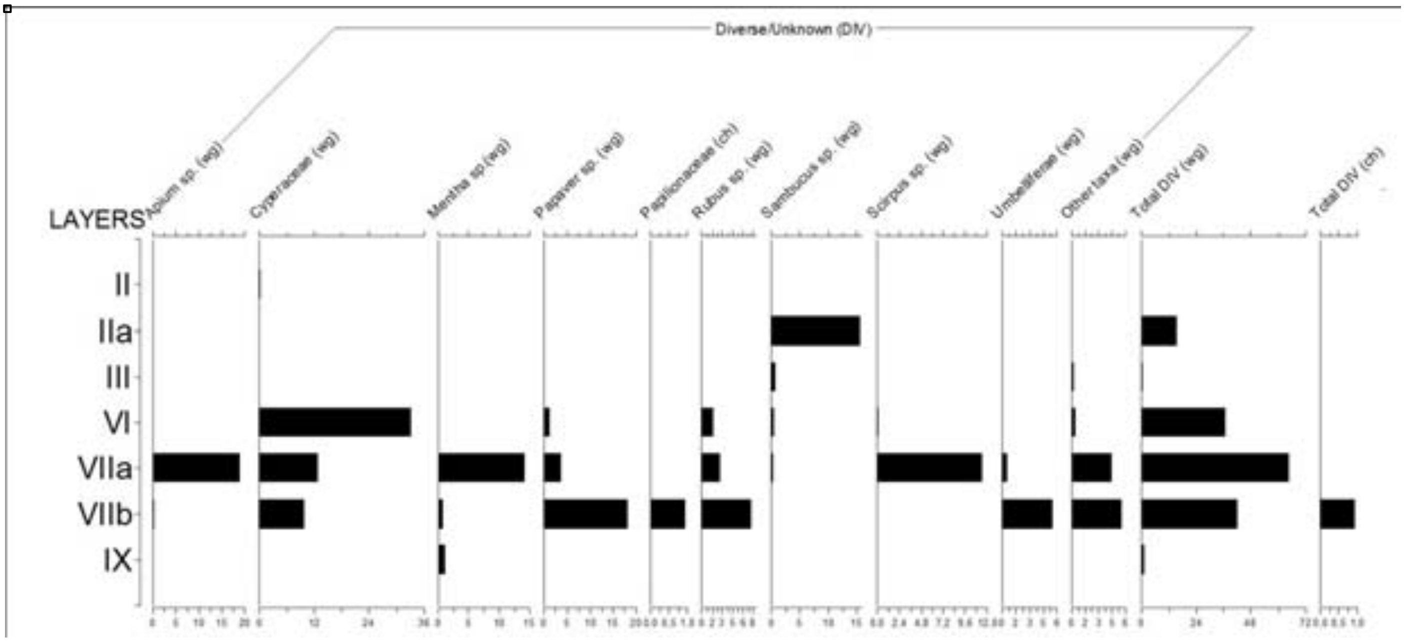


Fig. 4.89. Stratigraphic diagram showing the average concentration of seeds and fruits of plants of diverse or unknown ecology per litre of sediment from all the samples from each layer analysed in the profile samples.

Cultivars

Cultivars are represented both in charred and in waterlogged state. Two main types of cultivars were identified: cereals and opium poppy (*Papaver somniferum*). Seeds of opium poppy, unlike cereals, are only preserved in waterlogged state. Their distribution changes along the stratigraphy (Fig. 4.90). There is a clear shift in layer VI of the stratigraphy. In the layers below it, high concentrations of remains of cultivars in waterlogged state are found. On the other hand, very low densities of charred material are present. Above it, only charred remains (mainly grain) are found.

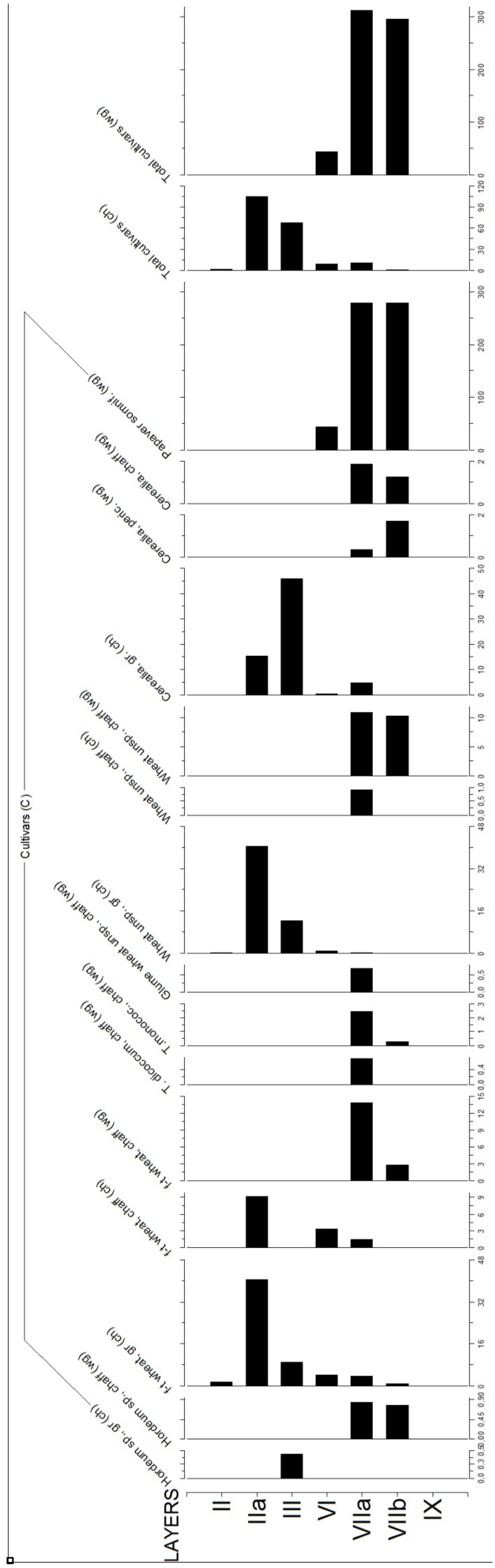


Fig. 4.90. Stratigraphic diagram showing the average concentration of seeds and fruits of cultivars per litre of sediment from all the samples from each layer analysed in the profile samples.

Seeds of opium poppy were mainly found in high concentrations (c. 250 r/l) in levels VIIb and VIIa. Barley was found as charred grains in layer III and as waterlogged chaff in levels VIIb and VIIa, in all cases in very low densities (below 1 r/l). Free-threshing wheat is found both in charred and waterlogged state in levels VIIa and b, but only in charred state in layers VI, III and IIa. The concentration of remains of charred grain of naked wheat increases towards the top of the stratigraphy, reaching its maximum in layer IIa (40 r/l). Charred chaff remains equally increase towards layer IIa. Waterlogged chaff remains, on the other hand, show their highest concentration (16 r/l) in level VIIa. Concerning glume wheats, only chaff remains in waterlogged state were recovered. These are particularly abundant (*c.* 4-5 r/l).

Weeds and ruderals, pastures and grasslands

Several taxa of a rather wide ecology were put inside this group and they primarily represent open (non-wooded) but relatively dry areas (away from the influence of the lake), except for *Urtica dioica*, which grows in wet habitats. They were only recovered in levels VIIb and VIIa, always in waterlogged state (Fig. 4.91). The better represented taxa in level VIIa are *Urtica dioica* and *Verbena officinalis* (both with more than 10 r/l). The concentrations observed for these taxa in level VIIb are much less significant.

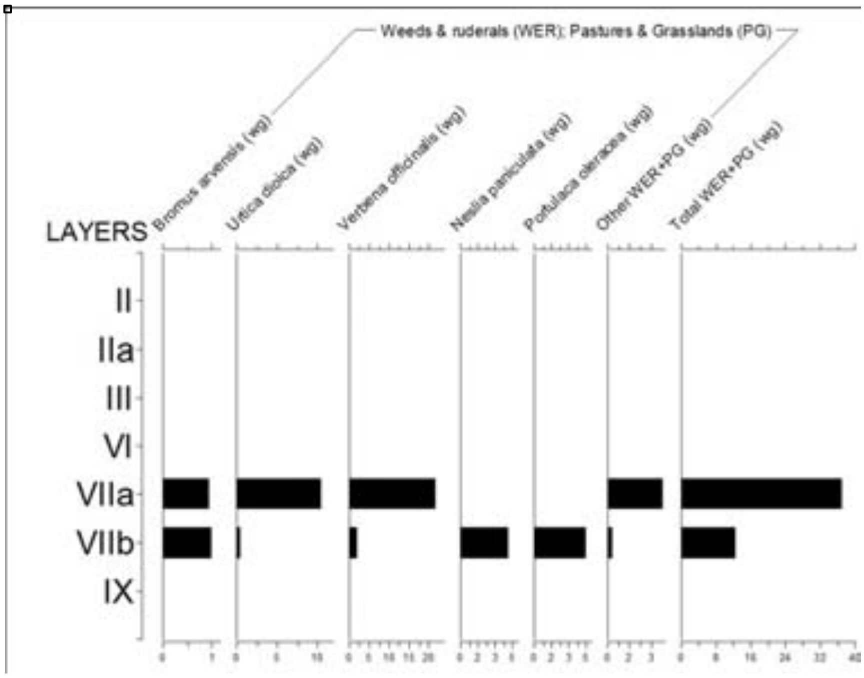


Fig. 4.91. Stratigraphic diagram showing the average concentration of seeds and fruits of weeds and ruderals as well as plants from pastures and grasslands per litre of sediment from all the samples from each layer analysed in the profile samples.

Woodland and woodland edges and clearings

All seeds and fruits from these groups were found in waterlogged state. The distribution of the taxa is diverse along the stratigraphy (Fig. 4.92). The largest taxonomic diversity is observed at the base of the stratigraphy, but the concentrations of remains are low. In layer VI, only *Physalis alkekengi* was identified, while *Sambucus nigra* was the only taxon present in layers III and IIa.

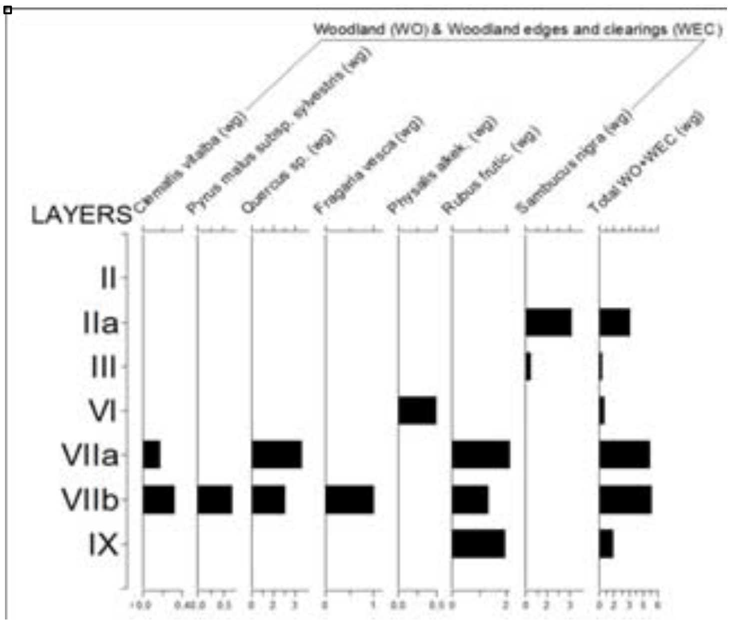


Fig. 4.92. Stratigraphic diagram showing the average concentration of seeds and fruits of plants from woodland areas and woodland edges and clearings per litre of sediment from all the samples from each layer analysed in the profile samples.

4.7.5.3.Discussion

4.7.5.3.1. Evaluation of the sampling strategy and the methods of analysis

The study of the three profile samples from La Draga allowed the presentation of new information concerning several key issues: the stratigraphy and formation processes of the site, and the botanical composition of the seed and fruit record. It is necessary at this point to evaluate the satisfactoriness of the methodology with respect to the aims of the analysis and to put forward some recommendations for future works.

First of all, it must be noted that the three profile samples were taken from a relatively small area, at some point towards the centre of the original village. As a result, the observations performed during this analysis might not be applicable to the whole site. For this purpose it would be interesting to obtain profile samples across two transects within the site: one in west-east direction and one in north-south (or North-East-southwest) direction, as recommended by other authors (Jacomet & Brombacher 2005, Jacomet 2013). On the other hand, their proximal location made it more feasible to amalgamate samples (from different profiles) from the same layer and treat all of them as one single context or stratum. This is of high importance when one of the aims of this work is to produce a more accurate description of the stratigraphy of the site. Unfortunately, it is not possible to demonstrate at present that these samples were strictly contemporary but it is very likely that they were formed within a similar limited chronological range.

The extraction of the profiles and their sampling in the laboratory made it possible to have a closer look to the stratigraphy in drier conditions (in comparison to work in the field), which allowed the identification of all those layers which were observed during fieldwork but also several levels and sub-levels. The proper characterization of the observed layers depends on the size/quantity of the analysed samples. The number of analysed samples per layer or the total volume of sediment processed per layer was acceptable for layers VII and VI (5 samples or more, present in the three profiles and around 3 litres of sediment) but insufficient for a proper evaluation of some of the layers, such as layer IIa (and probably layers II and III). These layers should be targeted in future works. Layer IX should also be the focus of future sampling actions if a reliable characterization of its composition is considered of interest. For this work, samples of the last 5 centimetres of lake marl were analysed, which is probably not enough and contamination from the superior layers cannot be discarded. While the analysis performed in this work can bring out significant new information at a layer scale, it is also very likely that the sub-levels that were identified (apart from levels VIIa and VIIb) cannot be sufficiently investigated.

The "non-seedy" composition of the samples was described using quantitative and semi-quantitative techniques, depending on the type of remains. Both methods produced useful results that were represented in graphs. Nevertheless, both proved to have some drawbacks. Fully-quantified materials allowed the representation of the absolute concentration of items per litre of sediment, which is useful for a comparative analysis between profiles. Nevertheless, the calculation of those numbers might be slightly problematic, since the subsampling of the 0,35 mm fraction was important and the use of high multiplying factors was frequent. The results of these multiplications were subsequently used for the calculation of the concentration values per litre of sediment, which usually required further multiplications. These calculations could have resulted in the overrepresentation of some materials (like dung) in the graphs. This problem can only be solved by the continuation of the sampling in order to produce more reliable average values. The semiquantification of other types of remains was also useful and time saving (in comparison to full quantification), but working with 2 fractions makes it difficult to give useful values that do not overrepresent the composition of the 0,35 mm fraction.

As a result, we can conclude that the performed methods allow a more in-depth characterization of the formation processes of the different settlement phases that took place in La Draga during the Neolithic. This will be analysed more in detail in chapter 4.7.4.3.2. These observations are also significant for the evaluation of the botanical spectrum of the seed and fruit record, since it seems that a sample-by-sample evaluation is not sensible at this stage of research. Instead, a comparison between the composition of the different layers, will allow a first approach to this problematic within the site.

A quantitative evaluation of the botanical composition of the samples requires a certain amount of remains per sample, as already mentioned. This optimal numbers were never reached in our samples. Nevertheless, it is interesting to note that 7 samples would have yielded more than 400 items (if our estimations are correct) if they had been sorted in their entirety (at least in the 0,35 mm fraction). These samples were mostly between 700 and 1000 ml of sediment. Some samples of similar volumes would not have reached these numbers, but they would always produce more than 100 items (Fig. 4.93). As a preliminary conclusion, one could say that the profiles should be taken in a way that larger samples could be analysed. In order to maximize the volume of the samples in future works there are three options: the first one would be to carry out a denser sampling in order to have more samples from the same layer that can be amalgamated; the second one would be to extract larger profile samples (25x25 cm); and the third one would be to avoid using the profile samples for other analyses, such as soil micromorphology analyses. Of these three possibilities, the third one is considered the more adequate, since samples for soil micromorphology can be taken next to the profile samples and they can still produce comparable results (although that should be evaluated in each particular case).

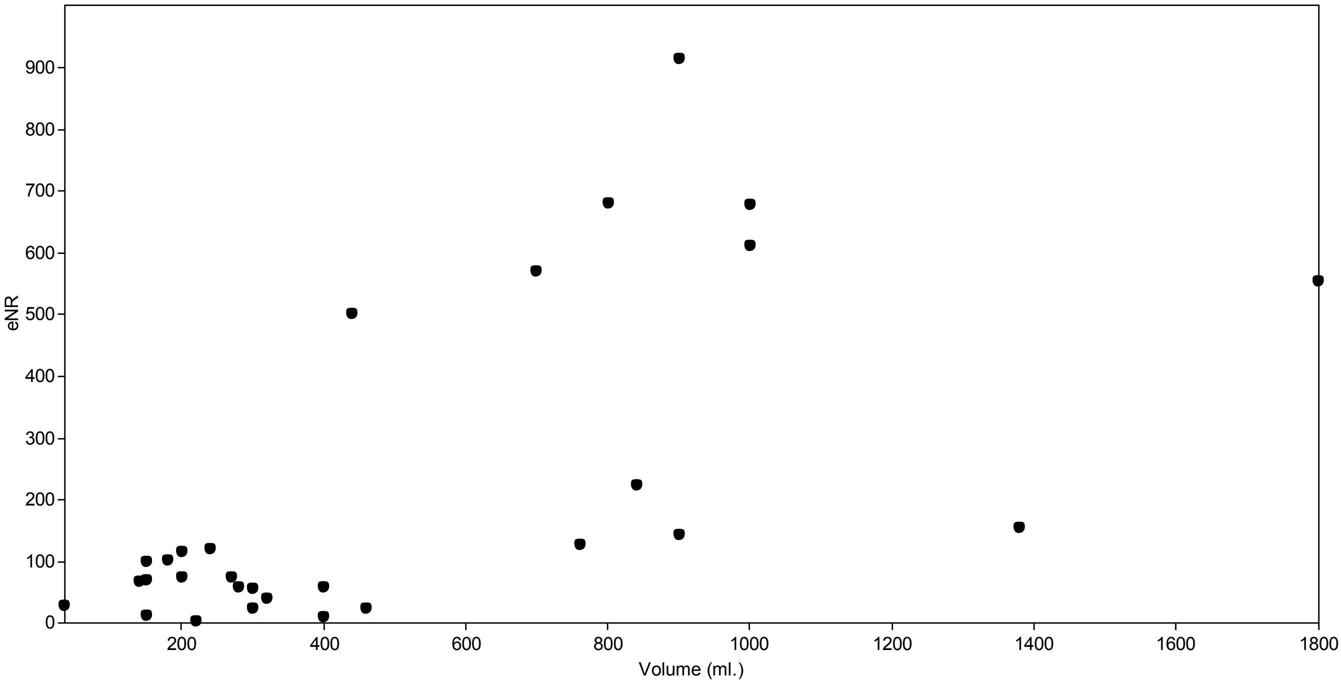


Fig. 4.93. Profile samples of La Draga. Number of items obtained per sample according to the volume of the sample (eNR: estimated number of remains).

As already stated, these results do not allow a quantitative evaluation at a sample level, only at a layer scale (and mainly for levels VIIa and b), after amalgamating all the samples. Some particular differences were observed between samples from the same layer but from different profiles, like the absence of water/lakeshore plants in the samples of layer VII of MP3. Nevertheless, it is not the moment yet to decide which samples show the typical composition of each layer and which do not. We lack of the appropriate framework to discard any sample. As a result, one must consider that the amalgamated results do not show, then, the most common composition of the samples, but the average of the available data in the current state of research. In any case, it is useful when comparing layers, as long as it is carried out with caution.

4.7.5.3.2. Insights into the stratigraphy of La Draga: did the profile sampling contribute to a better understanding of the stratigraphy at the site? Can settlement phases be easily identified?

After the presented results, a considerably more precise knowledge of the different layers at La Draga site can be presented. In the forthcoming lines, a synthetic description and interpretation of the main characteristics of each layer, including the main results of the seed and fruit analysis, is presented, in order to provide the best description possible of the analysed layers before continuing with the archaeological evaluations of the results.

Layer IX

The main component of this layer, which is below the first cultural layer, is lake marl. Most of it seems to be of travertinic origin. Some bioturbation could have taken place at the top of this layer during the first settlement phase (A. Balbo, unpublished). In fact, a narrow (1 cm) contact layer with level VIIb was observed in all profiles. Its composition seemed to be affected by the superior layer, for which it was analysed together with level VIIb.

Layer IX shows relatively high concentrations of fish remains, although this is only observed in MP1 (they might be overrepresented for the reasons mentioned above). These remains could belong to local fauna, but analyses from other lakeshore sites in central Europe point towards the fact that fish remains appear mostly in anthropogenic contexts (Hüster-Plogmann 2004). No further speculations can be done before the identification of these remains (A. Blanco and M. Saña, in progress).

The organic component of the layer is very low (only in MP2 slightly larger quantities were observed). There are rather high concentrations (1400 per litre of sediment in average) of malacofauna of lacustrine origin.

No charred seeds and fruits were recovered. The botanical diversity of the seed and fruit record is low. One seed of *Papaver somniferum*, a potential cultivar, was recovered. This is probably a contamination. More than 95% of the assemblage is dominated by Oogonia of Characeae, which are water-living organisms. This would indicate that the area was flooded in the moment previous to the first human occupation of the site.

Level VIIb

Layer VII was divided into two levels for this analysis: levels VIIa and VIIb. Level VIIb is below VIIa and it was characterized by a rich organic component with a clayey soil matrix. In MP1 and MP2, this level only had a thickness of around 2 cm. In MP3 a clayey layer above this organic layer was included within level VIIb because it had the same soil matrix. As a result, the thickness of VIIb was of 4-5 cm in this profile sample. This seems to be the first settlement phase.

The analysis of the components of this level showed that it had a high organic component, with relatively high quantities of waterlogged plant material (especially wood chips, bark, twigs, buds and bud scales, but also some leaf scales, leaf fragments and moss). It is significant to note the presence of ruminant and mice dung, which would indicate, at least, the temporal keeping of goats or sheep close to the dwelling area of the village. The relatively important presence of fish bones and fish scales could be interpreted as residues of human consumption, but this issue must be further investigated by the specialists (A.Blanco and M. Saña, in progress). High densities (*c.* 3000 r/l) of malacofaunal remains were recovered and important quantities of *Cristatella* sp. (*c.* 300 r/l) were found in MP3. Both evidences together might be indicating that the area was at least partially flooded and that the huts were built on water. A similar conclusion was reached by the soil micromorphological analyses (Balbo & Antolín, 2012).

Nearly 100% of the seed and fruit remains were found in waterlogged state. The average concentration of these remains is of 529,7 r/l and 26 taxa were identified. Despite the relatively large diversity of taxa, the spectrum was dominated by cultivars (around 80%) and lakeshore and aquatic plants (around 15%). Cultivars include barley, free-threshing wheat and einkorn, but especially opium poppy (*c.* 300 r/l in average). Among the wild plants from areas away from the lakeshore, the concentration values are rather low. The local vegetation is well represented, especially *Cladium mariscus* and Oogonia of Characeae (they appear in lower concentrations than in layer IX, but still above 100 r/l). These results might be indicating, as mentioned before, that the area was still at least partially flooded.

Level VIIa

Level VIIa is separated from VIIb by a clayey sub-level in MP1 and MP2 but not in MP3. Here a second organic sub-level separates level VIIa, then a clayey sub-level was identified and another organic sub-level acts as a boundary between level VIIa and the subsequent layer (VI). The fact that level VIIa seems to finish with a wood/charcoal rich layer would go in accordance with the final collapse of the aerial structures of the site, which was observed during fieldwork in sectors B and D. It seems that, in some areas, large concentrations of charred material (usually with large amounts of grain) appear. On the other hand, only a small amount of the wooden piles and beams show evidences of charring. For this reason, if some fires were involved at some point with this collapse or whether they were the reason for the abandonment of these structures, is not known. The thickness of the level is of around 4 cm in MP1 and MP2 and of 7 cm in MP3.

The average composition of level VIIa seems to show higher concentrations of bone and fish remains, but their distribution is rather uneven. Bones were primarily recovered at the basal sample of MP1, fish remains at the base of VIIa in MP2, and MP3 shows very low concentrations in the three samples. Thus, the distribution seems rather patchy, probably because these remains are the refuse from localized activities in the past.

The organic plant material seems as rich and diverse as in level VIIb, but with higher proportions of wood and charcoal, especially in the uppermost samples of the three profiles.

On the other hand, the average concentration of malacofaunal remains decreases considerably to 1000 r/l (and the figures are much lower in the uppermost sample of each profile).

The seed and fruit record is preserved, mainly, in waterlogged state. 38 taxa were identified and a concentration of 627,7 r/l was found. Cultivars still represent more than half of these remains, but lakeshore and aquatic plants are better represented than in level VIIb (25%). These results seem contradictory with the reduction of the concentration of malacofaunal remains and need of further evaluation.

Among the cultivars, barley, free-threshing wheat (16 r/l in average), emmer, einkorn and opium poppy (*c.* 300 r/l), were identified. Wild plants from areas away from the lakeshore were represented in low concentrations, but *Urtica dioica* (10 r/l) and *Verbena officinalis* (20 r/l) were rather abundant in particular samples. Among the lakeshore plants, *Alisma plantago-aquatica* and *Cladium mariscus* and *Lycopus europaeus* were the best-represented taxa, while Characeae seemed to slightly reduce their concentration. One could argue, then, that the area could have been less frequently flooded during this phase, but the lake influence still seems to be important.

Layer VI

Layer VI is a compact layer of light grey clay. It was of around 5 cm of thickness in MP1 and MP2, but much more complex in MP3, with 5 sub-levels within 16 cm. Two charcoal-rich and three clay-rich sub-levels were distinguished.

The organic component of this layer is low, only charcoal remains are abundant. Bone remains appeared in higher numbers in MP1 and in the two charcoal-rich sub-levels of MP3. Burnt bones and charred grains were also found in MP3-M21-23, the first charcoal-rich sub-level of MP3. All these evidences seem to respond to short episodes of consumption and they deserve specific attention in future works.

Plant macroremains other than charcoal were rare, but some bark and wood chips were present. Another radical change with respect to levels VIIa and VIIb was the scarcity of malacofaunal remains. This might indicate that there was barely any lake influence during the formation of this layer. The frequent presence of stones equally points towards the different origin of this layer. At the moment this question remains unsolved.

Despite the several noted differences, most of the seed and fruit remains were preserved in subfossil state. The concentration of items, though, was much reduced, 125,8 r/l, and so was the number of taxa, 11. Lakeshore and aquatic plants equalled 50% of the total of remains, while cultivars were 40%. Among the cultivars, charred remains of cereals (free-threshing wheat) and waterlogged remains of opium poppy (below 50 r/l) were identified. Their representation is much scarcer than in the previous layers. Among lakeshore and aquatic plants, Characeae were the better represented group (around 50 r/l), but much below the values observed in previous layers.

Layer III

Layer of light grey coloured clay. An apparent pavement made with travertine stones was observed during fieldwork all over the excavated area. This hypothesis was confirmed by the preliminary results of the soil micromorphology analyses, which demonstrated that travertine stones are not in primary position (Balbo & Antolín 2012) and that they could have been transported by humans in order to use them as isolation material. On top of this paved floor, another clay rich sub-level was observed in MP3.

The abundance of bone remains (some of which were burnt), as well as fish remains and flaked stones (flint and quartz) are clear evidences that this is another settlement phase, as observed by the archaeologists during fieldwork.

Waterlogging conditions did not prevail until the present and the organic plant component of the layer is only in charred form.

Malacological remains increase but they appear in lower concentrations than in levels VIIa and b (750 r/l).

Only 20% of the seed and fruit record was in charred state. Among the waterlogged material, only seeds with lignified endocarps, such as *Sambucus nigra*, were found. The concentration of remains is of 305,6 r/l and 7 taxa were identified. Barley and free-threshing wheat grains were identified as cultivars. No poppy seeds were recovered. The waterlogged assemblage from this layer is typical of a poorly preserved layer, where only the more resistant taxa have survived (Murphy & Wiltshire 1994). One could assume, as a result, that during this phase the area could have been rather moist, but not flooded.

Layer IIa

Layer of black peat of around 4 cm which was only identified in MP2, above layer III. It is not clear whether this layer is contemporary to layer III or slightly posterior. The organic component of the layer was very large, both including animal bone remains (also burnt), and charcoal. There was also a very high concentration of malacofaunal remains (around 3500 r/l). This fact makes this layer of a clear different origin with respect to layer III.

Seed and fruit remains were primarily found in charred state (*c.* 85%). Two taxa were identified. Cultivars represent 80% of the total of remains. Among the cultivars, free-threshing wheat grains (*c.* 40 r/l) and chaff (*c.* 9 r/l) were identified. Only seeds of *Sambucus nigra* were preserved in waterlogged state and no oogonia of Characeae were recovered.

The conditions of preservation were similar to layer III, probably dry. The conditions of preservation were probably dry. On the other hand, a large concentration of malacofauna was observed and it should be determined whether it is of lacustrine or terrigenous origin. More samples should be analysed in order to get a more representative view of this layer.

Layer II

Layer II is a dark brown layer of moder. It was not sampled in its entirety in MP1 (only the first 6 cm) but it was completely preserved in MP2, 14 cm. This stratum would cover both layers IIa and III, since layer IIa does not cover layer III in all of the excavated area.

There were some bone remains, as well as fish bones (in MP1). Malacofaunal remains are very abundant (2000 r/l). Some charcoal and charred grains were also found. Most of the seed and fruit record is in waterlogged state, and dominated (99%) by aquatic (Characeae) and lakeshore plants (*Eupatorium cannabinum*).

The taphonomy of this layer seems to be very complex due to the advanced state of degradation of the moder and it is not clear how to interpret these data. It does not seem to be an archaeological layer, despite some rare finds of anthropogenic origin.

4.7.6. The systematic surface samples

Layer VII was sampled at two different moments (Fig. 4.57): above the collapsed wooden structures (VIIa) and in-between and below these structures (VIIb). These levels are largely comparable to those identified in the profile samples, but it must be recognized that no clear sedimentary differences were observed between them during fieldwork. Therefore, the sampling was done in an intuitive way, under my instructions, especially taking into consideration the fragile boundary that the collapsed wooden structures seemed to make. As already mentioned, 40 systematic surface samples (19 from level VIIa and 21 from VIIb) were chosen for this analysis (Fig. 4.57), and processed with the wash-over technique. The total volume of soil processed was 29,79 litres and the average volume per sample was 0,79 litres (Fig. 4.60 and 4.62).

4.7.6.1. Results

First of all an evaluation of the non-seedy components recovered in the samples was performed, in order to get a better knowledge of the origin of the samples and their archaeological context. Then, an evaluation of the seed and fruit record of each level per separate was carried out, considering the charred and the waterlogged record individually.

4.7.6.1.1. Components of the levels (other than seeds and fruits): aquatic and lakeshore organisms/materials Vs. elements/organisms from outside the lakeshore

Following the same scheme that was used for the analysis of the non-seedy components of the samples from the profiles, the non-local (and of potential anthropogenic origin) materials were evaluated first, and then the local (and of potential natural origin) materials.

The average **organic component** of the samples of level VIIa is rather low, 32,39%, being 3% the minimum and 73,33% the maximum. The average percentage obtained for level VIIb is not much higher, 36,37%, but the maximum and minimum values are higher (97,62 and 17,5%, respectively). The vast majority of this organic component consisted on wood chips, charcoal, bark, twigs and other plant remains such as buds and leafs. These materials were semiquantified and the results plotted on the site plan (Fig. 4.94). The size of the pie charts represents the percentage of the organic fraction within the sample. This type of representation allows the observation of which were the main components of each sample and, at the same time, what proportion of the sample they corresponded to.

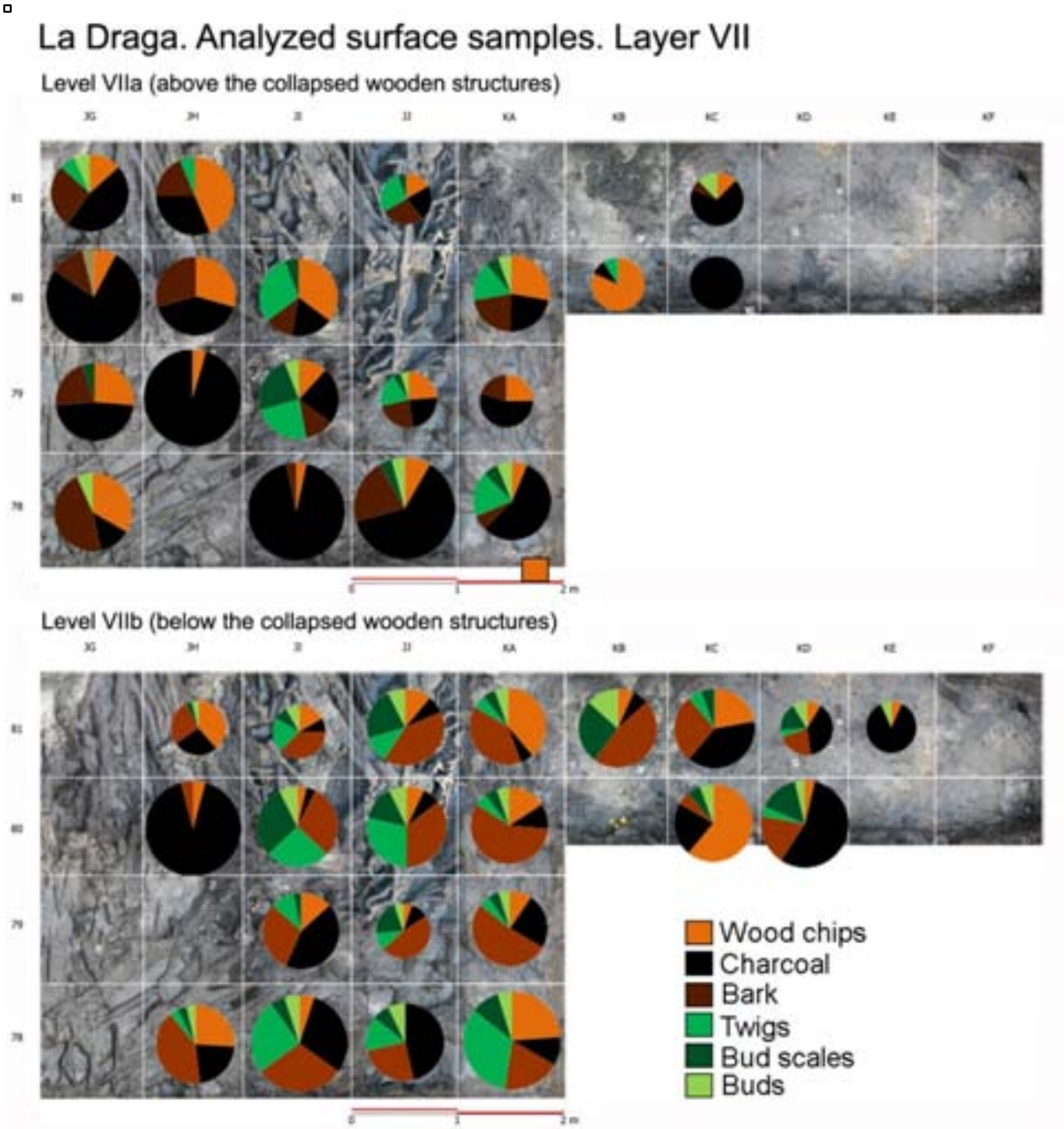


Fig.4.94. Spatial representation of the semiquantified organic component of non-local origin in the surface samples from sector D of La Draga.

In **level VIIb**, samples with a large organic content were observed all over the excavated area. In general, they seem diverse in their composition but it is possible to see that bark, charcoal and wood chips were dominant towards the western part of the trench, while the central part was far richer in remains of twigs and buds. Sample JH80 stands out from the general pattern for being very rich in organic material and predominantly consistent on charcoal. It is very similar to other samples in this area from level VIIa, for which one should consider the possibility that this sample belongs to that level, instead of VIIb. It is significant, then, that level VIIa has a much larger presence of charcoal, especially towards the western side of the excavated area.

In **level VIIa**, the more organic samples seem to concentrate towards the west and south of the trench. These were dominated by charcoal remains, which were very abundant. Woodchips, bark and charcoal equalled more than 90% in nearly all samples from this area. Twigs and buds were only present in a significant degree towards the centre of the excavated area. The samples towards the eastern side of the trench seem to be very poor in remains.

Other **components of non-local origin** were **fully quantified** and equally plotted in spatial graphs (Fig. 4.95). This time, the size of the pie charts was determined by the density of remains per litre. In **level VIIb** the largest concentrations of items were observed in the central area of the excavation and the best-represented materials were fish scales and, in sample KA78, dung. Charred amorphous objects were only found in the western part of the trench, while animal bones were recovered all over the excavated area. In **level VIIa**, the larger concentrations were distributed along the excavated area and mainly constituted by fish bones. Charred amorphous objects were also only present on the western side of the trench and bone remains seemed to appear more or less distributed along the area. Barely any fish scales were recovered.

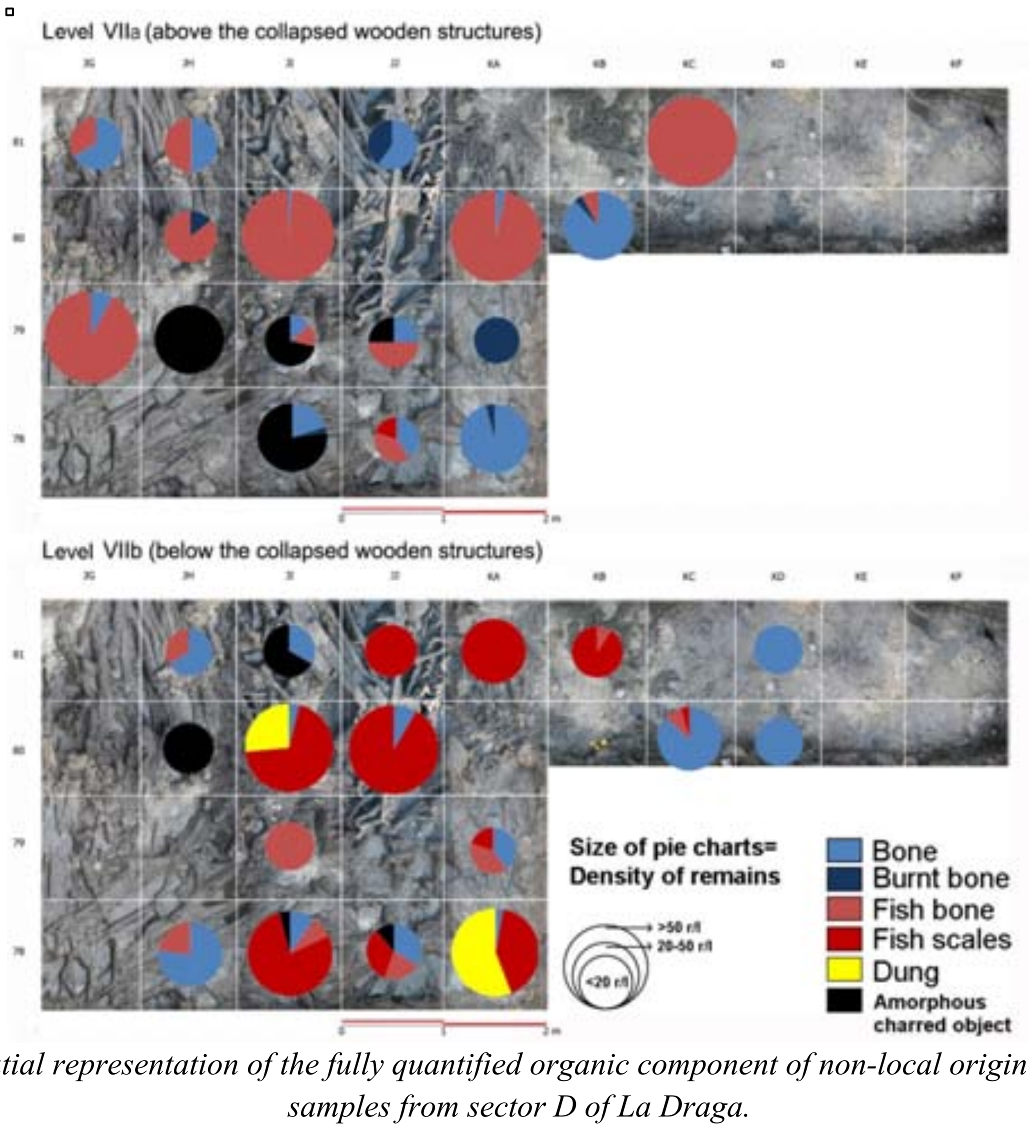


Fig.4.95. Spatial representation of the fully quantified organic component of non-local origin in the surface samples from sector D of La Draga.

The presence of **insect remains** (other than larvae cases of *Trichoptera*, see below) in the samples can only be interpreted once these remains are identified by the specialist (J.-B. Huchet, in progress), which would allow the evaluation of their habitat preferences. Nevertheless, the observation of their distribution in the samples could already yield interesting information (Fig. 4.96). The densities of remains in **level VIIb** were relatively high (121,34 r/l), especially towards the western and central part of the trench. It is very interesting to notice that the higher densities of remains (499,3 r/l) were achieved in square KA78, where the presence of dung was also attested. In **level VIIa**, their distribution focused on the central and eastern part of the trench and the concentration values were mostly low (96,03 r/l). Insect remains were mostly lacking from all the samples with large quantities of charcoal.

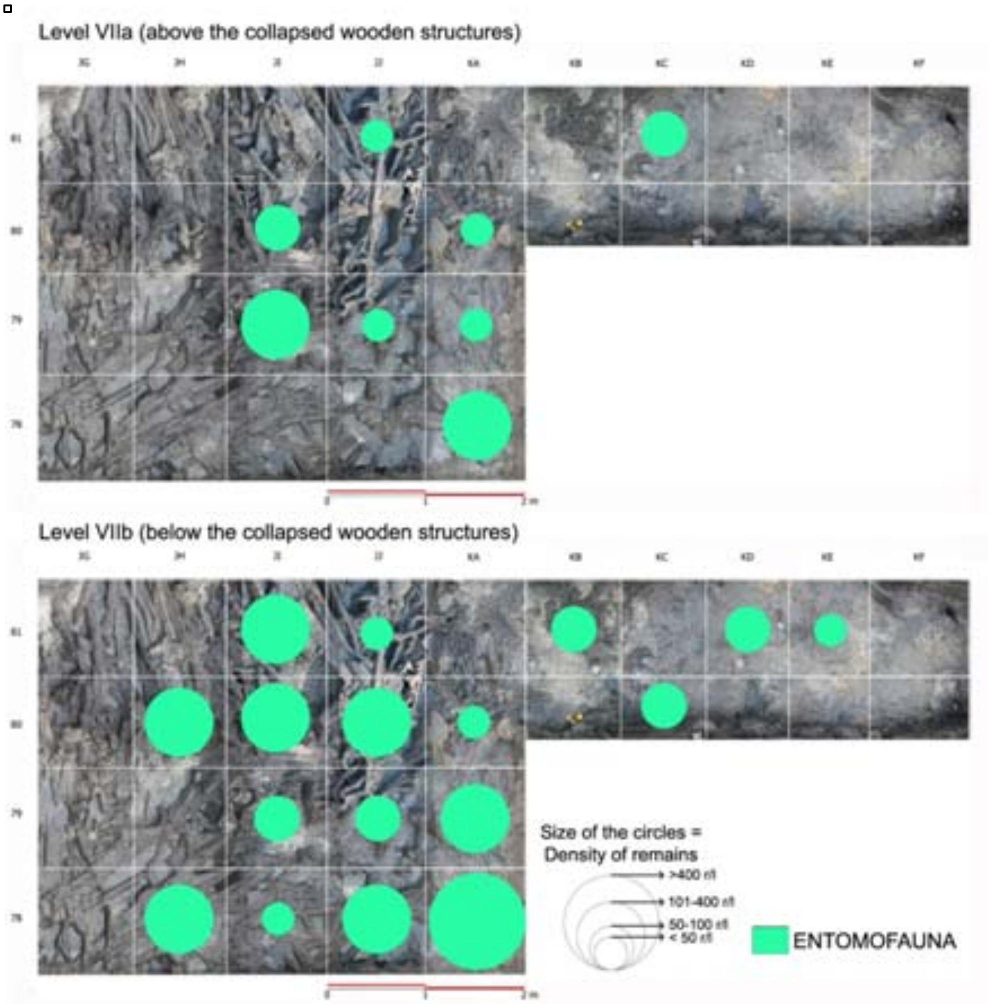


Fig. 4.96. Density of insect remains per sample in the surface samples from sector D of La Draga.

The analysis of the **materials of local origin** was also carried out separately for the fully quantified and the semiquantified remains. Concerning the **fully quantified** remains, they were very abundant in both levels, but especially in level VIIb. In level VIIa the larger concentrations were found towards the central area. Malacofaunal remains were the best represented in our samples, while opercula of *Bithynia* were basically found in the southern samples. Statoblasts of *Cristatella* sp. were also frequently identified in the central area.

In level VIIb, the overall densities are higher along the excavated trench. Statoblasts of *Cristatella* sp. were identified in most samples and the opercula of *Bithynia* were more ubiquitous.

Finally, concerning the **semiquantified mineral component** of the samples, this was classified as of lacustrine origin, even though other possibilities (e.g. construction or isolation material) should not be discarded. The results obtained were plotted in spatial diagrams and the size of the pie charts shows the proportion of the inorganic fraction with respect to the total volume of the sample (Fig. 4.97).

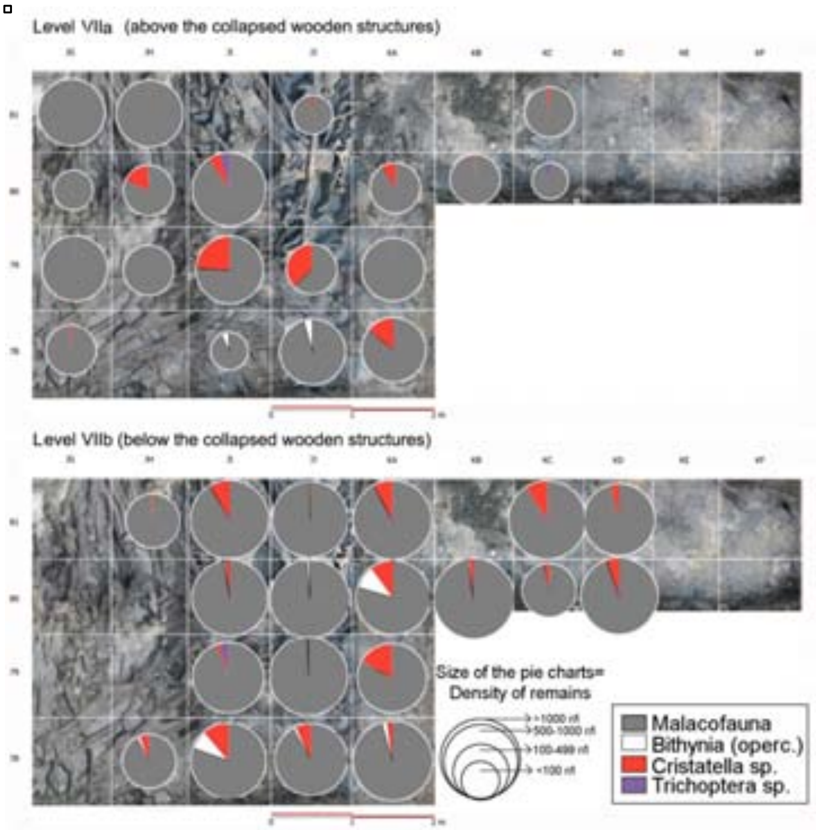


Fig. 4.97. Spatial representation of the fully quantified local (from the lake or the lakeshore area) components in the surface samples from sector D of La Draga site.

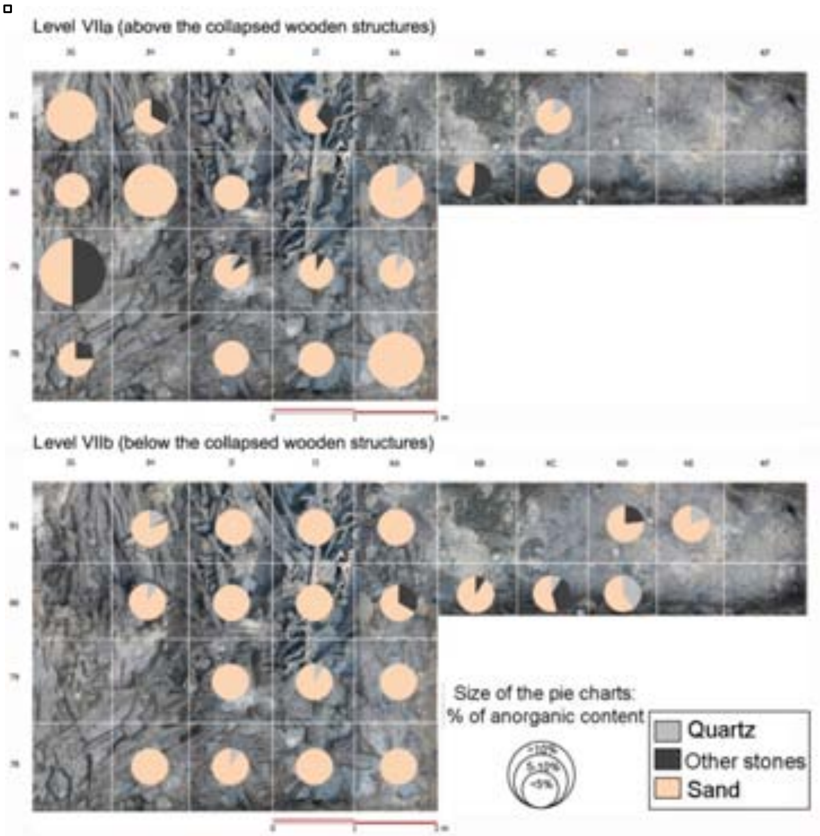


Fig. 4.98. Spatial representation of the semiquantified quantified local (from the lake or the lakeshore area) components in the surface samples from sector D of La Draga.

The results show that larger percentages of the inorganic fraction were obtained in level VIIa with respect to level VIIb. In any case, the percentage of the inorganic fraction is usually very low (0,5-3%). In level VIIa a larger quantity of stones were observed all over the excavated area, even though sand is the best represented mineral element. In level VIIb, the quantities of mineral elements were lower in all the samples and stones were mainly recovered in the eastern side of the trench.

As a **summary,** it was observed that the lower **level VIIb** presented a wider diversity of organic materials in its samples, with less wood and charcoal and more twigs and buds. Relatively large quantities of fish remains (especially scales) were recovered, as well as some bone remains (not burnt) and dung. Insects were also frequently recovered in the samples. The evidences of local fauna were also very well represented in these samples, especially malacofaunal remains and *Cristatella* sp. The presence of mineral remains of local (?) origin appeared only rarely. On the other hand, the upper **level VIIa** showed a much larger concentration of wood, bark and charcoal, especially on the western side of the trench. Some samples were especially rich in charcoal. Besides, relatively large concentrations of fish bones were recovered, but fish scales were very rarely found. Insect remains were relatively scarce. Among the evidences of local fauna, malacofaunal remains were very numerous, and only some samples in the centre of the trench allowed the identification of the presence of *Cristatella* sp. Charcoal-rich samples usually lacked of remains of insects or *Cristatella*. The mineral component of the samples was slightly larger in this level and stones were more ubiquitous. As a final remark it should be pointed out that one sample from level VIIb, JH80, had a very similar composition to those of level VIIa. The possibility that it corresponds to the same context should be further evaluated.

4.7.6.1.2. Seed and fruit remains: overall results and the major preservation type (charred Vs. waterlogged)

A first overlook to the general results of the seed and fruit analysis of both levels can yield interesting information concerning the taphonomic history of the assemblage (Fig. 4.99). A similar number of samples (around 20) and volume of sediment (around 15 litres) were analysed from both levels, for which the results are quite comparable. In fact, the number of items obtained is rather similar (*c.* 3000 items). The average density of remains of both levels is quite parallel, both having between 825 and 845 r/l. Concerning the preservation type, the percentage of charred remains seems higher in the upper level VIIa (37,3%), and so is the average density of charred remains per litre of sediment (307,3 in level VIIa, against 148,2 in level VIIb). On the other hand, waterlogged material seems to be much better represented in the lower level VIIb (78,64%) and it appears with a higher density (676,59 r/l in level VIIb, against 535,36 in level VIIb).

	Nr. of samples	Total volume of sediment	rNR	eNR	Average density r/l	% ch	% wg	Average density ch	Average density wg
Level VIIa	19	14,98	3330	13025	843,30	37,3	62,7	307,3	535,36
Level VIIb	21	14,81	2733	11674	827,64	21,36	78,64	148,2	678,59

Fig. 4.99. Synthesized results of the seed and fruit analysis of the systematic surface samples amalgamated per level from sector D of La Draga. Proportion of charred and waterlogged remains (rNR:real number of remains; eNR: estimated number of remains; r/l: remains per litre; ch: charred; wg: waterlogged).

The percentages of charred material observed are considerably high and demand of a separate evaluation of the charred and waterlogged material. This will be performed in the evaluation of the different taxa and ecological groups represented per sample. Nevertheless, I will first proceed to the numerical results obtained per sample, for which it was more practical to consider both charred and waterlogged remains together.

4.7.6.1.3. General results: volume of the samples and the obtained seed and fruit record, preservation type at a sample level

It was already observed in chapter 4.7.3.2 that most of the systematic surface samples are of around 0,7 litres in average (Fig. 4.62). Akin to the analysis of the profile samples, it was considered necessary to evaluate the numerical results obtained per sample and level in order to assess the satisfactoriness of the sampling and subsampling strategies.

Square	Sample volume (l.)	Fraction	Fract. vol. (ml)	Analyz. vol.	rNR	eNR	Density r/l	Nr. taxa	% ch	Target reached	Worth extra sorting?
JH78NE	**0,6**	**2**	**170**	**170**	**66**	66	776,66	20	7,69	NO	
		0,35	**110**	**10**	**50**	400			0		YES**
JH80NE	**0,84**	**2**	**620**	**620**	**1311**	2073	2467,9	14	98,47	YES	NO
		0,35	**200**	**11**	**55**	762			81,89	NO	YES*
JH81NE	**1**	**2**	**80**	**80**	**13**	13	382	19	30,77	NO	
		0,35	**130**	**10**	**45**	369			0		YES*
JI78SO	**0,6**	**2**	**190**	**190**	**266**	266	8748,3	26	27,44	NO	
		0,35	**140**	**10**	**368**	4983			0,84	YES	YES*
JI79NE	**0,7**	**2**	**230**	**230**	**119**	119	408,57	11	90,76	NO	NO
		0,35	**75**	**10**	**30**	167			0		
JI80NE	**1**	**2**	**140**	**140**	**3**	3	212	8	0	NO	NO
		0,35	**120**	**10**	**22**	209			0		
JI81NE	**1**	**2**	**100**	**100**	**47**	47	239	16	23,4	NO	NO
		0,35	**75**	**10**	**42**	192			0		
JJ78NE	**0,7**	**2**	**140**	**140**	**42**	42	270	8	78,57	NO	NO
		0,35	**120**	**10**	**15**	147			0		
JJ79NE	**0,5**	**2**	**70**	**70**	**21**	21	307,6	6	14,29	NO	NO
		0,35	**51**	**10**	**29**	133			0		
JJ80NE	**0,7**	**2**	**130**	**130**	**29**	29	287,14	7	62,01	NO	NO
		0,35	**130**	**12**	**24**	172			1,16		
JJ81NE	**0,76**	**2**	**120**	**120**	**13**	13	490,8	12	7,69	NO	
		0,35	**130**	**13**	**45**	360			0		YES**
KA78NE	**0,7**	**2**	**230**	**230**	**155**	155	298,57	16	6,45	NO	
		0,35	**135**	**10**	**4**	54			0		YES**
KA79NE	**0,55**	**2**	**80**	**80**	**22**	22	181,82	10	22,72	NO	NO
		0,35	**80**	**10**	**15**	78			2,56		
KA80NE	**0,8**	**2**	**110**	**110**	**16**	16	102,5	5	12,5	NO	NO
		0,35	**100**	**10**	**12**	66			0		
KA81NE	**0,3**	**2**	**70**	**70**	**1**	1	46,67	2	0	NO	NO
		0,35	**30**	**15**	**7**	13			0		
KB81NE	**0,6**	**2**	**110**	**110**	**16**	16	26,67	5	0	NO	
KC80NE	**0,62**	**2**	**90**	**90**	**30**	30	925,81	11	30	NO	NO
		0,35	**110**	**10**	**54**	544			0		
KC81NE	**0,5**	**2**	**90**	**90**	**14**	14	216	7	57,14	NO	NO
		0,35	**110**	**10**	**14**	94			0		
KD80NE	**0,74**	**2**	**150**	**150**	**219**	219	591,89	9	98,63	NO	NO
		0,35	**120**	**10**	**21**	219			0		
KD81NE	**0,7**	**2**	**70**	**70**	**21**	21	257,14	7	0	NO	NO
		0,35	**80**	**10**	**24**	157			1,27		
KE81NE	**0,9**	**2**	**80**	**80**	**24**	24	143,33	5	100	NO	NO
		0,35	**100**	**10**	**15**	105			0		

Fig. 4.100. Level VIIb, sector D (La Draga): samples, processed volume, analysed fractions with seed and fruit remains, volume of the fractions and the final analysed volume, number of obtained remains (rNR), estimated total number of remains (eNR), density of remains per litre, number of identified taxa and percentage of charred material per fraction.(:it might yield interesting data for the interpretation of charred remains; **: more taxa in waterlogged state might be identified).*

Square	Sample volume (l.)	Fraction	Fract. vol. (ml)	Analyz. vol.	rNR	eNR	Density r/l	Nr. taxa	% ch	Target reached	Worth extra sorting?
JG78NE	0,7	2	100	100	2	2	728,57	8	0	NO	
		0,35	120	10	46	508			0,2		NO
JG79NE	0,84	2	120	120	161	161	2340,26	21	93,79	NO	
		0,35	170	11	125	1805			0		YES*
JG80NE	0,9	2	550	550	1095	3265	3975,38	14	99,45	YES	NO
		0,35	110	13	41	313			44,09	NO	YES*
JG81NE	0,9	2	130	130	120	120	3265,22	20	73,33	NO	NO
		0,35	210	10	139	2819			0		YES*
JH79NE	1	2	520	520	482	482	711	13	100	YES	NO
		0,35	150	11	25	229			1,75	NO	NO
JH80NE	0,5	2	85	85	260	260	1711,8	14	98,08	NO	
		0,35	100	13	87	598			14,55	NO	YES*
JH81NE	0,5	2	60	60	13	13	382	14	53,84	NO	NO
		0,35	80	10	32	179			0	NO	
JI78NO	1	2	350	350	72	72	174	7	98,61	NO	NO
		0,35	260	13	7	102			2	NO	
JI79NE	0,82	2	60	60	26	26	79,43	11	80,77	NO	NO
		0,35	150	14	10	40			0		
JI80NE	0,64	2	70	70	19	19	479,69	15	84,21	NO	NO
		0,35	95	10	41	288			0		
JJ78NE	0,4	2	120	120	73	73	420	13	100	NO	NO
		0,35	90	11	23	95			0		
JJ79NE	0,8	2	60	60	10	10	95	12	100	NO	NO
		0,35	65	10	22	66			4,55		
JJ81NE	1	2	40	40	2	2	277	6	50	NO	NO
		0,35	90	10	35	275			0,36		
KA78NE	0,66	2	100	100	141	141	431,82	16	93,62	NO	NO
		0,35	110	11	27	144			1,38		
KA79NE	0,64	2	30	30	38	38	123,44	11	100	NO	NO
		0,35	70	10	11	41			0		
KA80NE	0,7	2	80	80	4	4	270	12	75	NO	NO
		0,35	100	12	31	185			0,54		
KB80NE	1,74	2	100	100	21	21	266,67	5	100	NO	NO
		0,35	130	10	35	443			0		
KC80NE	0,6	0,35	15	15	7	7	11,667	3	0		
KC81NE	0,64	2	70	70	20	20	279,69	9	50	NO	NO
		0,35	80	11	27	159			0		

Fig. 4.101. Level VIIa, sector D (La Draga): samples, processed volume, analysed fractions with seed and fruit remains, volume of the fractions and the final analysed volume, number of obtained remains (rNR), estimated total number of remains (eNR), density of remains per litre, number of identified taxa and percentage of charred material per fraction. .(:it might yield interesting data for the interpretation of charred remains).*

The results obtained for both levels are similar in some aspects (Fig. 4.100 and 4.101). From the lower **level VIIb** only two samples yielded around or more than 400 items in one of the fractions (2 mm fraction of JH80NE, and 0,35 mm fraction of JI78SO) (Fig. 4.102). If 100% of the 0,35 mm fraction had been sorted, 5 more samples would have yielded this population, but only in this fraction. Despite the average density of the level is over 800 r/l, which should be enough to reach our target number of remains, only five samples were of around 800 r/l or more, most of them presenting densities of below 300 r/l.

Nine samples yielded more than 10 taxa and two samples had 20 or more taxa (JH78NE and JI78NE). It seems that the samples from the western side of the trench present a wider botanical diversity and larger densities.

Concerning the type of preservation of the remains, the proportion of charred material is very high in the 2 mm fraction of some samples (JH80NE, JI79NE, JJ78NE, KC81NE, KD80NE and KE81NE). Only in one sample, JH80NE, the 0,35 mm fraction showed a comparable proportion of charred material. In the rest of the samples, most of the material recovered in this fraction is in waterlogged state. As a result, only one sample (JG80) presents more than half of the seed and fruit remains in charred state. The larger concentration of waterlogged material (JI78) is located in the south-western side of the trench (Fig. 4.104).

In the upper **level VIIa**, two samples produced more than 400 remains in the 2 mm fraction, JG80NE and JH79NE (Fig. 4.103). Six samples presented densities of over 700 r/l but only four of them would yield more than 400 items in the 0,35 mm fraction if this was sorted in its entirety (JG78, JG79, JG81and JH80). Besides these samples, KB80NE would also reach these figures even though its density is much lower (266,67 r/l). This can be explained by the fact that this sample was of 1,74 litres.

Considering the botanical diversity, eleven samples yielded more than 10 taxa and two of them produced 20 or more (JG79 and JG81). It seems that, just as in level VIIb, the samples with a larger botanical diversity are found in the western part of the excavated area.

With respect to the preservation type, 14 samples presented the majority of the remains of the 2 mm fraction in charred state, all over the excavated area. This percentage was never high in the 0,35 mm fraction, except for sample JG80NE (44,09%). As a result, only two samples have more than 50% of the seed and fruit record in charred state, JG80 and JH79, both in the western part of the excavated area. The larger concentrations of waterlogged remains are also found in this area (JG79, JG81, JH80) (Fig. 4.104).

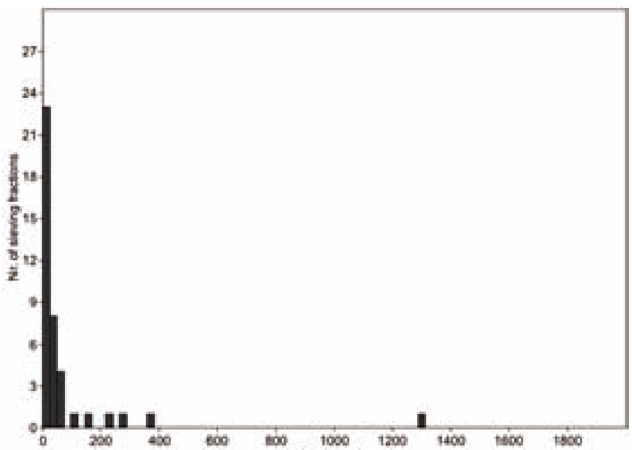


Fig. 4.102. Histogram showing the number of remains per sieving fraction (2mm or 0,35 mm) from the systematic surface samples of level VIIb from sector D of La Draga.

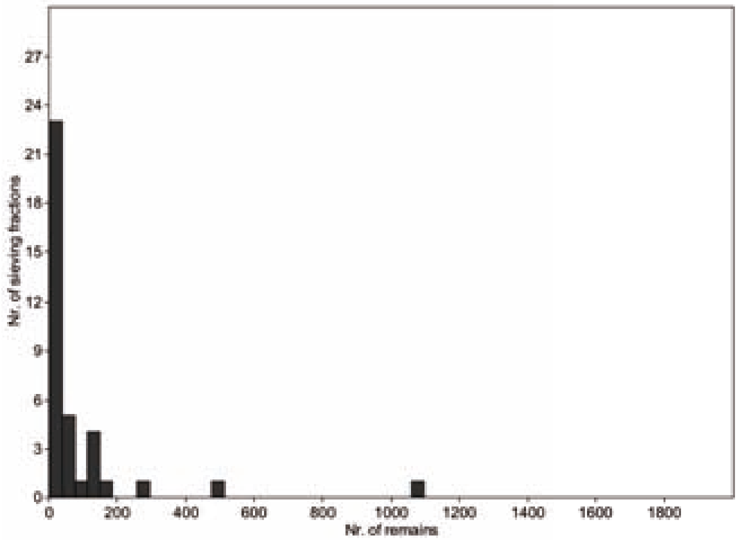


Fig. 4.103. Histogram showing the number of remains per sieving fraction (2mm or 0,35mm) from the systematic surface samples of level VIIa from sector D of La Draga.

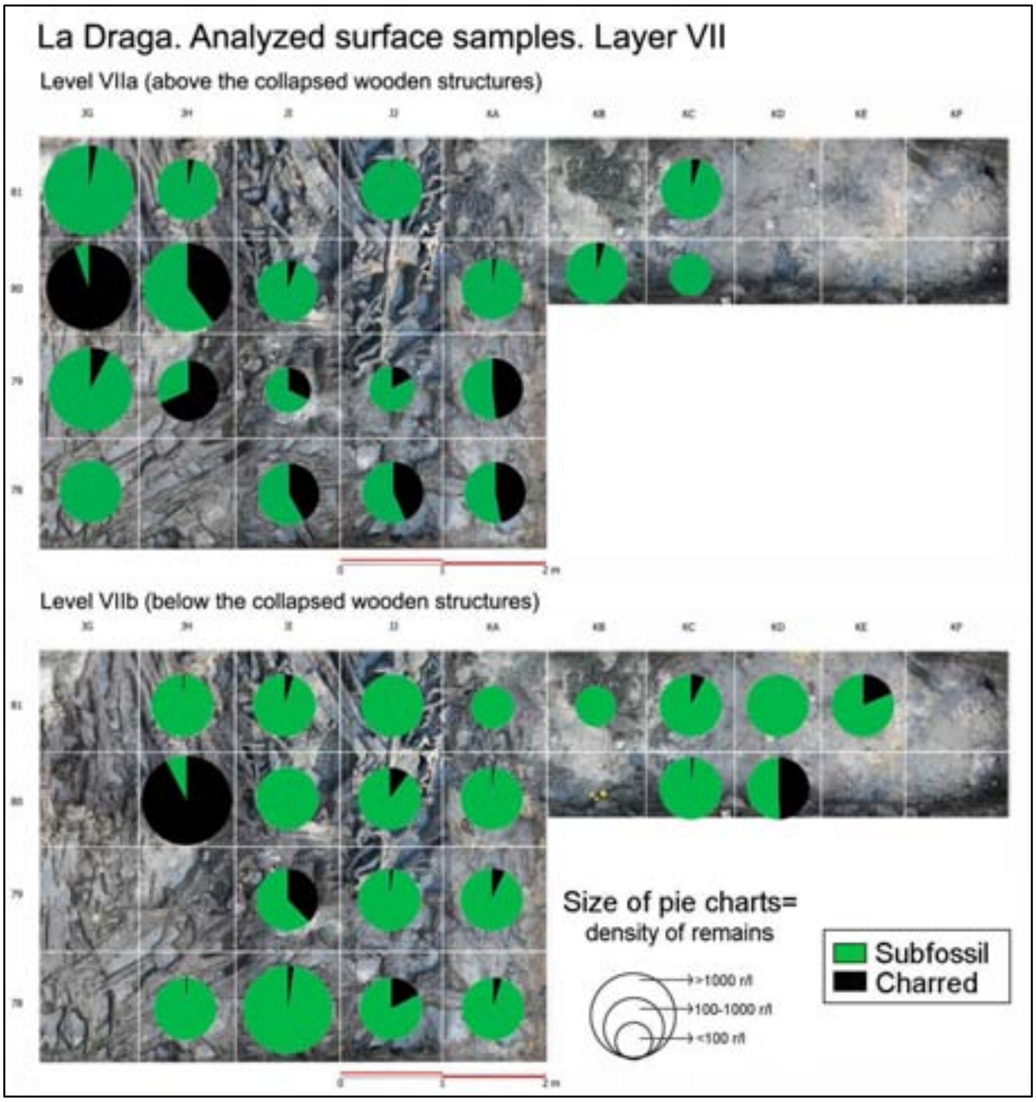


Fig. 4.104. Proportion of charred and waterlogged seed and fruit remains of the systematic surface samples from sector D of La Draga.

4.7.6.1.4. What information can one expect to obtain from each archaeological level and from each sample? Are both charred and waterlogged remains significant enough at a quantitative level?

The presented data allow a first consideration towards their potential. On the one hand, the fact that barely any sample yielded our target number of items makes a sample-by-sample evaluation more complicated and this will have to be discussed separately for the charred and the subfossil record. It must be reminded that these samples do not represent contexts. An evaluation of their composition must be performed first in order to define whether we can amalgamate samples, which could end up producing contexts with the desired number of items.

On the other hand, the results obtained per level are very good (large number of items and taxa) and the overall results of most of the taxa (except the larged-seeded taxa) should be considered representative at a level scale.

In the next lines, an evaluation of the seed and fruit record will be performed. The charred and the waterlogged material will be analysed separately. The focus of the systematic surface sampling was the spatial evaluation of the data, and this will be the main purpose in the analysis of the data. A final palaeoeconomic evaluation of the data will not be carried out until the final discussion at a site level (4.7.7.).

4.7.6.1.5. The charred record: number of remains, concentration and ecological groups

The results per sample of both levels VIIb and VIIa are presented in Fig. III.16. In the next lines, the text will focus on the charred record of these levels (Fig. 4.105, 4.106).

The results of **level VIIb** show that the botanical diversity of the charred record is much limited (Fig. 4.105). Eight taxa were identified. Of these, five were cereals (*Hordeum distichum, Triticum aestivum* type, *Triticum durum/turgidum* type, *Triticum dicoccum,* and *Triticum monococcum*) and the rest were wild plants: *Quercus* sp., *Vicia sepium* and *Alnus glutinosa.* At a quantitative level, cereals were the best-represented group, especially barley and naked wheat (Fig. 4.107). Among these, naked wheat (mainly of tetraploid type, according to the chaff remains) presents the highest average concentration per litre of sediment (59,52 r/l for the grains and 30,39 r/l for the chaff) and ubiquity percentages (61,9% for the grains and 38,1% for the chaff). Quite remarkable is the ubiquity of *Quercus* sp. (19,05%).

Concerning the cereal remains, barley (2-rowed type) shows a similar representation of chaff and grain remains, while naked wheat and emmer have approximately the double of grain than chaff remains. Regarding einkorn, chaff remains are far better represented than grains.

Ecol. group	Taxa	Represented part	Preserv. (1:charred to 5:uncharred)	VIIb TOTAL rNR	eNR	Aver. conc.	% Ubiq.
C	***Hordeum distichum***	**ear fragment (node=1)**	**1**	**28**	**28**	**1,59**	**4,76**
C	***Hordeum distichum***	**chaff (node=1)**	**1**	**26**	**181**	**10,26**	**4,76**
C	***Hordeum vulgare***	**grain (MNI)**	**1+2+3**	**177**	**183**	**10,87**	**23,81**
C	***Hordeum* sp.**	**Grain remains**	**1+2**	**11**	**11**	**0,71**	**23,81**
C	***Hordeum* sp.**	**chaff (node=1)**	**1+2**	**1**	**1**	**0,06**	**4,76**
C	***Triticum aest./dur./turg.* (incl. aest. and dur./turg.)**	**grain (MNI)**	**1+2**	**505**	**985**	**59,52**	**61,90**
C	***Triticum aest./dur./turg.* (incl. aest. and dur./turg.)**	**chaff (node=1)**	**1+2**	**166**	**515**	**30,39**	**38,10**
C	*Triticum durum/turgidum* type	chaff (node=1)	1+2	**112**	**272**	**16,39**	**14,29**
C	*Triticum aestivum* type	chaff (node=1)	1	**1**	**1**	**0,06**	**4,76**
C	***Triticum dicoccum***	**grain (MNI)**	**1+2**	**51**	**138**	**7,91**	**19,05**
C	***Triticum dicoccum***	**chaff (GB=1)**	**1**	**10**	**62**	**3,51**	**4,76**
C	***Triticum monococcum***	**grain (MNI)**	**1**	**12**	**12**	**0,70**	**9,52**
C	***Triticum monococcum***	**chaff (GB=1)**	**1**	**18**	**87**	**4,96**	**19,05**
C	***Triticum* sp. undiff.**	**grain**	**1**	**119**	**152**	**9,17**	**66,67**
C	***Triticum* sp. undiff.d**	**chaff (rachis fr.+SF+GB)**	**1**	**9**	**9**	**0,52**	**9,52**
C	**Cerealia, undiff.**	**grain (seed/fruit+FPreC+FPostC)**	**1**	**77**	**77**	**4,82**	**38,10**
C	**Cerealia, undiff.**	**chaff (rachis fr.+GB)**	**1**	**1**	**1**	**0,09**	**4,76**
C	**Cerealia, undiff.**	**straw (straw + straw node)**	**1**	**32**	**32**	**1,87**	**19,05**
WO	***Quercus* sp.**	**Total CU**	**1**	**7**	**7**	**0,46**	**19,05**
WEC	***Vicia sepium***	**seed/fruit**	**1**	**1**	**1**	**0,10**	**4,76**
LS	***Alnus glutinosa***	**total remains**	**1**	**2**	**2**	**0,11**	**4,76**
DIV	**Papilionaceae**	**seed/fruit**	**1+2**	**4**	**4**	**0,30**	**9,52**
DIV	**Poaceae**	**total remains**	**1**	**1**	**1**	**0,08**	**4,76**
DIV	***Vicia/Pisum***	**seed/fruit**	**1**	**1**	**1**	**0,07**	**4,76**
		Total number of items		**1259**	**2490**	**148,07**	
		Total number of taxa		**8**	**8**		

Fig. 4.105. Results of the analysis of the seed and fruit record in charred state from the systematic surface samples of level VIIb from sector D of La Draga: real number of items (rNR), estimated number of items (eNR), average concentration and percentage of ubiquity.

Ecol. group	Taxa	Represented part	Preserv. (1:charred to 5:uncharred)	VIIa TOTAL rNR	eNR	Aver. conc.	%Ubiq
C	***Hordeum distichum***	**ear fragment (node=1)**	**1**	**15**	**15**	**0,97**	**10,53**
C	***Hordeum distichum***	**chaff (node=1)**	**1**	**46**	**114**	**6,77**	**15,79**
C	***Hordeum vulgare* (cf. incl.)**	**grain (MNI)**	**1+2+3**	**281**	**281**	**18,15**	**52,63**
C	***Hordeum* sp. (cf. incl.)**	**grain (MNI)**	**1+2**	**31**	**31**	**2,16**	**26,32**
C	***Hordeum* sp. (cf. incl.)**	**chaff (node=1)**	**1+2**	**1**	**1**	**0,06**	**5,26**
C	***Triticum aest./dur./turg.* (incl. aest. and turg.)**	**grain (MNI)**	**1+2**	**1144**	**3132**	**195,42**	**84,21**
C	***Triticum aest./dur./turg.* (incl. aest. and turg.)**	**chaff (node=1)**	**1+2**	**202**	**296**	**20,34**	**36,84**
C	*Triticum turgidum*	chaff (node=1)	1+2	**176**	**262**	**18,05**	**31,58**
C	*Triticum aestivum*	chaff (node=1)	1	**1**	**1**	**0,05**	**5,26**
C	***Triticum* (cf.) *dicoccum***	**grain (MNI)**	**1+2**	**33**	**75**	**4,67**	**36,84**
C	***Triticum* (cf.) *dicoccum***	**chaff (GB=1)**	**1**	**14**	**14**	**0,82**	**15,79**
C	***Triticum* (cf.) *monococcum* (incl. 2-grain)**	**grain (MNI)**	**1**	**14**	**21**	**1,27**	**21,05**
C	***Triticum* (cf.) *monococcum* (incl. 2-grain)**	**chaff (GB=1)**	**1**	**20**	**20**	**1,35**	**26,32**
C	***Triticum* sp. unspecified**	**grain**	**1**	**328**	**447**	**28,69**	**63,16**
C	***Triticum* sp. unspecified**	**chaff (rachis fr.+SF+GB)**	**1**	**26**	**60**	**5,37**	**15,79**
C	**Cerealia, undiff.**	**grain (seed/fruit+FPreC+FPostC)**	**1**	**266**	**280**	**16,64**	**57,89**
C	**Cerealia/Poaceae, undiff.**	**straw (straw + straw node)**	**1**	**58**	**58**	**3,34**	**10,53**
C	***Papaver somniferum***	**MNI**	**1**	**2**	**2**	**0,13**	**10,53**
WER	**cf. *Avena* sp.**	**seed/fruit**	**1**	**1**	**1**	**0,05**	**5,26**
WO	***Quercus* sp. (incl. cf.)**	**Total CU**	**1**	**2**	**2**	**0,15**	**10,53**
LS	***Alnus glutinosa***	**total remains**	**1**	**1**	**1**	**0,11**	**5,26**
LS	***Vitis vinifera* subsp. *sylvestris***	**total CU**	**1**	**1**	**1**	**0,07**	**5,26**
DIV	**Papilionaceae**	**seed/fruit**	**1+2**	**7**	**7**	**0,60**	**31,58**
DIV	**Poaceae**	**total remains**	**1**	**1**	**1**	**0,05**	**5,26**
DIV	***Rubus* sp.**	**total CU**	**1**	**1**	**1**	**0,08**	**5,26**
DIV	***Vicia* sp.**	**seed/fruit**	**1**	**1**	**1**	**0,05**	**5,26**
		Total number of items		**2496**	**4862**	**307,3**	
		Total number of taxa		**11**	**11**		

Fig. 4.106. Results of the analysis of the seed and fruit record in charred state from the systematic surface samples of level VIIa from sector D of La Draga: real number of items (rNR), estimated number of items (eNR), average concentration and percentage of ubiquity.

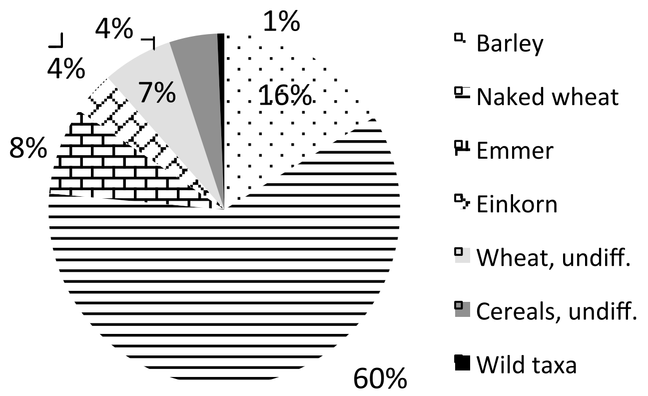


Fig. 4.107. Relative proportions (based on MNI) among the taxa recovered in charred state in the systematic surface samples of level VIIb from sector D of La Draga.

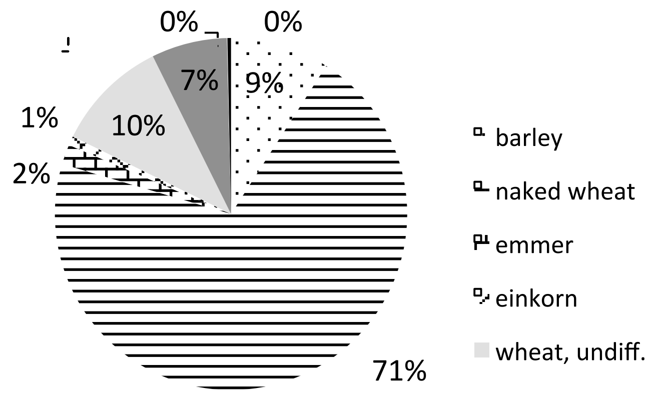


Fig. 4.108. Relative proportions (based on MNI) among the taxa recovered in charred state in the systematic surface samples of level VIIa from sector D of La Draga.

The results of **level VIIa** are similar in several aspects: the low number of taxa, the predominance of cereals and the presence of some legumes, and remains from acorns and alder (*Alnus glutinosa*). Eleven taxa were identified. Five of these were cultivars: five different cereals (*Hordeum distichum, Triticum aestivum* type, *Triticum durum/turgidum* type, *Triticum dicoccum*, *Triticum monococcum*) and one an oleaginous plant, opium poppy (*Papaver somniferum*). One potential weed or ruderal plant was identified, *Avena* sp.; one plant from woodland areas, *Quercus* sp.; and two from lakeshore areas, *Alnus glutinosa* and *Vitis vinifera* subsp. *sylvestris*. Cereals are the best-represented group, especially naked wheat (mainly of tetraploid type), which represents a higher percentage (71%) of the total of remains (Fig. 4.108). It appears with a much higher density than in level VIIb (around 215 r/l) and a higher ubiquity, mainly from the remains of grains (84,21%). Chaff is, in fact, less well represented than in level VIIb. Barley is slightly better represented, especially when observing the ubiquity of the grains (52,63%). On the other hand, both emmer and einkorn seem to have lower concentration values but higher ubiquities. Legumes also present a considerable ubiquity (31,58%), unfortunately, they were rarely identifiable to genus or species level.

As for the cereal remains, it should be stressed that the representation of grain is much better than in level VIIb. Barley (2-rowed type) has the double of grain than chaff, for naked wheat, chaff remains barely reach 10% of grain items, for emmer they barely reach 20% and for einkorn they are equally represented.

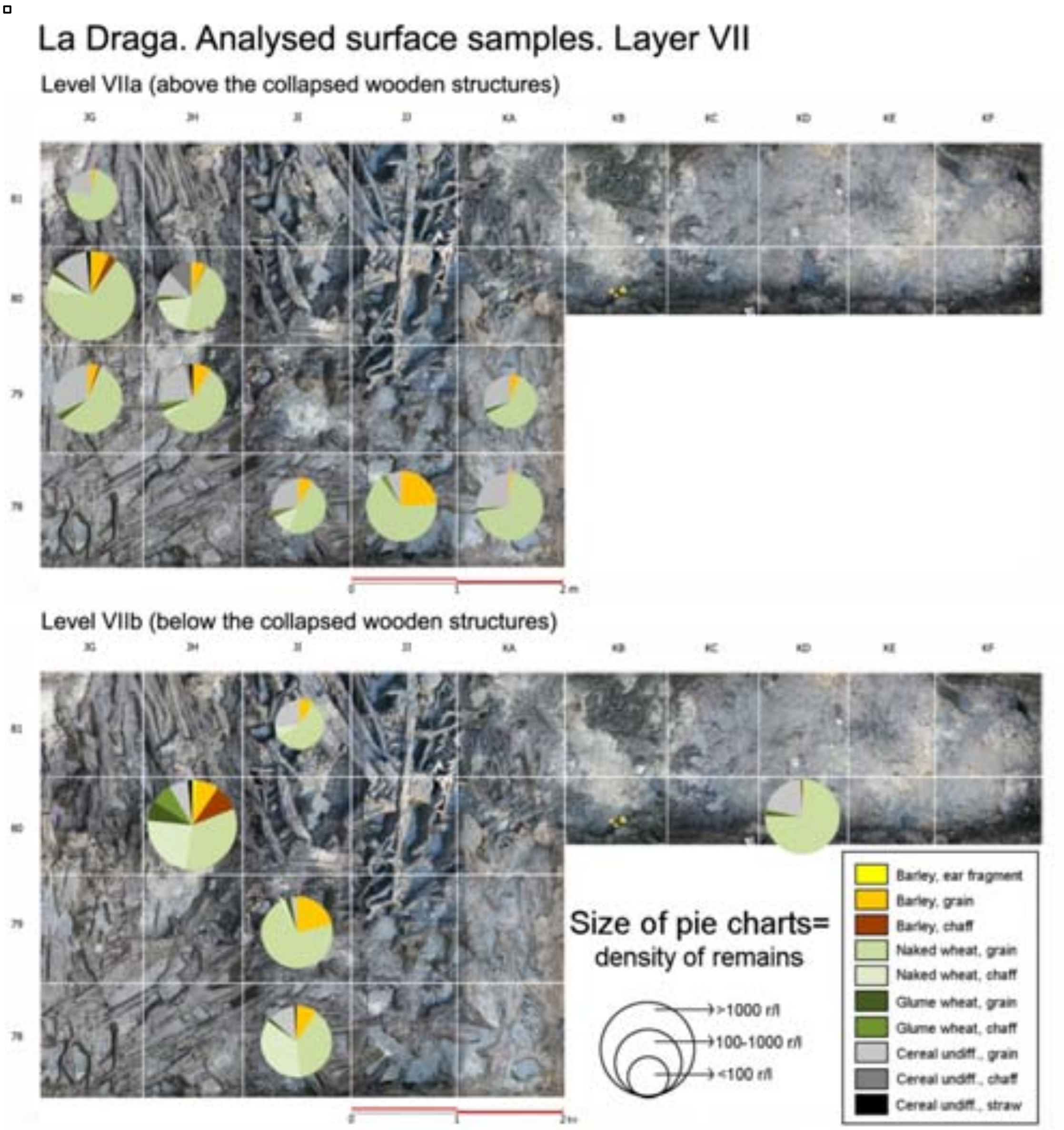


Fig. 4.109. Spatial representation (pie charts) of the results of the main categories of cereal taxa from the systematic soil samples from Sector D of La Draga.

Fig. 4.110. Pictures of ear fragments of 2-rowed barley (JH80NE VIIb), at the left, and straw fragments (JH79NE VIIa), at the right (Author: F.Antolín).

The results of the cereal remains at a sample level were represented in pie charts on the site plan for both levels separately (Fig. 4.109). Only samples with more than 35 remains were considered. Only five samples from level VIIb had more than 35 crop remains. From these, only a single sample presented a rather high density of charred remains, sample JH80NE. They are majorly located on the western side of the trench (except for KD80). Three of the samples (JI78SW, JI81NE and KD80NE) present a spectrum dominated by naked wheat, with a small percentage of barley (c. 10% or less) and a variable proportion of unidentified cereal remains. Of these, only JI78 presents an important proportion of chaff remains. Sample JI79NE is rather similar (c. 75% of free-threshing wheat grain) but the proportion of barley is slightly larger (c. 20%). Sample JH80NE presents a very different pattern. Glume wheats and barley are around 15% each and naked wheat is around 60% of the sample. In the three cases, chaff remains are as well represented as grain. Ear fragments of barley and fragments of straw were also recovered (Fig. 4.110). Straw was also recovered in JI18 and KD80.

In level VIIa, 9 samples allowed a graphical representation of the results obtained for the cereal crops. They seem to concentrate in two locations, around JG80 (5 samples) and around JJ78 and KA78 (4 samples). The composition of the samples is very similar to the one observed in level VIIb, a majority of naked wheat (mostly grain), with a variable percentage of undifferenciated cereal remains and a low proportion of barley grain and chaff. Only one sample, JJ78NE, contained c. 25% of barley grains. JH80NE is the sample which presents a larger proportion of naked wheat chaff and some ear fragments of barley (Fig. 4.110). Fragments of straw were recovered in sample JG80NE and JH79NE. These could belong to cereals but also to other Poaceae.

4.7.6.1.6. The charred record: taphonomic description of the cereal assemblages

The presented results raise many questions concerning the taphonomy of the samples. Why do these concentrations appear? Are they *in situ*? Is this a processed crop? Why is there so much chaff in some of the samples? In this chapter we will deal with the evidences from pre-depositional, depositional and post-depositional processes that can be observed on the seed and fruit record.

		VIIb			VIIb TOTAL			VIIa							VIIa TOTAL		
		JH80 NE	JI79 NE	KD80 NE	rNR	eNR	% Ubiq.	JG7 9NE	JG80 NE	JG81 NE	JH79 NE	JH80 NE	JI80 NE	KA78 NE	rNR	eNR	% Ubiq.
Naked wheat	cracked grain		1		**1**	**1**	**4,76**										
Naked wheat	cut/peeled grain		1		**1**	**1**	**4,76**		1			1			**2**	**2**	**10,5**
Naked wheat	FPreC	18		1	**7**	**19**	**9,52**		33	1			1	1	**8**	**36**	**21,1**
Einkorn	FPreC								1						**1**	**1**	**5,26**
Triticum dicoccum/"nudum"	FPreC			1	**1**	**1**	**4,76**										
Triticum sp.	FPreC	4		4	**8**	**8**	**9,52**	1	57	1		3		3	**51**	**65**	**26,3**
Cerealia	FPreC									1	2				**3**	**3**	**10,5**
Cerealia	agg. FPreC								16						**2**	**16**	**5,26**

Fig. 4.111. Evidences of crop processing and culinary processing practices on charred cereal grains obtained from the systematic surface samples from sector D of La Draga (FPreC: fragment produced prior to charring; rNR: real number of remains; eNR: estimated number of remains; ubiq.: ubiquity).

Regarding the evidences of **pre-depositional processes**, these concern any human action on the remains which can be observed in the record. The amount of evidence is relatively low. They were identified in samples JH80, JI79 and KD80 (Level VIIb) and samples JG79, JG80, JG81, JH79, JH80, JI80 and KA78

(Level VIIa). Cracked grains, cut/peeled grains and fragments of grain produced prior to charring (**FPreC**) were observed on remains of naked wheat. The most common finds are fragments produced prior to charring (Fig. 4.111). Unfortunately, these are more difficult to identify to species level due to their fragmented state and their distortion during charring, but it is very likely that the unidentified fragments belong to naked wheat. Very significant is the identification of aggregates of grains produced prior to charring in JG80 (Fig. 4.112).

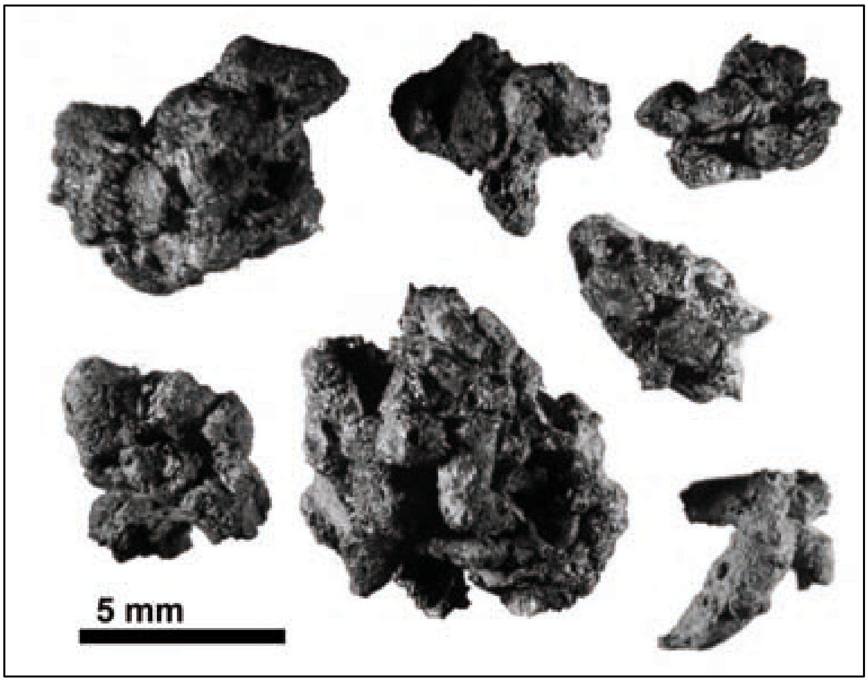


Fig. 4.112. Picture of aggregates of fragments of grain produced prior to charring obtained in the water-screened samples from sector D of La Draga (KD81) (Author: F.Antolín).

The **depositional processes** of the remains under analysis mainly concern the charring process (Fig. 4.113). In level VIIb, three samples (JH80 NE, JI79 NE, KD80 NE) produced valuable data concerning this issue; in level VIIa, only two (JG80 NE, JH80 NE). Effects of this process seem to be observed in all the identified taxa in both levels. In level VIIb the proportion of popped grains (**PS**) is rather low, except for barley grains in sample JH80 NE. The presence of protrusions (**PROT**) is rather high, especially for barley, but also for glume wheats and naked wheat (always above 10%). Concave flanks (**CC**) are observed in the three taxa and samples, with percentages around 15% for barley and the glume wheats and of less than 10% for naked wheat. The number of grain aggregates (**AGG**) is low and only observed on naked wheat (under 2%). In level VIIa, the results are rather similar. The appearance of protrusions in all taxa is well documented, with percentages over 20% in the wheats and above 45% in barley. Popped barley grains were also more frequent. Grains with concave flanks were less abundant, but still detected on the tree taxa. The number of aggregated grains was slightly higher (*c.* 5% of the naked wheat grain).

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Fig. 4.113.Quantified effects of the charring process observe don the charred cereal grains obtained from the systematic surface samples of level VIIb from sector D of La Draga (see references to the abbreviations in the text).

VIIa	JG80 NE								JH80 NE							
	PS		PROT		AGG		CC		PS		PROT		AGG		CC	
	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%
Barley	40	17,78	103	45,78			31	13,78	1		5				3	
Naked wheat	4	0,17	521	22,78	104	4,55	208	9,09	2	1,26	42	26,42	2	1,26	10	6,29
Glume wheat							4	5,80			2					
Wheat unsp.			48	20,08	1	0,42	2	0,84								

Fig. 4.114.Quantified effects of the charring process observe don the charred cereal grains obtained from the systematic surface samples of level VIIa from sector D of La Draga (see references to the abbreviations in the text).

The presence of fragile items in charred state is also an evidence of an appropriate charring process for a quantitative archaeobotanical evaluation. Examples of fragile items present in our samples are rachis fragments of *Hordeum* (as observed by other authors, for instance, Akeret 2005), found in several samples and particularly abundant in JG80 NE and JH79 NE (level VIIa) and in JH80 NE (VIIb) (Fig. III.17); as well as straw fragments (without culms), which have long been recognized as rarely present in archaeological sites due to taphonomic reasons (see, for instance, Hillman 1981).

Finally, concerning the effects of **post-depositional agents** on the grains, several aspects have been evaluated. First of all, the intensity and type of fragmentation was observed. The proportion between complete grains and fragments was calculated for those samples with more than 35 grain items and the results are very homogeneous for both levels (Fig. 4.115 and 4.116). The remains are largely intact: above 90% of complete grains in level VIIb and mostly above 80% in level VIIa. Most of this fragmentation occurred after charring, even though some fragmentation produced prior to charring was observed, as previously mentioned (Fig. 4.111).

This fragmentation is mainly of irregular type, according to the observations carried out in both levels (Fig. 4.117). On the other hand, the proportion between complementary fragments (apical and embryonal fragments) was calculated for sample JG80 NE VIIa (the only one which allowed such an evaluation) and the results seem to show a moderately good correspondence: 65% of apical fragments against 35% of embryonal fragments.

The state of the surface of the grains shows very different results between samples. In level VIIb, intact remains were only dominant (over 60%) in JH80 (Fig. 4.118). Intact and semi-intact remains made between 65% and 80% in JI78, JI79 and KD80, but less than 40% in JJ78. In level VIIa (Fig. 4.119), similar differences were observed. Samples JG80 and JH80 show the largest proportion of intact remains (around 40-50%), and of intact and semi-intact remains altogether (70-80%), along with sample JJ78 (70%). The rest of the samples have between 30 and 65% of intact and semi-intact remains in sum.

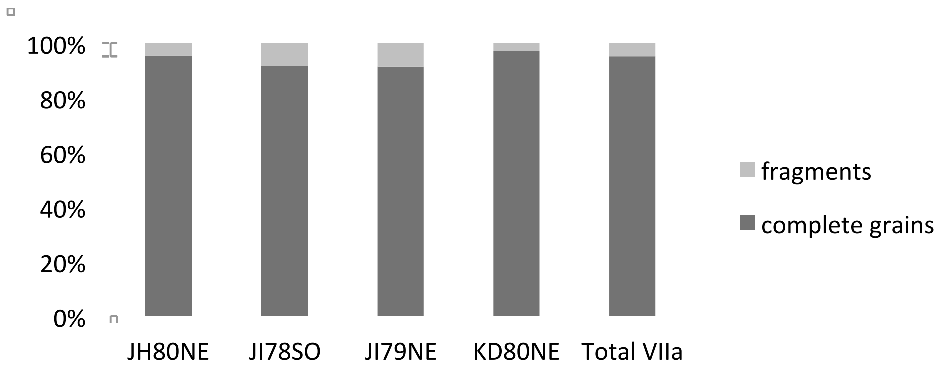

Fig. 4.115. Relative proportions between complete grains and fragments from systematic surface samples of level VIIb from sector D of La Draga.

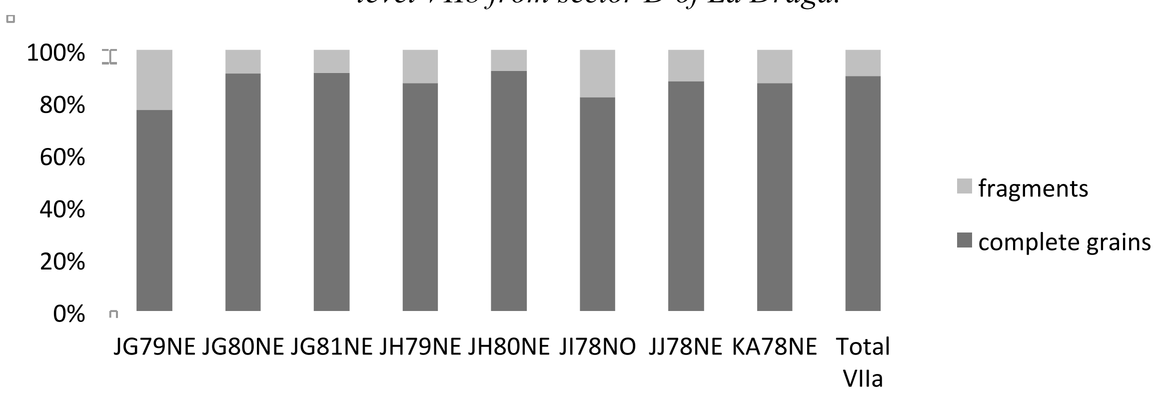

Fig. 4.116. Relative proportions between complete grains and fragments from systematic surface samples of level VIIa from sector D of La Draga.

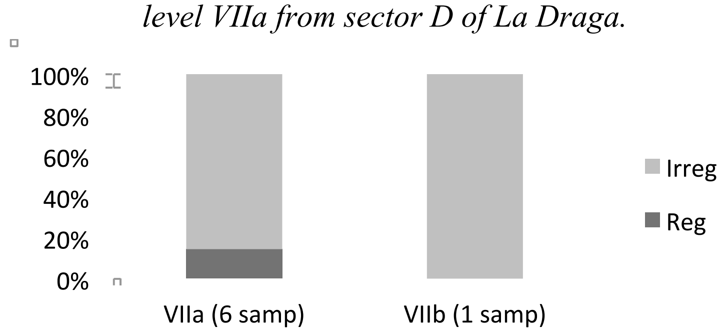

Fig. 4.117. Relative proportion between regular and irregular fragments of cereal grains from the systematic surface samples of La Draga from sector D of La Draga.

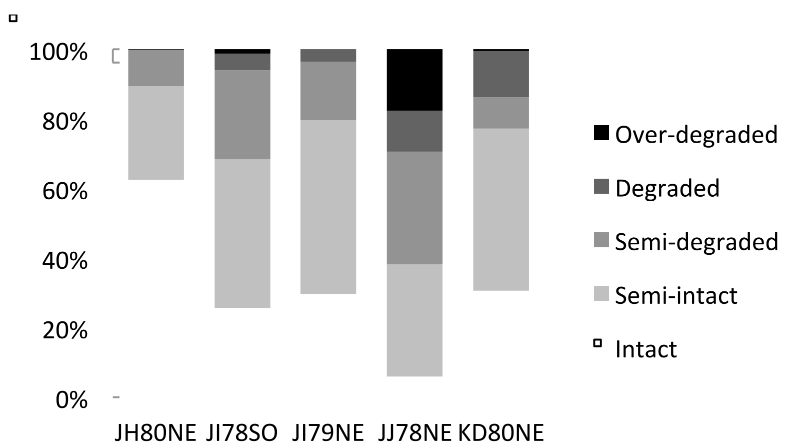

Fig. 4.118. Relative proportions between the different states of preservation of the surface of the grains recovered from the systematic surface samples of level VIIb from sector D of La Draga.

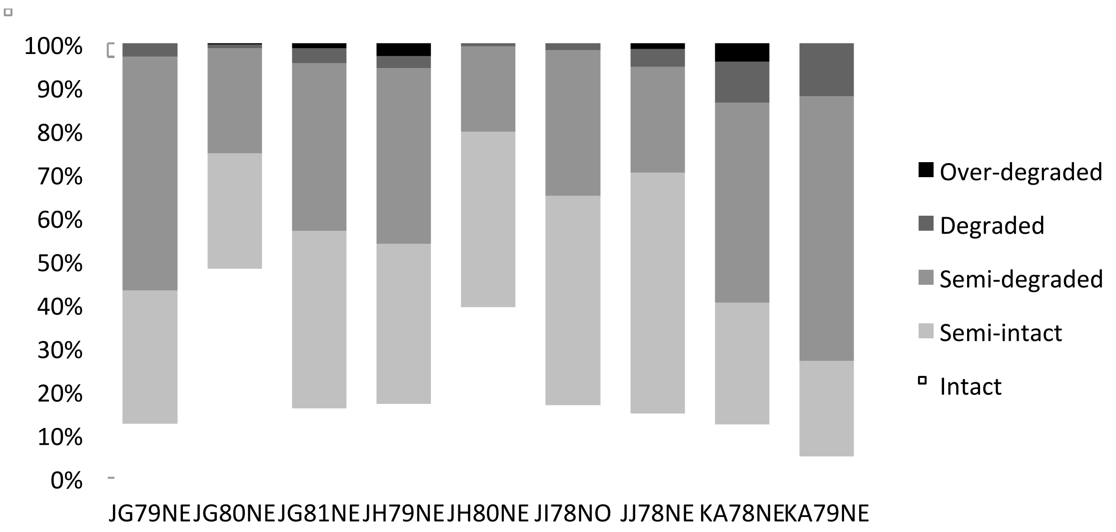

Fig. 4.119. Relative proportions between the different states of preservation of the surface of the grains recovered from the systematic surface samples of level VIIa from sector D of La Draga.

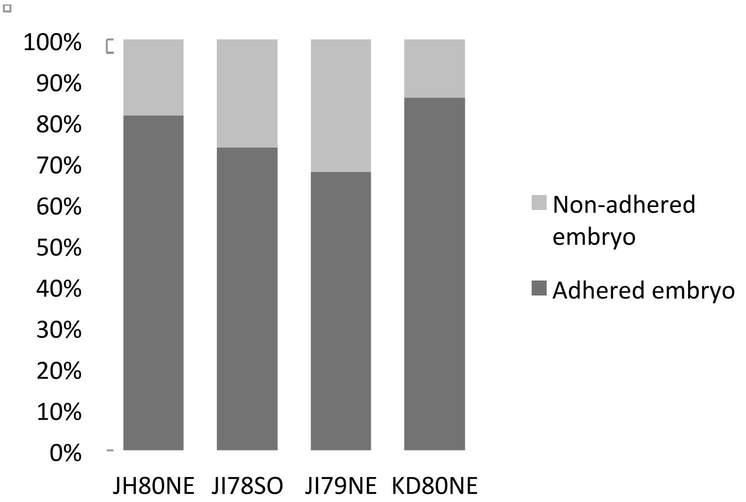

Fig. 4.120. Relative proportions between the grains with and without an adhered embryo recovered from the systematic surface samples of level VIIb from sector D of La Draga.

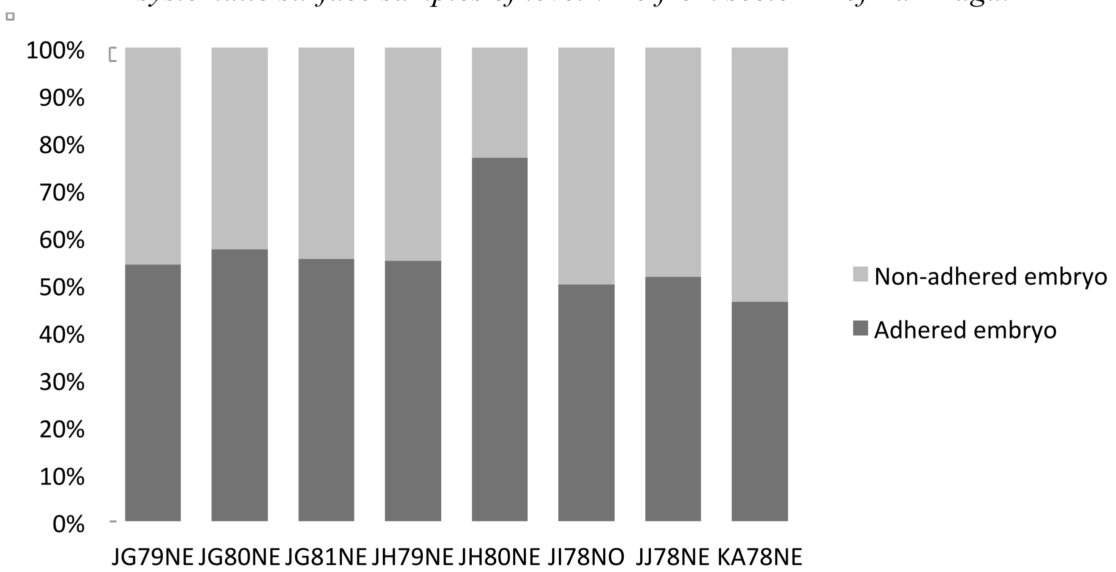

Fig. 4.121. Relative proportions between the grains with and without an adhered embryo recovered from the systematic surface samples of level VIIa from sector D of La Draga.

The results obtained with respect of the presence or absence of the embryo on the grains also show rather different results between samples and levels. In level VIIb, this was evaluated in four samples (JH80, JI18, JI79 and KD80). They all present percentages of around 70-85% of grains with adhered embryo (Fig. 4.120). On the other hand, in level VIIa, most samples have percentages of around 50%, except for JH80, where the percentage is of 75% (Fig. 4.121).

4.7.6.1.7. The subfossil record: number of remains, concentration and ecological groups

The detailed results per sample can be observed in Fig. III.17. Synthesized overall results for each level are presented here (Figs. 4.122 and 4.123).

In **level VIIb**, 56 taxa were identified (Fig. 4.122). Five of these were cultivars (**C**): four cereals (*Hordeum* sp., *Triticum durum/turgidum* type, *Triticum dicoccum, Triticum monococcum*) and opium poppy (*Papaver somniferum*). Eight belonged to the weeds and ruderals group: *Ammi majus, Avena* sp., *Bromus hordeaceus/secalinus*, *Galium aparine* subsp. *spurium*, cf. *Scandix pecten-veneris, Silene gallica, Urtica dioica* and *Verbena officinalis*. Six were classified as plants from pastures and grasslands: *Apium graveolens, Arenaria serpyllifolia, Campanula* cf. *rotundifolia*, *Epilobium* sp.[6], *Hypericum perforatum* and *Linum catharticum*. Six taxa were ascribed to woodland areas: *Cornus sanguinea, Corylus avellana, Euphorbia amygdaloides, Pyrus malus* subsp. *sylvestris*, *Quercus* sp. and *Viola* cf. *alba*. A reduced group of three taxa was included in the group of plants from woodland edges and clearings: *Origanum vulgare, Prunus spinosa* and *Rubus fruticosus*. Fourteen taxa were grouped into lakeshore plants: *Alisma plantago-aquatica, Apium nodiflorum* subsp. *nodiflorum*, *Cladium mariscus, Cyperus fuscus, Eupatorium cannabinum, Juncus* sp., *Lycopus europaeus, Mentha* cf. *aquatica, Phragmites australis, Plantago major* subsp. *intermedia, Ranunculus sceleratus, Scirpus lacustris, Typha* sp. and *Vitis vinifera* subsp. *sylvestris*. Finally, four taxa were identified as aquatic plants: *Najas marina, Potamogeton* cf. *coloratus*, *Ranunculus aquatilis* and Characeae. The remaining ten taxa were not possible to ascribe to any of the preceding groups: *Carex* sp. *bicarpellate, Carex* sp. *tricarpellate, Cerastium* sp., *Crepis* sp., *Polygonum* sp., *Potentilla* sp., *Setaria* sp., *Stellaria* sp., *Torilis* sp. and Trifolieae).

The results obtained are very different from the ones observed in the charred record. Concerning the cultivars, opium poppy is by far the best-represented taxon (169,9 r/l and 100% of ubiquity). The cereal remains are badly represented in waterlogged state and the average concentrations stay mostly below 3 r/l. The percentage ubiquity values are higher, though. Naked wheat appeared in nearly 30% of the samples, while barley and the glume wheats present ubiquities between 14 and 19%. It is significant to note that the estimated total number of items of einkorn is actually higher than the one of naked wheat (Fig. 4.124). On the other hand, average concentration and ubiquity values are lower. Chaff remains are the best represented within the cereals. Few pericarp/testa fragments of cereal grains (bran) were recovered (2,33 r/l and 14,29% of ubiquity). Regarding opium poppy, only seed remains were identified.

The weeds and ruderals are very mildly represented and only *Verbena officinalis* presents a higher concentration (6,90 r/l) and ubiquity (23,81%). A similar picture is observed when looking at the results of the plants from pastures and grasslands, only one taxon seems to be better represented, *Epilobium* sp. It presents a rather high density (12,38 r/l) but its ubiquity is very low (4,76%).

[6] It is probably *Epilobium tetragonum, E.hirsutum* or *E. parviflorum*.

Plants from woodland areas are also sparsely represented. *Quercus* sp. is the taxon which yielded a higher number of items (mainly fragments of pericarp) and which presents a higher density (9,53 r/l) and a particularly high ubiquity (71,43%). On the other hand, *Rubus fruticosus* is the best-represented taxon (4,45 r/l and 38,10%, without considering the remains of *Rubus* sp.) within the group of plants from woodland edges and clearings.

Among the lakeshore plants, several taxa are well represented, especially *Cladium mariscus* (17,68 r/l and 52,38% of ubiquity), *Lycopus europaeus* (5,11 r/l and 33,33% of ubiquity) and *Ranunculus sceleratus* (23,16 r/l and 33,33% of ubiquity). *Vitis vinifera* subsp. *sylvestris* also appeared with a relatively high ubiquity (28,57%). Waterplants are well represented in the record, especially the Characeae group (367,79 r/l and 85,71% of ubiquity).

In **level VIIa**, 38 taxa in waterlogged state were identified (Fig. 4.123). Three of them were cultivars (*Triticum durum/turgidum* type, *Triticum dicoccum* and *Papaver somniferum*), seven were grouped as weeds and ruderals (*Chenopodium album, Euphorbia helioscopia* subsp. *helioscopia, Hyoscyamus niger, Polygonum aviculare, Reseda phyteuma, Urtica dioica* and *Verbena officinalis*), four as pastures and grasslands (*Apium graveolens, Hypericum perforatum, Petrorhagia prolifera* and *Thymelaea* sp.), four were classified as woodland plants (*Cornus sanguinea, Corylus avellana, Prunus* cf. *avium* and *Quercus* sp.), three were put to the group of plants from woodland edges and clearings (*Origanum vulgare, Physalis alkekengi* and *Rubus fruticosus*), ten to the lakeshore plants (*Alisma plantago-aquatica, Apium nodiflorum* subsp. *nodiflorum, Cladium mariscus, Eupatorium cannabinum, Lycopus europaeus, Plantago major* subsp. *intermedia, Ranunculus sceleratus, Scirpus lacustris, Typha* sp., *Vitis vinifera* subsp. *sylvestris*) and two to the aquatic plants (*Potamogeton* cf. *coloratus* and Characeae). The rest of the taxa were not possible to include in any ecological group: *Cerastium* sp., *Cyperus* sp., *Mentha* sp., *Stellaria* sp., *Viola* sp.

Among the cultivars, the cereals were very badly represented, and only naked wheat (chaff) was identified in more than one sample. On the other hand, opium poppy was recovered in a higher density (220,66 r/l) and a very similar ubiquity (94,74%) than in level VIIb.

Concerning the weeds and ruderals, *Verbena officinalis* is still well represented in the samples (6,19 r/l and 57,89% of ubiquity), while, regarding the plants from pastures and grasslands, *Apium graveolens* shows a high average concentration (21,42 r/l).

The woodland plants are, as in level VIIb, rather badly represented, except for *Quercus* sp. Nevertheless, its average concentration (1,49 r/l) and ubiquity (31,58%) are lower than in level VIIb. The opposite case is observed with *Rubus fruticosus*, the only well represented taxon within the woodland edges and clearings group. It presents a higher concentration of remains (8,10 r/l) and a particularly higher ubiquity (78,95%).

Within the lakeshore plants, most taxa are well represented, especially *Alisma plantago-aquatica* (63,,39 r/l and 42,11% of ubiquity) and *Cladium mariscus* (41,93 r/l and 68,42% of ubiquity). Other taxa present high ubiquities as well, such as *Lycopus europaeus* (47,37%), *Ranunculus sceleratus* (42,11%) and *Vitis vinifera* subsp. *sylvestris* (36,84%).

The aquatic plants do not seem to be so well represented, especially the Oogonia of Characeae, which present a concentration of around 30 r/l, but still a high percentage of ubiquity (73,7%).

Ecol. group	Taxa	Represented part	rNR	eNR	Aver. concentr.	% Ubiq.
C	***Hordeum*** **sp. (cf. incl.)**	chaff (node=1)	8	8	0,52	14,29
C	***Triticum durum/turgidum*** **type**	chaff (node=1)	40	40	2,61	28,57
C	***Triticum dicoccum***	chaff (GB=1)	4	4	0,24	14,29
C	***Triticum monococcum***	chaff (GB=1)	10	43	2,14	19,05
C	Triticum sp.	chaff (rachis fr.+SF+GB)	26	39	3,27	38,10
C	Cerealia, undiff.	grain pericarp	8	25	2,33	14,29
C	Cerealia, undiff.	chaff (rachis fr.+SF+GB)	12	12	0,87	33,33
C	Papaver somniferum (cf. incl.)	MNI	348	2522	169,79	100,00
WER	Ammi majus	seed/fruit	1	1	0,07	4,76
WER	Avena sp.	spikelet fork (SF=1)	1	1	0,05	4,76
WER	Bromus hordeaceus/secalinus	Pericarp	1	1	0,07	4,76
WER	Galium aparine subsp. spurium	Pericarp	1	1	0,07	4,76
WER	cf. Scandix pecten-veneris	seed/fruit	1	1	0,05	4,76
WER	Silene gallica	fragment	1	1	0,05	4,76
WER	Urtica dioica	seed/fruit	1	1	0,05	4,76
WER	Verbena officinalis	total CU	13	86	6,90	23,81
PG	Apium graveolens	seed/fruit	1	1	0,05	4,76
PG	Arenaria serpyllifolia	seed/fruit	3	3	0,23	9,52
PG	Campanula cf. rotundifolia	seed/fruit	1	1	0,08	4,76
PG	Epilobium sp.	seed/fruit	13	156	12,38	4,76
PG	Hypericum perforatum (incl. cf.)	seed/fruit	1	1	0,06	4,76
PG	Linum catharticum	seed/fruit	1	1	0,05	4,76
WO	Cornus sanguinea	Total CU	2	2	0,14	9,52
WO	Corylus avellana (cf. incl.)	shell fragment	1	1	0,07	4,76
WO	Euphorbia amygdaloides	seed/fruit	1	1	0,05	4,76
WO	Maloideae	pericarp fragment	1	1	0,08	4,76
WO	Pyrus malus subsp. sylvestris	seed fragment	1	1	0,07	4,76
WO	Quercus sp. (incl. cf.)	Total CU	137	139	9,53	71,43
WO	Viola cf. alba	seed/fruit	1	1	0,08	4,76
WEC	Origanum vulgare	seed/fruit	6	6	0,39	19,05
WEC	Prunus spinosa	fruit stone fragment	1	1	0,05	4,76
WEC	Rubus fruticosus agg.	total CU	17	89	4,45	38,10
LS	Alisma plantago-aquatica	seed/fruit	13	91	7,06	23,81
LS	Apium nodiflorum subsp. nodiflorum	seed/fruit	1	1	0,08	4,76
LS	Cladium mariscus	total of CU	41	261	17,68	52,38
LS	Cyperus fuscus	seed/fruit	5	5	0,39	14,29
LS	Eupatorium cannabinum	Total CU	5	5	0,33	23,81
LS	Juncus sp.	seed/fruit	2	2	0,16	9,52
LS	Lycopus europaeus	total CU	14	66	5,11	33,33
LS	Mentha cf. aquatica	seed/fruit	1	1	0,08	4,76
LS	Phragmites australis	pericarp	1	1	0,08	4,76
LS	Plantago major subsp. intermedia	seed/fruit	1	1	0,08	4,76
LS	Ranunculus sceleratus	total CU	32	314	23,16	33,33
LS	Scirpus lacustris (incl. cf.)	seed/fruit	6	6	0,45	9,52
LS	Typha sp.	seed/fruit	5	5	0,38	19,05
LS	Vitis vinifera subsp. sylvestris	total CU	6	6	0,39	28,57
WP	Najas marina	total CU	3	3	0,22	9,52
WP	Potamogeton cf. coloratus	seed/fruit	2	2	0,14	9,52
WP	Ranunculus aquatilis	seed/fruit	1	1	0,08	4,76
WP	Characeae	Oogonia with outer chalky layer	94	805	60,27	66,67
WP	Characeae	Oogonia without outer chalky layer	473	4144	327,52	57,14
DIV	Ammi/Apium	seed/fruit	5	53	2,52	9,52
DIV	Asteraceae	fragment	1	1	0,05	4,76
DIV	Carex sp. bicarpellate	seed/fruit	1	1	0,08	4,76
DIV	Carex sp. tricarpellate	seed/fruit	1	1	0,08	4,76
DIV	Cerastium sp.	seed/fruit	7	7	0,43	19,05
DIV	Crepis sp.	seed/fruit	1	1	0,10	4,76
DIV	Cyperaceae	seed/fruit	7	37	2,86	19,05
DIV	Euphorbia sp.	fragment	1	1	0,09	4,76
DIV	Lamiaceae	fragment	1	1	0,08	4,76
DIV	Mentha sp.	seed/fruit	6	6	0,42	14,29
DIV	Poaceae	total remains	12	103	8,17	23,81
DIV	Polygonum sp.	seed/fruit	1	1	0,05	4,76
DIV	Potentilla sp.	seed/fruit	3	3	0,24	4,76
DIV	Ranunculus sp.	seed/fruit	1	1	0,08	4,76
DIV	Rosa/Rubus	spine	1	1	0,05	4,76
DIV	Rubus sp.	total CU	11	11	0,71	47,62
DIV.	Scirpus sp.	seed/fruit	2	2	0,12	9,52
DIV	Setaria sp.	glume base	1	1	0,07	4,76
DIV	Stellaria sp.	seed/fruit	1	1	0,09	4,76
DIV	Torilis sp.	seed/fruit	1	1	0,08	4,76
DIV	Trifolieae	seed/fruit	1	1	0,07	4,76
DIV	Umbelliferae	total CU	1	1	0,08	4,76
DIV	Viola sp.	seed/fruit	1	1	0,07	4,76
		Total remains	1438	9148	677	
		Total number of taxa	56	56		

Fig. 4.122. Results of the analysis of the seed and fruit record in subfossil state from the systematic surface samples of level VIIb from sector D of La Draga: real number of items (rNR), estimated number of items (eNR), average concentration and percentage of ubiquity (CU: counted unit; for the abbreviations of ecological groups, see chapter 3.2.7).

Ecol. group	Taxa	Represented part	rNR	eNR	Aver. conc.	% Ubiq.
C	***Triticum aest./dur./turg.***	**chaff (node=1)**	**6**	**6**	**0,42**	**15,79**
C	***Triticum durum/turgidum* type**	**chaff (node=1)**	**6**	**6**	**0,42**	**15,79**
C	***Triticum dicoccum***	**chaff (GB=1)**	**1**	**1**	**0,07**	**5,26**
C	***Triticum* sp.**	**chaff (rachis fr.+SF+GB)**	**1**	**1**	**0,07**	**5,26**
C	***Papaver somniferum* (cf. incl.)**	**MNI**	**302**	**3203**	**220,66**	**94,74**
WER	***Chenopodium album***	**fragment**	**1**	**1**	**0,06**	**5,26**
WER	***Euphorbia helioscopia* subsp. *helioscopia***	**seed/fruit**	**1**	**1**	**0,08**	**5,26**
WER	***Hyoscyamus niger***	**seed/fruit**	**1**	**1**	**0,06**	**5,3**
WER	***Polygonum aviculare***	**seed/fruit**	**2**	**2**	**0,15**	**10,53**
WER	***Reseda phyteuma***	**Total CU**	**2**	**2**	**0,15**	**5,26**
WER	***Urtica dioica***	**seed/fruit**	**1**	**1**	**0,06**	**5,26**
WER	***Verbena officinalis***	**total CU**	**20**	**93**	**6,19**	**57,89**
PG	***Apium graveolens***	**Total CU**	**19**	**363**	**21,42**	**15,79**
PG	***Hypericum perforatum* (incl. cf.)**	**Total CU**	**1**	**1**	**0,08**	**5,26**
PG	***Petrorhagia prolifera***	**seed/fruit**	**1**	**1**	**0,13**	**5,26**
PG	***Thymelaea* sp.**	**fragment**	**1**	**1**	**0,08**	**5,26**
WO	***Cornus sanguinea***	**total CU**	**3**	**3**	**0,18**	**5,26**
WO	***Corylus avellana* (cf. incl.)**	**MNI**	**1**	**1**	**0,06**	**5,26**
WO	***Prunus* cf. *avium***	**bead fragment**	**1**	**1**	**0,06**	**5,26**
WO	***Quercus* sp. (incl. cf.)**	**Total CU**	**20**	**20**	**1,49**	**31,58**
WEC	***Origanum vulgare***	**seed/fruit**	**4**	**4**	**0,31**	**21,05**
WEC	***Physalis alkekengi***	**Total CU**	**3**	**47**	**2,94**	**5,26**
WEC	***Rubus fruticosus* agg.**	**Total CU**	**30**	**130**	**8,10**	**78,95**
LS	***Alisma plantago-aquatica***	**seed/fruit**	**68**	**983**	**63,39**	**42,11**
LS	***Apium nodiflorum* subsp. *nodiflorum***	**Total CU**	**3**	**3**	**0,29**	**10,53**
LS	***Cladium mariscus***	**Total CU**	**59**	**603**	**41,93**	**68,42**
LS	***Eupatorium cannabinum***	**Total CU**	**10**	**106**	**3,30**	**15,79**
LS	***Lycopus europaeus***	**Total CU**	**49**	**595**	**36,96**	**47,37**
LS	***Plantago major* subsp. *intermedia***	**seed/fruit**	**33**	**481**	**30,13**	**10,53**
LS	***Ranunculus sceleratus***	**Total CU**	**23**	**258**	**16,32**	**42,11**
LS	***Scirpus lacustris* (incl. cf.)**	**seed/fruit**	**24**	**379**	**24,04**	**10,53**
LS	***Typha* sp.**	**seed/fruit**	**2**	**2**	**0,12**	**10,53**
LS	***Vitis vinifera* subsp. *sylvestris***	**total CU**	**15**	**15**	**1,09**	**36,84**
WP	***Potamogeton* cf. *coloratus***	**seed/fruit**	**8**	**8**	**0,61**	**36,84**
WP	**Characeae**	**Oogonia with outer chalky layer**	**14**	**74**	**2,58**	**36,84**
WP	**Characeae**	**Oogonia without outer chalky layer**	**42**	**421**	**29,98**	**63,16**
DIV	***Cerastium* sp.**	**seed/fruit**	**5**	**5**	**0,36**	**15,79**
DIV	**Cyperaceae**	**seed/fruit**	**6**	**6**	**0,39**	**21,05**
DIV	***Cyperus* sp.**	**seed/fruit**	**8**	**148**	**8,67**	**10,53**
DIV	***Hypericum* sp.**	**fragment**	**1**	**1**	**0,06**	**5,26**
DIV	***Mentha* sp.**	**seed/fruit**	**9**	**42**	**3,12**	**26,32**
DIV	**Poaceae**	**total remains**	**2**	**2**	**0,14**	**10,53**
DIV	**Rosaceae**	**spine**	**1**	**1**	**0,05**	**5,26**
DIV	***Rubus* sp.**	**total CU**	**7**	**7**	**0,58**	**31,58**
DIV	**Solanaceae**	**fragment**	**9**	**125**	**7,87**	**10,53**
DIV	***Stellaria* sp.**	**seed/fruit**	**2**	**2**	**0,13**	**5,26**
DIV	**Umbelliferae**	**total CU**	**3**	**3**	**0,25**	**15,79**
DIV	***Viola* sp.**	**seed/fruit**	**2**	**2**	**0,17**	**10,53**
		Total nr. of items	**827**	**8156**	**535,35**	
		Nr. of taxa	**38**	**38**		

Fig. 4.123. Results of the analysis of the seed and fruit record in subfossil state from the systematic surface samples of level VIIa from sector D of La Draga: real number of items (rNR), estimated number of items (eNR), average concentration and percentage of ubiquity samples (CU: counted unit; for the abbreviations of ecological groups, see chapter 3.2.7).

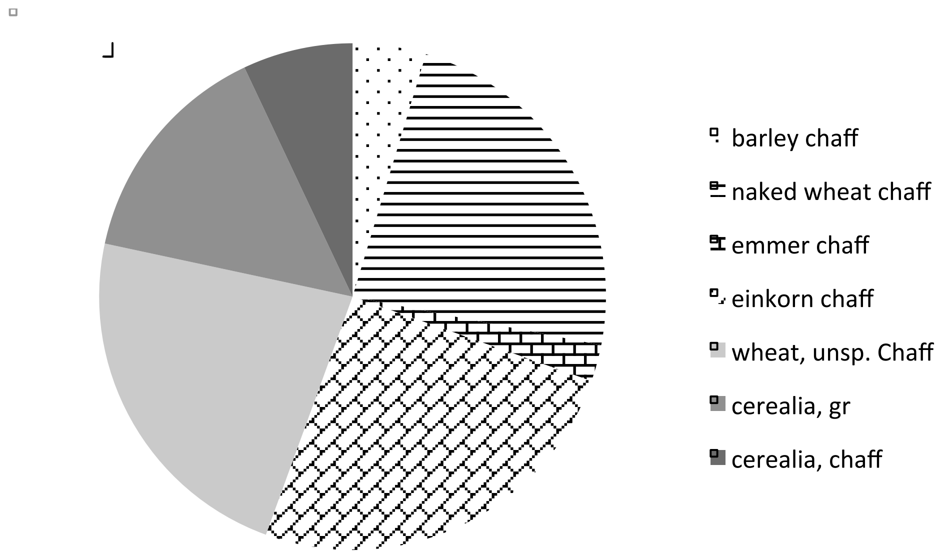

Fig. 4.124. Relative proportions among the cereal finds in waterlogged state of the systematic surface samples of level VIIb from sector D of La Draga.

The comparison between the results of both levels was carried out at a level and at a sample scale. First of all, at a level scale, the number of taxa (Fig. 4.125) and the number of items (Fig. 4.126) within each ecological group were compared independently. Then, at a sample scale, the number of items per ecological group was plotted per sample on the site plan (4.127).

Level VIIb yielded a larger number of taxa. This is evident in all ecological groups, but specially in the groups of weeds and ruderals, pastures and grasslands and lakeshore plants (Fig. 4.126). On the other hand, the relative proportions of the seed and fruit remains per ecological group between both levels present some relevant differences. Cultivars are much better represented in level VIIb (*c.* 30%) than in level VIIa (*c.* 5%). Weeds and ruderals are slightly better represented in level VIIa, as well as plants from woodland edges and clearings. Plants of woodland areas are badly represented in both levels. Finally, there is a sharp change from level VIIb to VIIa when looking at the local vegetation. Lakeshore plants are very sparse in level VIIb, where aquatic plants make the largest part of the seed and fruit record (over 50%). In level VIIa, lakeshore plants are more than 60%.

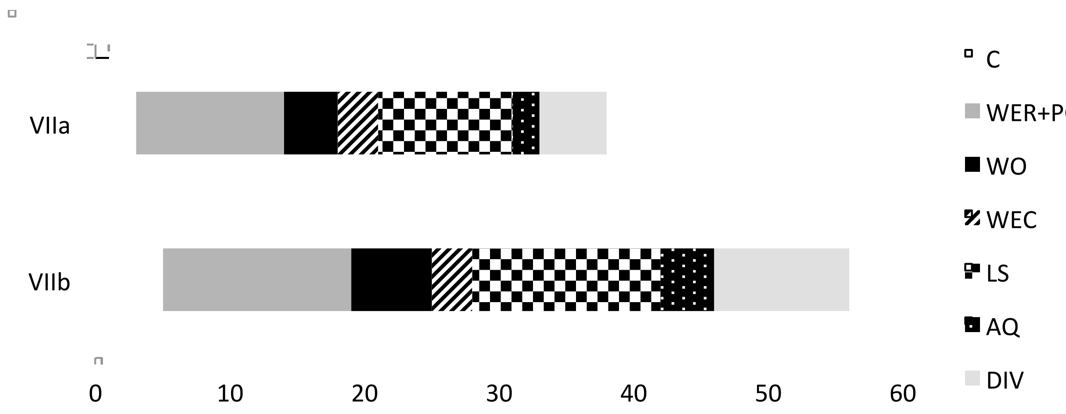

Fig. 4.125. Number of taxa per ecological group in levels VIIa and VIIb. Systematic soil samples from sector D of La Draga (for the abbreviations of ecological groups, see chapter 3.2.7).

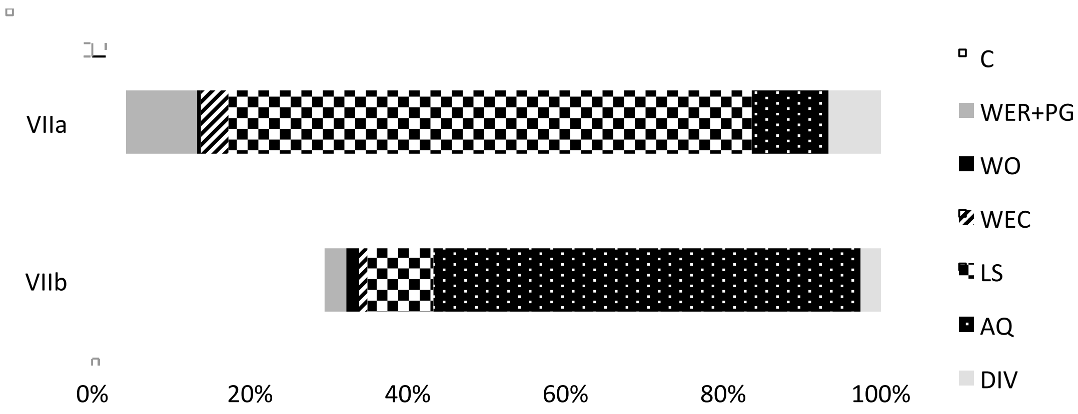

Fig. 4.126. Relative proportions among the estimated total number of items per ecological group in levels VIIa and VIIb. Systematic soil samples from sector D of La Draga (for the abbreviations of ecological groups, see chapter 3.2.7).

A **sample-by-sample** evaluation can be performed by plotting the results per ecological group on the site plan (Fig. 4.127). It was considered interesting to give different colours to cereals and poppy in order to see their representation at a sample level. In **level VIIb**, medium concentrations (100-1000 r/l) were mostly obtained (in 16 of the 21 samples). Only in samples KC80NE and JI78NE larger concentrations were found. Poppy seeds are dominant in most samples, especially at the northern half of the trench. In the south-western sector, large quantities of aquatic plants were recovered (also in other areas like in sample JJ81). Ten samples present 90% or more of cultivars. Only in three of them, cereals have a significant presence (15-30%). For the remaining samples, poppy is the dominant taxon. Some samples present particular concentrations of other ecological groups. In KA79 there are around 25% of seeds of weeds and ruderals/pastures and grasslands. This is due to a concentration of seeds of *Verbena officinalis* (43,46 r/l) in this sample. In KA78, a similar percentage of plants of woodland areas was recovered, due to the presence of a concentration of remains of *Quercus* sp. (71,43 r/l). Finally, in sample JH81, also around 25% of seeds of plants of woodland edges and clearings were identified. Here, a concentration of 79 r/l of *Rubus fruticosus* was found.

In level VIIa, a larger diversity of concentration of remains per litre in the samples is observed. Four samples out of 19 (=21%) presented less than 100 r/l. Poppy seeds are very well represented in most samples. In the western samples, lakeshore taxa are dominant, and aquatic taxa are only significant in some of the southern samples (and KB80). Only six samples present 90% of cultivars and all of them are mostly consisting of poppy seeds. No particular concentrations of weeds and ruderals, woodland or plants from woodland edges were observed.

After the presented results, one could proceed with a detailed taphonomic evaluation of both levels, considering the state of preservation of the surface of the remains and its degree of fragmentation. This was not performed because the presented data already indicate that the preservation was bad (low presence of fragile items like moss, fragments of testa of cereal grains, chaff remains, etc.).

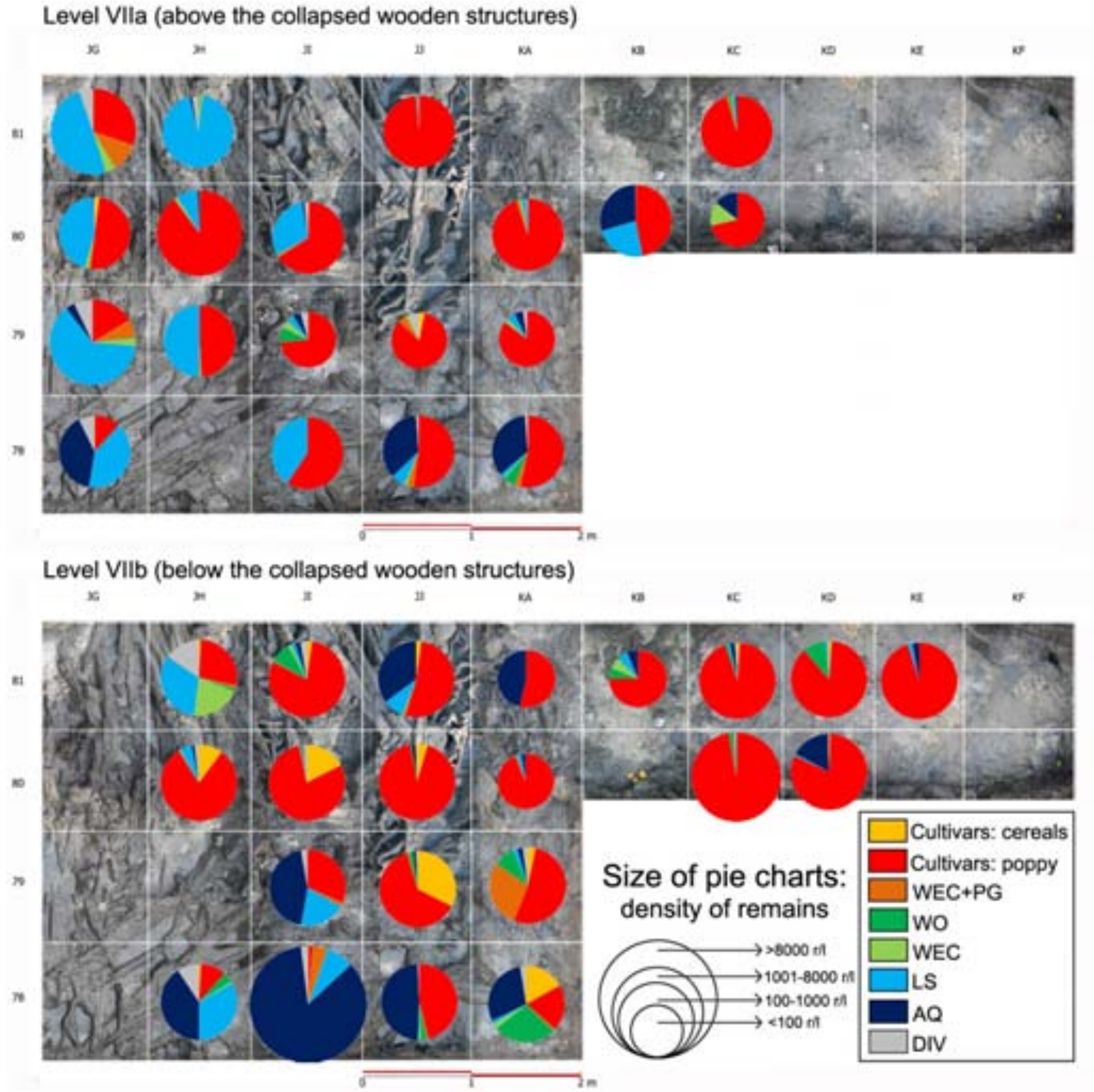

Fig. 4.127. Spatial representation (pie charts) of the results of the number of seeds and fruits in subfossil state obtained per ecological group in the systematic soil samples of sector D of La Draga.

4.7.6.2. Discussion

4.7.6.2.1. Was the sampling strategy adequate for a spatial evaluation? Did the samples yield the expected number of remains? What recommendations can be put forward for future fieldworks?

As already observed, the applied sampling strategy had several positive outcomes: it allowed a spatial approach to the non-seedy composition of the levels; it resulted on a large volume of data (rNR: 6063 seed and fruit remains) rather evenly distributed between both levels (VIIb and VIIa); it permitted the spatial representation of results concerning the charred and waterlogged seed and fruit record separately.

However, the strategy had some drawbacks. First of all, the volumes of the samples were too low. Even though 1 litre jars were used for sampling, these were only occasionally filled up by the archaeologists and rather smaller volumes were processed for some samples. This produced that some samples did not reach our target number not because they were poor in remains but because they were too small. In fact, nine samples from level VIIb and five from level VIIa would have yielded significantly better results if samples of 1 litre had been processed (Figs. 4.128 and 4.129). In the future, using large plastic bags of 2-3 litres might be more efficient in order to have samples of 1 litre or more. Besides, the concentration of items per litre of sediment was also rather variable. As a result, volumes of 1 litre would have been partly satisfactory for the samples from the western area of the excavation but not for many samples of the central and eastern areas. Taking these results into account, it was considered interesting to observe the composition of the samples which turned out to be less rich in remains, so that some guidelines could be presented to the field archaeologists for future works.

Square	Sample volume (l.)	Fraction	Fract. vol. (ml)	Analyz. vol.	rNR	eNR	eNR if vol = 1 l.
JH78NE	0,6	2	170	170	66	66	110
		0,35	110	10	50	400	667
JH80NE	0,84	2	620	620	1311	2073	2468
		0,35	200	11	55	762	907
JH81NE	1	2	80	80	13	13	13
		0,35	130	10	45	369	369
JI78SO	0,6	2	190	190	266	266	443,333333
		0,35	140	10	368	4983	8305
JI79NE	0,7	2	230	230	119	119	170
		0,35	75	10	30	167	239
JI80NE	1	2	140	140	3	3	3
		0,35	120	10	22	209	209
JI81NE	1	2	100	100	47	47	47
		0,35	75	10	42	192	192
JJ78NE	0,7	2	140	140	42	42	60
		0,35	120	10	15	147	210
JJ79NE	0,5	2	70	70	21	21	42
		0,35	51	10	29	133	266
JJ80NE	0,7	2	130	130	29	29	41
		0,35	130	12	24	172	246
JJ81NE	0,76	2	120	120	13	13	17
		0,35	130	13	45	360	474
KA78NE	0,7	2	230	230	155	155	221
		0,35	135	10	4	54	77
KA79NE	0,55	2	80	80	22	22	40
		0,35	80	10	15	78	142
KA80NE	0,8	2	110	110	16	16	20
		0,35	100	10	12	66	82,5
KA81NE	0,3	2	70	70	1	1	3
		0,35	30	15	7	13	43
KB81NE	0,6	2	110	110	16	16	27
KC80NE	0,62	2	90	90	30	30	48
		0,35	110	10	54	544	877
KC81NE	0,5	2	90	90	14	14	28
		0,35	110	10	14	94	188
KD80NE	0,74	2	150	150	219	219	296
		0,35	120	10	21	219	296
KD81NE	0,7	2	70	70	21	21	30
		0,35	80	10	24	157	224
KE81NE	0,9	2	80	80	24	24	27
		0,35	100	10	15	105	117

Fig. 4.128. Analysed systematic soil samples from level VIIb from sector D of La Draga: volume, analysed volume per fraction, real number of remains obtained (rNR), estimated number of remains (eNR) and eNR if a sample of 1 litre would have been taken (highlighted samples would have produced significantly more representative results).

Square	Sample volume (l.)	Fraction	Fract. vol. (ml)	Analyz. vol.	rNR	eNR	eNR if vol = 1 l.
JG78NE	0,7	2	100	100	2	2	3
		0,35	120	10	46	508	726
JG79NE	0,84	2	120	120	161	161	192
		0,35	170	11	125	1805	2149
JG80NE	0,9	2	550	550	1095	3265	3628
		0,35	110	13	41	313	348
JG81NE	0,9	2	130	130	120	120	133
		0,35	210	10	139	2819	3132
JH79NE	1	2	520	520	482	482	482
		0,35	150	11	25	229	229
JH80NE	0,5	2	85	85	260	260	520
		0,35	100	13	87	598	1196
JH81NE	0,5	2	60	60	13	13	26
		0,35	80	10	32	179	358
JI78NO	1	2	350	350	72	72	72
		0,35	260	13	7	102	102
JI79NE	0,82	2	60	60	26	26	32
		0,35	150	14	10	40	49
JI80NE	0,64	2	70	70	19	19	30
		0,35	95	10	41	288	450
JJ78NE	0,4	2	120	120	73	73	183
		0,35	90	11	23	95	238
JJ79NE	0,8	2	60	60	10	10	13
		0,35	65	10	22	66	83
JJ81NE	1	2	40	40	2	2	2
		0,35	90	10	35	275	275
KA78NE	0,66	2	100	100	141	141	214
		0,35	110	11	27	144	218
KA79NE	0,64	2	30	30	38	38	59
		0,35	70	10	11	41	64
KA80NE	0,7	2	80	80	4	4	6
		0,35	100	12	31	185	264
KB80NE	1,74	2	100	100	21	21	12
		0,35	130	10	35	443	255
KC80NE	0,6	0,35	15	15	7	7	12
KC81NE	0,64	2	70	70	20	20	31
		0,35	80	11	27	159	248

Fig. 4.129. Analysed systematic soil samples from level VIIa from sector D of La Draga: volume, analysed volume per fraction, real number of remains obtained (rNR), estimated number of remains (eNR) and eNR if a sample of 1 litre would have been taken (highlighted samples would have produced significantly more representative results).

A linear correlation (Pearson's correlation) between the concentration of seeds per litre of sediment in each sample and the percentage of organic content of the sample was conducted. The percentage of organic content was chosen as a variable because it is something which can be rapidly observed during fieldwork (presence of twigs, leafs, charcoal, etc.). A positive correlation would indicate that samples which present a more organic composition have a higher probability of yielding a higher concentration of seed and fruit remains. We obtained a correlation value of 0,46 for level VIIb and 0,52 for level VIIa, which should be interpreted as a strong positive correlation (being 1 a direct perfect correlation). Therefore, larger samples should always be taken when the soil matrix is not obviously rich in organic materials such as wood, bark or charcoal. On the other hand, organic sediments are more likely to yield good results with only 1 litre of sediment.

Despite the unsatisfactory results at a sample level, the sampling strategy applied allowed the obtention of representative results at a level scale for charred material (rNR VIIb: 1259; rNR VIIa: 2497) and waterlogged remains (rNR VIIb: 1438; rNR VIIa: 826). Therefore, a relatively reliable evaluation of the levels was possible. Five samples from level VIIb and nine from level VIIa were possible to include in the evaluation of the charred cereal remains and their taphonomy. Nevertheless, higher figures would have permitted more representative results. Concerning the waterlogged material, the numbers at a sample level were relatively low and very frequently depending on particular concentrations of a relatively low number of taxa. As a result, they were only evaluated considering the number of items per ecological group, only separating cereals and poppy within the cultivars group. Larger samples will probably be needed in order to get more representative results for large-seeded items such as acorns (rNR: 137 (wg) and 7 (ch) in level VIIb and 20 (wg) and 2(ch) in VIIa) or hazelnuts (rNR: 2 (wg), one in each level).

As a final remark, it would be interesting to analyse in the future all the available systematic samples in order to get a more complete insight into the distribution patterns of the material and facilitate the amalgamation of the samples into contexts, whenever possible.

4.7.6.2.2. Are VIIa and VIIb two different *layers*? Were all samples properly ascribed to each level? What activities could each level be representing? Are there independent spatial trends in both levels?

A number of evidences have been presented so far and they provide proofs that the differences in the composition of the samples taken from levels VIIa and VIIb are important and that they most likely bring out information on two aspects of the same settlement phase (layer VII).

First of all, the non-seedy components of the samples were evaluated. The non-local components of these samples include all those non-seedy plant macroremains, animal bones, fish remains, etc., which could have been brought to the site by humans. The percentage of organic component of both levels seemed similar but level VIIa had a much more significant charred component in its samples. This might suggest each layer had a different taphonomic origin. One could propose, at a hypothetical level, that this could be due to some incidental fire which could have affected some of the wooden structures. Nevertheless, this is not supported by the wood and charcoal analyses. Significant differences are observed among the composition of both records. It is, for this reason, more likely, that both records had different taphonomic origins. In both levels, the more highly organic samples were in the western and southern part of the trench. This continuity in the patterns of deposition could be interpreted as permanence in the settlement structure.

Secondly, the distribution of animal bones, dung and charred amorphous objects within the site plan also allowed the observation that fish scales were mostly preserved in level VIIb, while fish bones were better represented in VIIa. Burnt bone was mainly found in VIIa and dung remains only in VIIb. The scarcity of dung and fish scales in VIIa could be only due to preservation reasons (the preservation of this level could be worse). But it could also be respond to the fact that both levels were originated in a different way. Level VIIb could have formed below the dwelling spaces, as a gradual accumulation of various sorts of residues of human and animal activities. On the other hand, level VIIa might mostly contain what was on the aerial part of the dwellings. And one cannot discard the possibility that some postdepositional mixing between both levels took place.

Thirdly, insect remains were significantly more abundant in level VIIb. This might also respond to both preservation and other taphonomic issues.

Concerning aquatic organisms, it seems that they were more abundant in the samples from level VIIb. This correlates well with the hypothesis that the huts were built at a certain height above the lake chalk (Tarrús 2008). Further supporting evidence was obtained through the soil micromorphology analyses (Balbo & Antolín 2012): it was clear on the thin slides that the first setting of the site was made on water. Maybe also as a result of the water influence, lower percentages of inorganic components were observed in the samples (analysed in this work) from level VIIb. The larger percentages were found in level VIIa and they could be related to human activities (construction elements, craftworks, etc.).

The overall results of the seed and fruit analysis also pointed out divergences which lead to some of the already mentioned interpretations. These differences were primarily obvious when comparing the percentage of charred material in the record. This was 21% in level VIIb against 37% in level VIIa. Such results were more obvious when only looking at the 2 mm-fraction of the samples (Fig. 4.100 and 4.101). In level VIIb, five samples had around 75% or more of charred remains in this fraction. In level VIIa, 14 samples showed such results. These results support the interpretation of the different taphonomic origin of supphase VIIa and VIIb.

Finally, some clear differences between both levels were observed when comparing the number of identified taxa and the representation of the different ecological groups in both levels. Level VIIb yielded a larger number of taxa. The ecological groups which were better represented in this level were weeds and ruderals, plants from pastures and grasslands and lakeshore plants. It is difficult to tell whether these results were obtained because the preservation of level VIIb was better or because VIIb had a different taphonomic origin than VIIa. Both possibilities could also be take place at the same time. A good indicator for the better preservation of level VIIb is the fact that cereals were only significantly present in waterlogged state in this level. The high densities observed on Characeae seem to be in accordance with the hypothesis that this level formed inside water and this could have also favoured a better preservation of the organic remains. This situation changed in level VIIa, when lakeshore vegetation became much better represented. This might indicate more marshy conditions.

These general observations allow the identification of "outliers" within the samples obtained from each level. At least one outlier seems to be present in each level. In **level VIIb JH80** stands out for a variety of reasons: its high content in charcoal, the lack of insect remains or fish scales, its high proportion of charred seed and fruit remains in the two fractions (2 and 0,35 mm) and in the overall results of the sample, the presence of ear fragments of barley, and the lack of aquatic plants. This sum of characteristics makes us believe that this sample should be considered as coming from the base of level VIIa, rather than from VIIb. On the other hand, one sample from **level VIIa** also seems to present several characteristics from level VIIb. This is sample **JG78**. It presents a low percentage of charcoal and no charred grains and the composition of the waterlogged seed and fruit record is very similar to JH78 (in level VIIb), with important percentages of both lakeshore and aquatic plants. Consequently, both samples were re-ascribed to the levels to which they most likely belonged. This re-ascription of the samples could only be performed at this stage of the research when the main characteristics of both levels were known. Re-calculations of the results resulting from this change will only be carried out when they are considered of major need. In the rest of the cases, these changes only reinforce the observed trends for each level and any presentation of new percentages or densities would only result in a tedious repetition.

What can we say on the taphonomy of the levels in a spatial scale? Charcoal-rich samples and amorphous charred objects concentrate on the western side of the trench in both levels. In level VIIa, the major concentrations of charred cereal remains were also recovered in this area. This set of evidences could be interpreted as the result of an *in situ* burnt storage. In order to test this hypothesis, a taphonomic evaluation of the charred material is presented in chapter 4.7.5.2.4. Bone and fish remains, together with insect remains, seem to concentrate between lines JI and KA (the central area of the trench), together with more spare finds of grains. These might respond to accumulations of refuse from human consumption.

As a result, one might be able to put forward, at a hypothetical level, that we are dealing with part of a domestic space (more or less lines JG and JH) and an intervening space between huts were a variety of residues accumulated over the years (more or less lines JI to KA) can be found. The small area between KB and KF is more difficult to interpret under the available evidence. Unfortunately, the investigated area is too small and such proposals could only be confirmed with a more interdisciplinary approach

At the same time, in level VIIb, aquatic plants are better represented in the western area, while lakeshore plants have a similar role in level VIIa. The presence of these plants in this particular area might respond to three factors. The first one is that they could grow under the huts were less accumulation of rubbish took place (this possibility needs of a more interdisciplinary evaluation). The second factor would be just that this area was closer to the lakeshore. A similar patterning was observed after the analysis of the profile samples. The third one concerns the preservation conditions. It seems that level VII could become thicker towards the lakeshore. The lake marl seems to go higher in inland direction (R.Piqué, pers.com.), which would have an important effect on preservation conditions.

4.7.6.2.3. Re-evaluation of some general results after the re-ascription of two samples

The re-ascription of two samples (JG78 VIIa was moved to layer VIIb; JH80 VIIb was moved to layer VIIa) affected significantly the overall results of the seed and fruit analysis for both levels, for which they were re-calculated (Fig. 4.130).

	Nr. of samples	Total volume of sediment	rNR	eNR	Average density r/l	% ch	% wg
Level VIIa	19	15,12	4648	14588	934,84	46,46	53,54
Level VIIb	21	14,67	1415	10111	744,81	5,73	94,27

Fig. 4.130. Synthesized results of the seed and fruit analysis of the systematic surface samples from sector D of La Draga, amalgamated per level after the re-ascription of two samples. Proportion of charred and waterlogged remains.

As can be observed, the applied changes accentuate the differences of preservation type between both levels. Level VIIa is characterized by a mixed composition of charred and waterlogged remains that appear in a rather high density (close to 1000 r/l) and level VIIb presents a somewhat lower density (744,81 r/l) but mostly in waterlogged state. These results are more in accordance with the taphonomic observations performed above. There is one particular important implication in these changes. The charred record of level VIIb became too reduced to be considered representative and it cannot be compared to the results from level VIIa. Those samples with more than 35 crop remains will be evaluated on their own as far as possible. On the other hand, the waterlogged record of both levels can still be compared.

4.7.6.2.4. Charred assemblage: re-evaluation, taphonomy and spatial analysis

After the mentioned changes, the most important changes in the final overall results per level should be briefly presented before the discussion.

In **level VIIb**, the charred record became much reduced after changing the ascription of JH80 (from this point onwards I will refer to this sample as JH80 (VIIb)) (Fig. 4.131). Only four samples yielded more than 35 crop items and chaff remains were poorly represented, except in sample JI78. Naked wheat is still the best-represented taxon, followed by barley. The lower densities of remains probably indicate that these respond to the everyday discarding of residues of consumption or processing (following criteria established by other authors, e.g. van der Veen & Jones 2006). The charred seed of poppy does not appear together with cereal remains but on its own in sample JG78. For this reason, it should not be treated as a potential weed. All legumes were recovered in samples where cereal remains were found. They could be interpreted as potential weeds or as a potentially consumed product. The spatial distribution of the samples (Fig. 4.109) shows a rather clear pattern: the only concentrations were found in the central and eastern part of the trench. This distribution favours our hypothesis that lines JG and JH in the site plan were probably underneath the floor of a hut, where the layer formation processes had a different dynamic.

In **level VIIa**, the average density of charred cereal remains was very high, over 400 r/l. This can almost only respond to the accidental burning of a stored crop (see for instance van der Veen & Jones 2006)). As in level VIIb, naked wheat is the best-represented taxon. Grain is more abundant than chaff (*c*. 20% of chaff for naked wheat; *c*. 40% for barley (2-rowed type); *c*. 25% for emmer and *c*. 75% for einkorn). The re-ascription of sample JH80 into this level only reinforces the impression that two areas can be defined: the stored crop, on the western end and the smaller concentrations in the central area. The charred poppy seed was recovered in square JJ81, which is not a cereal-rich sample, as observed in level VIIb. All the samples which present a larger density of crop remains were weed-free. All charred potential weeds were found in other samples. The grain of cf. *Avena* sp. was recovered in the sample JH79, for which it could belong to the stored crop (as a weed). Most of the wild legumes were found in line JI of the site plan. Thus, they were not directly related to the stored crop. Two other wild taxa with good edibility potential were found in charred state: *Quercus* sp. and *Vitis vinifera* subsp. *sylvestris.* They were recovered in the central area of the trench (squares JJ79 and KA79). They probably respond to some cleaning of residues of consumption from a nearby dwelling.

It is very important to determine whether these assemblages were originated by the same sort of activities, whether they were exposed to a similar heating treatment and if they present signs of postdepositional displacement (are they in the place where they were discarded?).

Taxa	Represented part	Total VIIb			
		rNR	eNR	Aver. concentr.	% Ubiq.
Hordeum vulgare **(cf. incl.)**	**grain (MNI)**	33	33	2,4	19,0
Hordeum **sp. (cf. incl.)**	**grain**	7	7	0,5	19,0
Triticum aestivum/durum/ turgidum **(incl. aest. and turg.)**	**grain (MNI)**	343	343	23,1	57,1
Triticum aestivum/durum/ turgidum **(incl. aest. and turg.)**	**chaff (node=1)**	16	55	4,3	33,3
Triticum durum/turgidum type	chaff (node=1)	5	44	3,5	9,5
Triticum **(cf.)** ***dicoccum***	**grain (MNI)**	8	8	0,5	14,3
Triticum **(cf.)** ***monococcum*** **(incl. 2-grain)**	**grain (MNI)**	1	1	0,1	4,8
Triticum **(cf.)** ***monococcum*** **(incl. 2-grain)**	**chaff (GB=1)**	4	4	0,3	14,3
Triticum **sp. unspecified**	**grain**	51	51	3,4	61,9
Triticum **sp. unspecified**	**chaff**	1	1	0,1	4,8
Cerealia, undiff.	**grain**	53	53	3,5	33,3
Cerealia, undiff.	**chaff**	1	1	0,1	4,8
Cerealia, undiff.	**straw (straw + straw node)**	4	4	0,3	14,3
Papaver somniferum	**MNI**	1	1	0,1	4,8
Quercus **sp. (incl. cf.)**	**Total CU**	7	7	0,5	19,0
Vicia sepium	**seed/fruit**	1	1	0,1	4,8
Papilionaceae	**seed/fruit**	4	4	0,3	9,5
Poaceae	**total remains**	1	1	0,1	4,8
Vicia/Pisum	**seed/fruit**	1	1	0,1	4,8
	Total nr. of items	537	576	43,3	
	Nr. of taxa	7	7		

Fig.4.131. Results of the analysis of the seed and fruit record in charred state from the systematic surface samples of level VIIb from sector D of La Draga, without sample JH80 and including JG78.

Taxa	Represented part	TOTAL VIIa			
		rNR	eNR	Aver. concentr.	% Ubiq.
Hordeum distichum	**ear fragment (node=1)**	43	43	2,7	15,8
Hordeum distichum	**chaff (node=1)**	72	295	18,1	21,1
Hordeum vulgare **(cf. incl.)**	**grain (MNI)**	425	431	27,5	57,9
Hordeum **sp. (cf. incl.)**	**grain**	35	35	2,4	31,6
Hordeum **sp. (cf. incl.)**	**chaff (node=1)**	2	2	0,1	10,5
Triticum aestivum/durum/ turgidum **(incl. aest. and turg.)**	**grain (MNI)**	1306	3774	235,7	89,5
Triticum aestivum/ durum/turgidum **(incl. aest. and turg.)**	**chaff (node=1)**	352	756	49,2	42,1
Triticum durum/turgidum type	**chaff (node=1)**	283	490	32,3	36,8
Triticum aestivum type	**chaff (node=1)**	2	2	0,1	10,5
Triticum **(cf.)** ***dicoccum***	**grain (MNI)**	76	205	12,8	42,1
Triticum **(cf.)** ***dicoccum***	**chaff (GB=1)**	24	76	4,7	21,1
Triticum **(cf.)** ***monococcum*** **(incl. 2-grain)**	**grain (MNI)**	25	32	2,0	26,3
Triticum **(cf.)** ***monococcum*** **(incl. 2-grain)**	**chaff (GB=1)**	34	103	6,6	31,6
Triticum **sp. unspecified**	**grain**	396	548	35,0	68,4
Triticum **sp. unspecified**	**chaff**	34	68	5,9	21,1
Cerealia, undiff.	**grain**	290	304	18,1	63,2
Cerealia, undiff.	**straw**	86	86	5,1	15,8
Papaver somniferum	**MNI**	1	1	0,1	5,3
cf. ***Avena*** **sp.**	**seed/fruit**	1	1	0,1	5,3
Quercus **sp. (incl. cf.)**	**Total CU**	2	2	0,1	10,5
Alnus glutinosa	**total remains**	3	3	0,2	10,5
Vitis vinifera **subsp.** ***sylvestris***	**total CU**	1	1	0,1	5,3
Papilionaceae	**seed/fruit**	7	7	0,6	31,6
Poaceae	**total remains**	1	1	0,1	5,3
Rubus **sp.**	**total CU**	1	1	0,1	5,3
Vicia **sp.**	**seed/fruit**	1	1	0,1	5,3
	Total nr. of items	3218	6778	427,4	
	N. Taxa	12	12		

Fig.4.132. Results of the analysis of the seed and fruit record in charred state from the systematic surface samples of level VIIb from sector D of La Draga, without sample JH80 and including JG78.

Concerning the first issue, two elements were considered for the **pre-depositional** characterization of the samples: the stage of processing of the crop samples (following Jones 1987 and Valamoti 2004) and the presence of evidences of processing activities on the grains themselves. In order to characterize the **stage of processing** of each sample, first of all, samples from pure crops (*sensu* Bogaard 2004, 64) were identified. In our case, all samples were pure crops except one, JH80 (VIIb), which showed a relatively high percentage of glume wheats (Fig. 4.109). The scarcity of charred weeds in the record is evident (Fig. 4.133): many samples did not contain any weed seeds at all, while others presented a very low density (a maximum of 15,2 per 1000 grains). Thus, the stage of processing had to be evaluated mainly considering the proportion of chaff to grain. This was performed per sample and taxon (Fig. 4.134). **Barley** seemed to appear in **ear form** in samples JG80 and JH80 (VIIb), while clean grain was recovered in JH79. Ear fragments of barley were recovered in JG80 and JH80, for which it is very likely that it was originally in ear form in the three samples. **Naked wheat** was mainly found as **clean grain** in all samples except in the two samples of square JH80 and in JI78 (level VIIb), where the proportion of chaff was very high, even too high for a crop in ear form in JH80 (VIIb) and JI78. **Glume wheats** were mostly found in **spikelet form**, except in JG80, where the amount of chaff seemed to be somewhat lower.

		Nr. of weeds per 1000 grains
VIIa	JG79	7,4
VIIa	JG80	0,0
VIIa	JG81	0,0
VIIa	JH79	2,5
VIIa	JH80	0,0
VIIa	JI78	0,0
VIIa	JJ78	15,2
VIIa	KA78	7,6
VIIa	KA79	0,0
VIIa (VIIb)	JH80	0,0
VIIb	JI78	14,1
VIIb	JI79	0,0
VIIb	JJ78	0,0
VIIb	KD80	0,0

Fig. 4.133. Number of charred weeds per 1000 grains in the analysed systematic surface samples from sector D of La Draga.

		Hulled barley, GR	Hulled barley, CH	Naked wheat, GR	Naked wheat, CH	Glume wheat, GR	Glume wheat, CH	BARLEY	NAKED WHEAT	GLUME WHEAT
VIIa	**JG79**	0	0	100	0	0	0		clean grain	
VIIa	**JG80**	65,9	34,1	92,3	7,7	83,5	16,5	ears	clean grain	clean grain
VIIa	**JG81**	0	0	100	0	0	0		clean grain	
VIIa	**JH79**	100	0	94,1	5,9	53,3	46,7	grain	clean grain	spikelets
VIIa	**JH80 (VIIb)**	47,1	52,9	59,2	40,8	51,6	48,4	ears	ears?added chaff?	spikelets
VIIa	**JH80**	0	0	65,3	34,7	0	0		ears?	
VIIa	**JI78**	0	0	83,3	16,7	0	0		clean grain	
VIIa	**JJ78**	0	0	95,9	4,1	0	0		clean grain	
VIIa	**KA78**	0	0	99,2	0,8	0	0		clean grain	
VIIb	**JI78**	0	0	57,1	42,9	0	0		ears? added chaff?	
VIIb	**JI79**	0	0	97,6	2,4	0	0		grain	
VIIb	**JJ78**	0	0	93,3	6, 7	0	0		grain	
VIIb	**KD80**	0	0	100	0	0	0		grain	

Fig. 4.134. Relative proportion of charred chaff and grain per taxon and sample and corresponding state of the crop in the analysed systematic surface samples from sector D of La Draga.

If the ratios rachis:grain and weed:grain are calculated for naked wheat and 2-rowed barley, one should be able to classify the stage of processing of all samples by comparison with ethnographic references (following Jones 1986, Valamoti 2004). This proved to have successful results for all the samples which were classified as clean grain but not for those which presented high quantities of chaff, since the almost lacking weeds do not match the results (Fig. 4.135). The same feature was observed when conducting a ternary analysis on the samples from level VIIa (Fig. 4.136) and VIIb (not shown). In these cases, the chaff-rich samples do not show comparable results to any of the ethnographic references. It is very likely that they respond to some **mixing of chaff with clean grain** (for further discussion see chapter 4.7.8.3.1).

		naked wheat		2-rowed barley	
		rachis:grain	weed:grain	rachis:grain	
VIIa	JG79	0	0,0		clean product
VIIa	JG80	0,1	0	0,5	clean product (wheat), fine-sieving by-product lacking weeds ? (barley)
VIIa	JG81	0	0		clean product
VIIa	JH79	0,1	0,0	0	clean product
VIIa	JH80 (VIIb)	0,7	0	1,0	fine-sieving by-product lacking weeds?
VIIa	JH80	0,5	0	0,1	fine-sieving by-product lacking weeds?
VIIa	JI78	0,2	0	not enough	fine-sieving by-product lacking weeds?
VIIa	JJ78	0,04	0,02	not enough	clean product
VIIa	KA78	0,01	0,01	not enough	clean product
VIIa	KA79	0	0	not enough	clean product
VIIb	JI78	0,75	0,02		fine-sieving by-product with few weeds?
VIIb	JI79	0,03	0		clean product
VIIb	JJ78	0,07	0		clean product
VIIb	KD80	0	0		clean product

Fig. 4.135. Calculation of the ratios chaff:grain and weed:grain for the analysed systematic surface samples from sector D of La Draga.

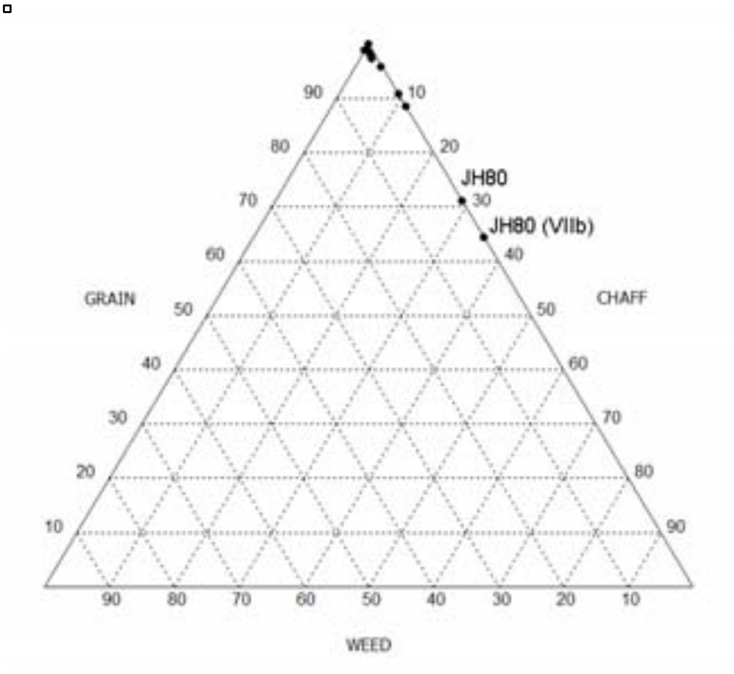

Fig. 4.136. Ternary plot showing the relative proportions of charred grain, chaff and weeds of the systematic surface samples of level VIIa from sector D of La Draga.

When looking at these data with a spatial sense (Fig. 4.9., note that sample JH80 of level VIIb was re-ascribed to layer VIIb), which is the target of this analysis at the moment, one can see a majority of samples dominated by clean naked wheat, with a large concentration of chaff in JH80 (and an important presence in JI78 of level VIIb). In squares JG80 and JH80, naked wheat is mixed with unthreshed barley in ear form, and only in JH79 it is mixed with barley grain. Only one sample, JH80 (VIIb) showed high percentages of glume wheats. Glume wheats also appeared mostly in spikelet form. As a result, there is a clear difference in the composition of the samples from the western area, not only because they are richer in chaff remains but also because they are mixed with other crops. At the same time each sample seems to have some particularities and it might be worth to treat them as independent contexts. Only the two samples from JH80 seem to show a very similar composition. The remaining samples, except JI78 (level VIIb) merely contain naked wheat grain.

Regarding the identification of **evidences of processing on the grains**, it must be noted that two samples from level VIIb presented evidences of cracked and cut/peeled grains (JI79), on the one hand, and fragments produced prior to charring, on the other hand (KD80). These results indicate that some mechanical activity (either during the processing to free the grain from the chaff or during the culinary processing of the grain) took place and produced these effects on the grain. Both samples consisted of clean grain, for which this fragmentation could have originated during threshing. More quantitatively significant were the results from level VIIa. Here the amount of fragments of grain produced prior to charring was larger, especially in samples JG80 (4,5% of fragments) and JH80 VIIa(b) (3,3%). Several other samples showed equally high figures, such as JG81 (4,5%) and KA78 (4,12%). The rest of the samples, JH80 VIIa, JG79 and JH79 had less than 2% of fragments. These results are high enough to be considered as significant and as having been originated during grain processing. This would support the interpretation that, despite presenting high quantities of chaff, these samples belong to a **storage of clean grain**.

In JG80 one of the grain fragments was identified as einkorn, for which some dehusking activity should not be discarded for this taxon. It could have been processed together with naked wheat, as a contaminant.

At a spatial level, it is interesting to note that the vast majority of grain fragments are found within the largest concentration of grain and only very few fragments were present in the central area of the excavation (JI80 and KA78). Such differences contribute to former interpretations which oppose the stored grain and the discarded residues of everyday consumption.

The analysis of the **depositional processes shows** that all samples present a very similar charring history (Fig. 4.137). This was around 300 and 350°C and it took place with a low heating rate. They were probably within the limit for the preservation of remains of straw and chaff (*c*. 300ºC) (Boardman & Jones 1990).

		Popped seeds	Protrusions	Aggregates	Concave flanks	Heating treatment
VIIa	**JG80**	<20%	<50%	<5%	<15%	300-350 LHR
VIIa	**JH80**	<10%	<30%	<10%	<10%	300-350 LHR
VIIa(b)	**JH80**	<10%	<30%	<5%	<15%	300-350 LHR
VIIb	**JI79**	<10%	<30%		<10%	300-350 LHR
VIIb	**KD80**	<10%	<30%	<5%	<10%	300-350 LHR

Fig. 4.137. Hypothetical charring history of the charred grain from the systematic surface samples from sector D of La Draga (LHR: low heating rate).

The overall results of the analysis of the effects of the **post-depositional processes** on the grains are summarized in Fig. 4.138. Only samples JG80, JH80 and JH80 (VIIb) from level VIIa and JI79 and KD80 from level VIIb were interpreted as being *in situ*. Given that the fragmentation was very low in all samples (also thanks to the appropriate excavation of these samples by the archaeologists), the degree of erosion of the surface of the grains and the density of grains per litre of sediment were considered the more reliable variables for the identification of *in situ* samples. These results have two main implications which contribute to the spatial evaluation of the levels. On the one hand, the samples from level VIIa would indicate that they belong to an ***in situ* burnt storage** of a variety of crops. The identification of other concentrations of charred grain to the west of this finding (JE78) in more recent fieldworks would support this hypothesis.These crops include clean naked wheat, and barley and glume wheats in ear or spikelet form (respectively) and chaff remains of naked wheat. On the other hand, the *in situ* samples from level VIIb only contain charred grain (mainly). These samples could have a completely different origin (by-product of grain cooking). Finally, the chaff-rich sample from level VIIb, JI78, is very likely to respond to a mixture of different residues of crop processing.

		fragmentation	complementarity	% irregular fragm	erosion	adherence of the embryo	density	IN SITU
VIIa	**JG79**	low		98,6	high	medium	medium	no
VIIa	**JG80**	low	medium	84	low	medium	high	yes
VIIa	**JG81**	low			medium	medium	low	cf.no
VIIa	**JH79**	low		98,7	medium	medium	medium	cf.no
VIIa	**JH80**	low		98	low	most	medium	yes
VIIa(b)	**JH80**	low		100	low	most	high	yes
VIIa	**JI78**	low			medium	medium	low	cf.no
VIIa	**JJ78**	low			medium	medium	medium	cf.no
VIIa	**KA78**	low		89	high	medium	medium	no
VIIa	**KA79**	low			high		low	no
VIIb	**JI78**	low			medium	medium	medium	cf.no
VIIb	**JI79**	low			low	medium	medium	yes
VIIb	**JJ78**	low			high		low	no
VIIb	**KD80**	low			low	most	medium	yes

Fig. 4.138. Synthesis of the effects of post-depositional agents observed on the charred grains of the systematic surface samples from sector D of La Draga and final interpretation.

4.7.6.2.5. Waterlogged assemblage: evaluation and spatial analysis

The results of the waterlogged record were also slightly modified after the re-ascription of two samples. But the final changes are small (for the overall results before the re-ascription of samples see chapter 4.7.6.1.7). Concerning the botanical diversity, level VIIa only added one more taxon, the water plant *Najas marina.* The densities of remains for the main taxa did not change significantly (see Fig. III.18).

The obtained results cannot be considered as economically representative due to their scarcity. Despite this, they are of major interest due to the fact that this is the only Neolithic lakeshore site from the Iberian Peninsula and because, even when being meagre, they can contribute to the spatial evaluation of distribution of seed and fruit remains within the site.

In layer VIIb, cereal chaff, seeds of opium poppy, pericarps of acorns and some plants of lakeshore (*Cladium mariscus*) and aquatic ecology (Characeae) were found in larger concentrations and frequencies.

In layer VIIa, opium poppy was found with higher average frequencies (see the spatial representation in Fig. 4.127, note that JG78 VIIa was moved to layer VIIb and JH80 VIIb was moved to layer VIIa), together with *Rubus fruticosus*, *Alisma plantago-aquatica* and *Cladium mariscus*. These differences, at a layer scale, seem to indicate that the preservation of layer VIIb was significantly better than that of level VIIa and, at the same time, that some environmental changes could have happened in the excavated area. Concerning the latter, the increase in the concentration of seeds and fruit remains of lakeshore plants and the decrease in the presence of water plants in level VIIa is very clear (Fig. 4.139). Such a change cannot only be due to taphonomic problems but to a real change in the local vegetation. It seems, thus, that a progressive process of sedimentation took place in the area. This could have made this area less permanently flooded than in previous times, when the settlement was established.

	VIIb	VIIa
LS	69	202
AQ	402	18

Fig. 4.139. Average densities of remains per litre of lakeshore plants (LS) and aquatic plants AQ in the systematic surface samples of levels VIIb and VIIa from sector D of La Draga.

As already observed, the distribution of aquatic and lakeshore plants seems to concentrate in the western area of the excavated trench, the area which is closest to the lake at present times. This could indicate that the influence of the lake was not permanent in all the excavated area, which could be due to the topography of the lakeshore. It is interesting to note that cereal chaff is found in the central area of the trench. The distribution of chaff remains, as well as the larger concentrations of potential residues of wild fruit consumption (e.g. pericarps of acorns) in level VIIb presents a very interesting contrast with the distribution of the concentrations of charred cereal remains. Such distribution could indicate areas of waste disposal or plant processing *versus* areas of crop storage. This interpretation coincides with the conclusions obtained in chapter 4.7.5.2.2.

4.7.7. The bulk surface samples from sector D and sector B

The purpose of the analysis of large bulk samples from sectors B and D was to get a rough overview on the composition of different layers other than layer VII in sector D and to increase the number of taxa identified in the systematic and profile samples. Besides, some data were obtained for the comparison between sectors B and D (see the location in Fig. 3.9), which could help into the discussion of the homogeneity of the cultural layer VII, the pile-dwelling phase. Sector B lies to the north of sector D and it was excavated between 1997 and 2004 (for further data see chapter 3.1.7).

4.7.7.1. Materials and methods

The results obtained from the study of the water-screened bulk surface samples from La Draga were presented elsewhere (Antolín, Buxó & Jacomet in press). In this chapter I will also include the analysed samples from sector B, which were obtained from the pile-dwelling phase of occupation between 1997 and 2004 (the spatial location of all the samples is presented in Fig. 4.58 and 4.59).

The bulk surface samples from layers II to IV from the 2010 campaign in sector D mainly consisted of samples of 10 litres of sediment taken per square. The ones from layer VII were usually much larger (sometimes 100% of the sediment was processed), since the presence of large waterlogged seeds and fruits was more significant. These samples were water-screened in the field and sorted by myself directly from the sieve when still wet. Despite the fact that this process was carried out with the maximum accuracy possible under the given circumstances, the goal of this sampling was not the total recovery of the seed and fruit remains from the remaining fraction (a mesh of 2 mm size was used) but to record large-seeded taxa and most of the plant remains in order to get a first overview on the richness and the composition of each layer. For this reason only a rough quantification of the obtained data was carried out. The results obtained from the analysis of bulk samples from layer VII in sector D are preliminary, since there are more samples to be sorted from the same squares. Unlike with the rest of the layers, some of these samples were sorted after sieving, in the laboratory. The presented results, thus, are only partial and they are purely meant to discuss the reasons for the continuation or abandonment of their analysis.

The samples from sector B, on the other hand, were recovered by the archaeologists (under the instructions of R. Buxó), and treated with a flotation machine or by water-screening. Sieves of 4, 2 and 0,5 mm of mesh size were used in all cases. Some of the samples, like sample JH84-85, were dried after processing them. The rest were mostly kept in wet conditions, but without temperature or light control, for which some of them had grown fungi. Except for sample JH84-85, which was analysed in 2010 and the obtained results were already published (Antolín & Buxó 2011c), the 0,5 mm fraction was systematically subsampled using the grid method, analyzing 20 ml per fraction (Fig. 4.140). The recovered items were fully quantified.

Square	Vol. of the sample (l.)	Fraction	Vol. (ml)	Vol. of the subsample
JI90	6	0,5 F	110	20
		2 F	350	100
		4 F	525	
KB90	10	0,5 F	100	10
		2 F	162	
		4 F	700	
KC87	10	0,5 F	180	20
		2 F	170	
		4 F	150	
KC88	6	0,5 F	75	20
		2 F	250	
		4 F	550	
KC90	8	0,5 F	160	20
		2 F	550	
		4 F	650	
KC91	6	0,5 F	145	20
		2 F	180	
		4 F	250	
JH 84-85	15	0,5 F		5%
		1 C		5%
		1 F		5%
		2 F		5%

Fig. 4.140. Subsampling of the different fractions of the bulk samples from Sector B of La Draga.

The results of the samples from layer VII of sector D and the samples from sector B will be presented and discussed together, since they are considered as belonging to the same settlement phase.

4.7.7.2. Results

Layer VII: sector D

A large number of seed and fruit remains were recovered from the bulk samples from the 2mm-fraction of several squares of sector D, especially JH80, JI80, JI81, KC81, KD80 and KD81. Particularly noteworthy is the fact that three of these samples are from the eastern and less well-known sector of the excavation due to the poor results of the systematic samples taken in this area. The obtained results are presented in Fig. 4.141.

Most of the recovered remains were preserved in charred state (between c.75-98%) (Fig. 4.142). Likewise, most of these remains belong to cultivars and the proportion of other ecological groups is rather parallel to the percentages of waterlogged remains (Fig. 4.143).

Concerning the cereal remains, exclusively preserved in charred state, the obtained results show a rather similar composition than that of the systematic samples (Fig. 4.144). The major component is naked wheat grain. Naked wheat chaff is only found in significant proportions in JH80 and JI80. Both barley and glume wheats are present in most of the samples, but always in a low proportion. Of particular significance is the finding of two spikelet forks, which seem to belong to the so-called new glume wheat (squares JH80 and JI80). Ear fragments of barley and naked wheat (Fig. 4.145) were found in JH80 and JI80, respectively. The ear is of type A1 (following the typology of Maier, 1996), that is to say, with two-grained spikelets which are at *c.*45º with respect to the rachis.

Other cereal remains of huge interest were also recovered, such as several aggregates of fragments of grain produced prior to charring, found in KD81. Besides, several fragments of straw were found in this sample and in JI80.

Another element of high interest is a fragment of capsule lid of opium poppy, which was recovered in square JH80 in charred state (Fig. 4.145).

The remains of wild plants were both preserved in charred and in waterlogged state. Seven taxa were preserved in charred state, mostly legumes (n=70; *Lathyrus aphaca* type, *Vicia villosa* and other unspecified legumes, which could or not have been cultivated). Besides, *Quercus* (n=4), *Vitis* (n=2), *Rubus* (n=1), cf. *Bromus* sp. (n=1) and *Alnus* (n=1) were also identified in charred state. Most of the charred remains of wild plants were recovered in JI80 or in the eastern sector of the trench. Only *Bromus* was identified in JH80.

As a final remark for the charred record, 24 amorphous charred objectes which could be bread, fruit flesh or tubers were also recovered in squares JH80 and JI80 and are in the process of being identified (M. Berihuete, in progress, Hohenheim University).

				Bulk samples from layer VII: sector D										
			Square	**JH78**	**KB80**	**JH80**	**JH80**	**JI80**	**JI80**	**JI81**	**KB81**	**KC81**	**KD80**	**KD81**
Ecol. group	**Taxa**	**Represented part**	**Preserv. type**	**rNr**	**rNr**	**rNr**	**rNr**	**rNr**	**rNr**	**rNr**	**rNr**	**rNr**	**rNr**	**rNr**
C	*Hordeum distichum*	chaff (node=1)	ch				15							1
C	*Hordeum distichum*	ear fragment	ch				10							
C	*Hordeum vulgare* (cf. incl.)	grain (MNI)	ch	26	2		83		25	5		10	1	2
C	*Hordeum* sp. (cf. incl.)	grain	ch				12							3
C	*Hordeum* sp. (cf. incl.)	chaff	ch				2							
C	*Triticum aest./dur./turg.*	grain (MNI)	ch	106	25		1033	1	261	283	6	112	346	432
C	*Triticum aest./dur./turg.*	chaff (node=1)	ch				208		28	1				8
C	*Triticum aestivum* type	chaff (node=1)	ch				1							2
C	*Triticum dur./turg.* type	ear fragment	ch						3					
C	*Triticum dur./turg.* type	chaff (node=1)	ch				207		50					3
C	*Triticum* (cf.) *dicoccum*	grain (MNI)	ch	3	1		5		12	5		1	2	1
C	*Triticum* (cf.) *dicoccum*	glume base (GB=1)	ch				10		2					2
C	*Triticum* (cf.) *monococcum*	grain (MNI)	ch				15		6	3				
C	*Triticum* (cf.) *monococcum*	glume base (GB=1)	ch				18		6					2
C	Glume wheat, undiff.	chaff	ch				2		2					
C	*Triticum* sp. undiff.	grain	ch	3			26		16					33
C	*Triticum* sp. undiff.	chaff	ch				10							
C	Cerealia, undiff.	grain	ch	2					5					156
C	Cerealia/Poaceae, undiff.	straw	ch						2					2
C	*Papaver somniferum*	capsule fragment	ch				1							
C	*Papaver somniferum*	total CU	ch				2							
WER	*Carthamus* cf. *lanatus*	total CU	wg				1							
WER	*Lathyrus aphaca* type	seed/fruit	ch						1			3		
WO	*Cornus sanguinea*	total CU	wg							1		3		1
WO	*Corylus avellana* (cf. incl.)	total CU	wg					1		12				
WO	*Euphorbia amygdaloides*	total CU	wg						3	6				
WO	*Prunus avium* (incl. cf.)	bead	wg					2		2				
WO	*Pyrus malus* subsp. *sylvestris*	seed/fruit	wg	1										
WO	*Quercus* sp. (incl. cf.)	base	wg		1		1	2	4	14	1	8	7	6
WO	*Quercus* sp. (incl. cf.)	pericarp	wg	1	2	1	1	5	3	11		25	4	4
WO	*Quercus* sp. (incl. cf.)	cupule	wg							1	1	1		1
WO	*Quercus* sp. (incl. cf.)	base	ch									1		
WO	*Quercus* sp. (incl. cf.)	cupule	ch							1		1		1
WO	*Taxus baccata*	seed/fruit	wg	1										
WEC	*Agrimonia eupatoria*	fruit	wg						1					
WEC	*Prunus spinosa*	fruit stone	wg					1	1					
WEC	*Rubus fruticosus* agg.	total CU	wg	4			6		13	3		2		5
WEC	*Rubus fruticosus* agg.	seed/fruit	ch									1		
WEC	*Vicia villosa* type	seed/fruit	ch							3				
LS	*Alnus glutinosa*	fruit	ch											1
LS	*Cladium mariscus*	total CU	wg				6		4	1				
LS	*Vitis vinifera subsp. sylvestris*	total CU	wg				4		3	6		3		3
LS	*Vitis vinifera* subsp. *sylvestris*	seed/fruit	ch								1	1		
AQ	*Iris pseudacorus*	fragment	wg	1				1						
AQ	*Najas marina*	seed/fruit	wg						1					
DIV	Amorphous object (bread?)	fragment	ch				20	4						
DIV	cf. *Bromus* sp.	seed/fruit	ch				1							
DIV	*Crataegus* sp.	seed/fruit	wg	1										
DIV	*Euphorbia* sp.	seed/fruit	wg										1	
DIV	*Lathyrus* sp.	seed/fruit	ch										2	
DIV	Papilionaceae	total CU	ch									9	1	13
DIV	*Poaceae*	straw fragment	wg						2					
DIV	*Prunus* sp.	fruit stone fragment	wg							1			1	
DIV	*Ranunculus* sp.	seed/fruit	wg						1					
DIV	*Rubus* sp.	total CU	wg				16							
DIV	*Vicia* sp. (small)	seed/fruit	ch									1		
DIV	*Vicia/Pisum*	seed/fruit	ch							1				
DIV	Vicieae	seed/fruit	ch							33	3			
DIV	*Viola* sp.	seed/fruit	wg											1
			Total	**149**	**31**	**1**	**1532**	**17**	**411**	**397**	**12**	**182**	**367**	**679**
			Sample vol. (l.)	**35**	**20**	**30**	**5**	**155**	**12**	**120**	**22**	**80**	**30**	**100**
			Nr. taxa	**9**	**4**	**1**	**12**	**6**	**14**	**13**	**3**	**9**	**7**	**12**

Fig. 4.141. Results of the analysis of the bulk samples (2 mm fraction) from layer VII in sector D of La Draga (CU: counted unit; for the abbreviations of ecological groups, see chapter 3.2.7).

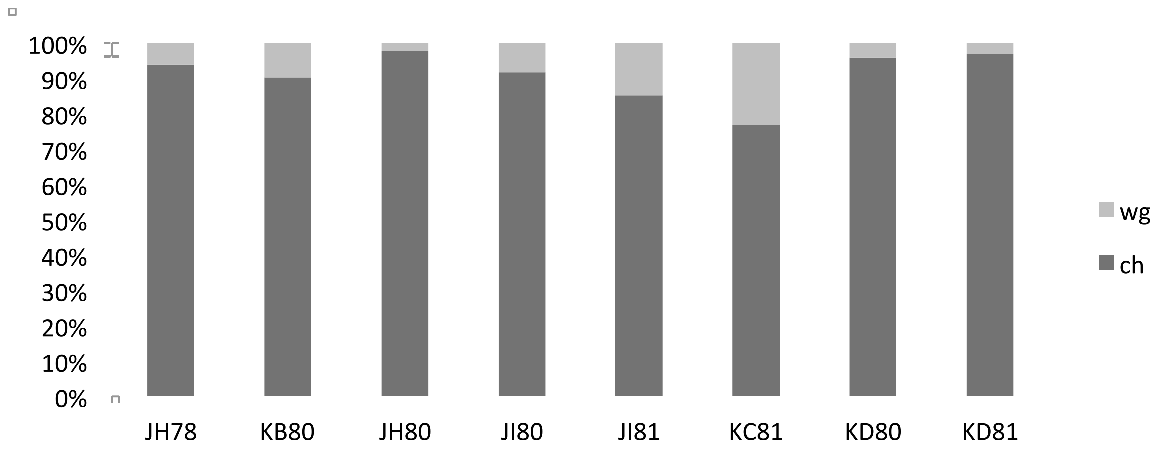

Fig. 4.142. Proportion of charred (ch) and waterlogged (wg) remains obtained from the bulk samples (2mm fraction) of sector D of La Draga.

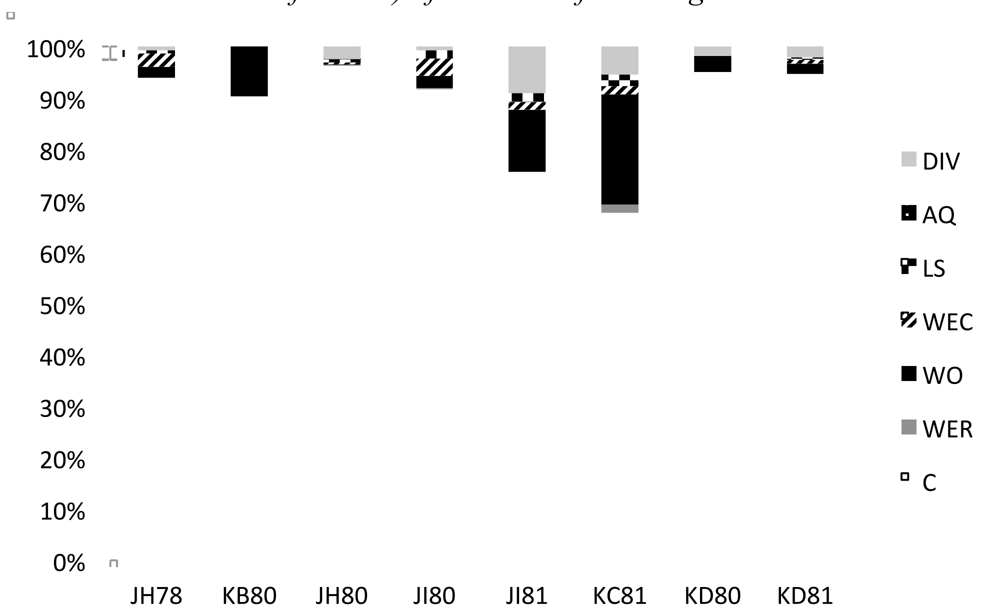

Fig. 4.143. Proportion of the ecological groups based on the number of remains obtained from the bulk samples (2mm fraction) of sector D of La Draga (for the abbreviations of ecological groups, see chapter 3.2.7).

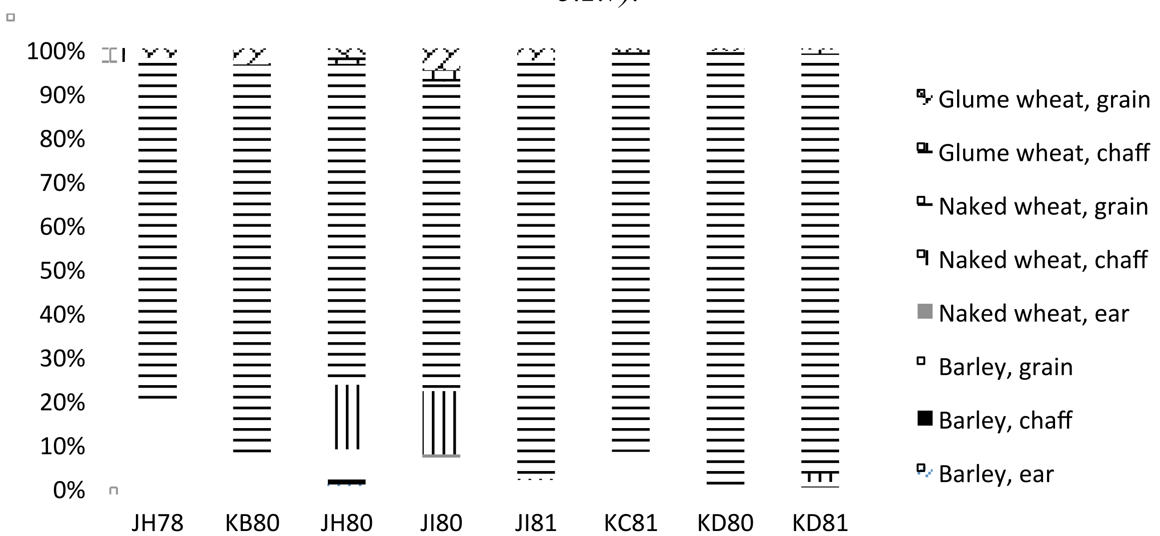

Fig. 4.144.Proportion among the different crop types recovered in the bulk samples (2mm fraction) from layer VII in sector D of La Draga.

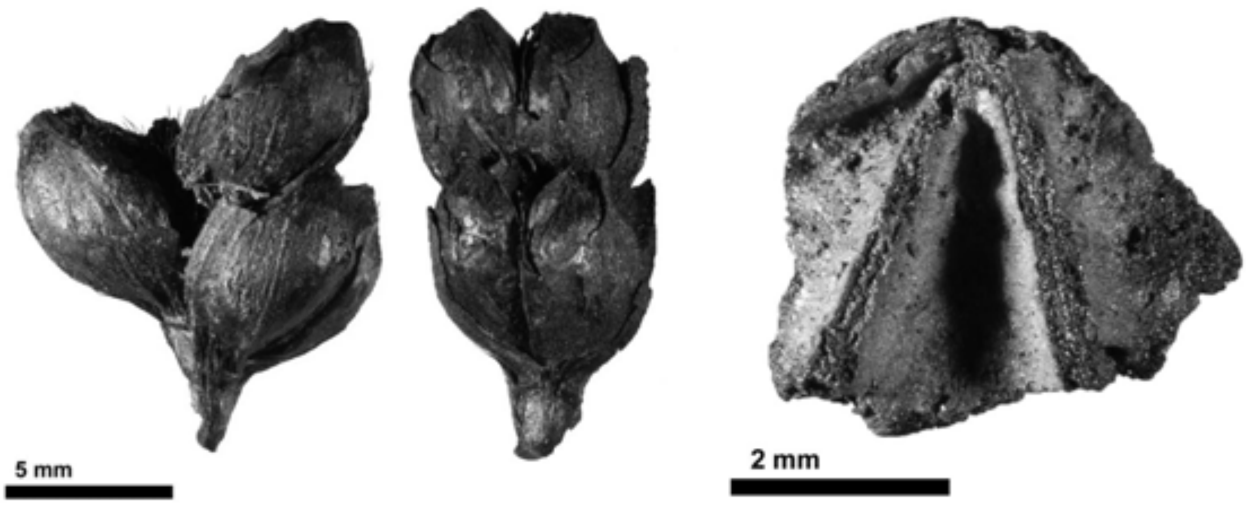

Fig. 4.145. Ear fragment of tetraploid naked wheat recovered in JI80 (left) (Layer VII, sector D, La Draga) and capsule fragment (lid) of opium poppy recovered in JH80 (right) (Layer VII, sector D, La Draga) (Author: F. Antolín).

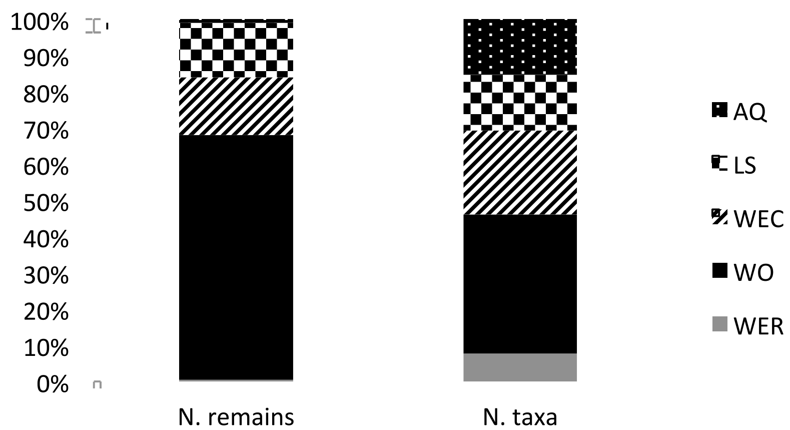

Fig. 4.146. Proportion of the number of remains and number of taxa per ecological group recovered in waterlogged state in the bulk samples (2mm fraction) from layer VII in sector D of La Draga (for the abbreviations of ecological groups, see chapter 3.2.7).

Regarding the seeds and fruits in waterlogged state, these were recovered in all the samples but mostly in KC81 and JI80. Woodland taxa are the better represented both considering the number of taxa and the number of identified remains. Acorns, are the best represented taxon within this group, 44 bases were recovered, mostly in JI81 and KC81. Hazelnuts were rather well represented in JI81. It is significant to note the presence of *Cornus sanguinea, Euphorbia amygdaloides, Taxus baccata, Pyrus malus* subsp. *sylvestris* and beads made with stones of *Prunus avium.* Within the group of plants from woodland edges and clearings, *Rubus fruticosus* was the best-represented taxon, especially in JI80. *Agrimonia eupatoria* and *Prunus spinosa* were also identified. Lakeshore taxa were rather scarce in the record, but the presence of *Vitis vinifera* must be highlighted. Finally, weeds and ruderals and aquatic plants were only represented by very few items, but from relatively rare taxa, such as *Carthamus lanatus* in the former group, and *Iris pseudacorus* and *Najas marina* in the latter one.

			Layer	Bulk samples: Sector B													
			Square	JI90	JI90	KB90	KB90	KC87	KC 87	KC 88	KC 88	KC90	KC90	KC91	KC91	JH 84-85	JH 84-85
			Sample vol. (l.)	6	6	10	10	10	10	6	6	8	8	6	6	0.75	0,75
EG	Taxa	Represented part	Pres. type	eNr	Con.	eNr	Con.	eNr	Con	eNr	Con.	eNr	Con.	eNr	Con.	rNr	Con.
C	Hordeum vulgare	grain (MNI)	ch	22	3,67	9	0,9	1	0,1	2	0,33	20	2,5	3	0,5	35	46,7
C	Hordeum sp.	grain	ch			2	0,2	2	0,2	4	0,67					10	13,3
C	Hordeum sp.	chaff (node=1)	ch													16	21,3
C	Triticum	grain (MNI)	ch	1509	251,5	179	17,9	150	15	150	25	507	63,38	254	42,33	8310	11080
C	aestivum/durum/turgidum	chaff (node=1)	ch	44	7,333	11	1,1	1	0,1			72	9	88,5	14,75	348	464
C	(incl. aestivum and turgidum)	chaff (node=1)	wg	66	11	20	2			1	0,167	1	0,125			15	20
C	Triticum turgidum	grain (MNI)	ch			1	0,1									1	1,333
C	Triticum turgidum	chaff (node=1)	ch			10	1	1	0,1			72	9	86,5	14,42	296	394,7
C	Triticum turgidum	chaff (node=1)	wg	33	5,5	19	1,9			1	0,167	1	0,125			15	20
C	Triticum dicoccum	grain (MNI)	ch	1	0,167	3	0,3	3	0,3	16	2,667	30	3,75	15	2,5	37	49,33
C	Triticum dicoccum	chaff (GB=1)	ch	33	5,5	6	0,6	1	0,1	6	1	136	17	4	0,667	34	45,33
C	Triticum dicoccum	chaff (GB=1)	wg			2	0,2	27	2,7			2	0,25	39,5	6,583	6	8
C	Triticum monococ.	grain (MNI)	ch			1	0,1					2	0,25			13	17,33
C	Triticum monococ.	chaff (GB=1)	ch									24	3			26	34,67
C	Glume wheat, unsp.	chaff (nr)	ch							2	0,333						
C	Triticum sp. unsp.	grain	ch	192,5	32,08	51	5,1	10	1	21	3,5	153	19,13	31	5,167	1998	2664
C	Triticum sp. unsp.	chaff	ch	49,5	8,25	3	0,3					1	0,125			65	86,67
C	Triticum sp. unsp.	chaff	wg			2	0,2					2	0,25			4	5,333
C	Cerealia, unsp.	grain	ch	17,5	2,917	20	2			20	3,333			15	2,5	635	846,7
C	Cerealia, unsp.	chaff	ch													1	1,333
C	Papaver somnifer.	MNI	wg			320	32					216	27	187,5	31,25	57	76
WER	Carthamus cf. lanatus	total remains	wg			1	0,1					5	0,625	1	0,167		
WER	Chenopodium album	total remains	wg	1	0,167			36	3,6	15	2,5	40	5	45	7,5	1	1,333
WER	Polygonum aviculare	total remains	wg			30	3							2	0,333		
WER	Polygonum lapathifolium	seed/fruit	wg													1	1,333
WER	Reseda phyteuma	total remains	wg	**1**	0,167							1	0,125			8	10,67
WER	Silene vulgaris/latifolia	seed/fruit	wg									1	0,125				
WER	Silybum marianum	fragment	wg	1	0,167					1	0,167						
WER	Stellaria med. subsp. med.	seed/fruit	wg			1	0,1										
WER	Urtica dioica	seed/fruit	wg											1	0,167		
WER	Verbena officinalis	total CU	wg			440	44					440	55	165	27,5	36	48
PG	Apium graveolens	total remains	wg			1	0,1										
PG	Hypericum perforatum	total remains	wg													1	1,333
PG	Petrorhagia prolifera	seed/fruit	wg									1	0,125				
PG	Potentilla cf. reptans	seed/fruit	wg			1	0,1										
PG	Silene gallica	total remains	wg					1	0,1					1	0,167		
PG	Stellaria med. subsp. major	seed/fruit	wg			1	0,1							1	0,167		
PG	Valerianella cf. dentata	seed/fruit	wg			1	0,1									2	2,667
WO	Corylus avellana	total CU	wg	1	0,167	1	0,1			1	0,167	1	0,125	1	0,167		
WO	Moehringia trinervia	seed/fruit	wg											1	0,167	6	8
WO	Prunus avium	bead	wg									1	0,125	1	0,167		
WO	Pyrus malus subsp. sylv.	total CU	wg	1	0,167							3	0,375	5	0,833		
WO	Quercus sp.	base	ch									1	125			1	1,25
WO	Quercus sp.	base	wg	14	2,3	6	0,6			2	0,33	5	0,625	3	0,5		
WO	Quercus sp.	pericarp	wg	2	0,3	2	0,2			1	0,167	14	1,75	5	0,83		
WEC	Crataegus monogyna	total CU	wg	2	0,333					3	0,5			2	0,333		
WEC	Physalis alkekengi	total CU	wg					1	0,1								
WEC	Prunus spinosa	total remains	wg									5	0,625	1	0,167	1	1,333
WEC	Rubus fruticosus	seed/fruit	ch													11	14,67
WEC	Rubus fruticosus	seed/fruit	wg	354,5	59,08	155	15,5	182	18,2	344,5	57,42	164	20,5	136,5	22,75	568	757,3
LS	Alisma plantago-aquatica	seed/fruit	wg			1	0,1					2	0,25				
LS	Alnus glutinosa	total remains	ch											1	0,167	6	8
LS	Alnus glutinosa	total remains	wg					1	0,1	1	0,167					5	6,667
LS	Cladium mariscus	total of CU	wg	138,5	23,08	51	5,1	63	6,3	37,5	6,25	80	10	112,5	18,75	256	341,3
LS	Eupatorium cannabinum	Total CU	wg													1	1,333
LS	Lycopus europaeus	total CU	wg			40	4					24	3	2	0,333	19	25,33
LS	Ranunculus sceleratus	total CU	wg			150	15					48	6	112,5	18,75		
LS	Scirpus lacustris	seed/fruit	wg	1	0,167												
LS	Vitis vinif. subsp. sylvestris	seed/fruit	wg	14	2,333	21	2,1	2	0,2	33	5,5	19	2,375	12	2	29	38,67
LS	Vitis vinif. subsp. sylvestris	seed/fruit	ch													5	6,667
AQ	Najas marina	total CU	wg	347,5	57,92	137	13,7	198	19,8	174	29	158	19,75	834,5	139,1		
AQ	Nymphaea alba	seed/fruit	wg									1	0,125				
AQ	Potamogeton cf. coloratus	seed/fruit	wg									1	0,125				
AQ	Potamogeton sp.	seed/fruit	wg			30	3									5	6,667
AQ	Ranunculus aquatilis	seed/fruit	wg			1	0,1										
DIV	Amaranthus sp.	seed/fruit	wg			1	0,1										
DIV	cf. Brassicaceae	seed/fruit	wg													1	1,333
DIV	Carex sp. unspecified	seed/fruit	wg													1	1,333
DIV	Chenopodiaceae	total remains	wg	1	0,167	1	0,1										
DIV	Cirsium sp. type	seed/fruit	wg													1	1,333
DIV	Cyperaceae	total remains	wg													3	4
DIV	Euphorbia sp.	total remains	wg			1	0,1									1	1,333
DIV	Galium sp.	total remains	ch			1	0,1					1	0,125				
DIV	Lolium sp.	seed/fruit	ch													1	1,333
DIV	Mentha sp.	seed/fruit	wg									24	3				
DIV	Poaceae	total remains	ch			1	0,1									6	8
DIV	Polygonum sp.	seed/fruit	wg							1	0,167						
DIV	Ranunculus sp.	total remains	wg	1	0,167							1	0,125	1	0,167	4	5,333
DIV	Rubiaceae	seed/fruit	wg											1	0,167		
DIV	Rubus sp.	total CU	ch													1	1,333
DIV	Rumex sp.	total remains	wg	37	6,333	2	0,2	2	0,2			31	3,875	30	5	7	9,333
DIV	Rumex sp.	total remains	ch	2	0,333							1	0,125			2	2,667
DIV	Sambucus sp.	total CU	wg													1	1,333
DIV	Silene sp.	seed/fruit	wg	1	0,167	2	0,2									4	5,333
DIV	Solanaceae	fragment	wg			30	3					1	0,125	2	0,333		
DIV	Stachys sp.	seed/fruit	wg													1	1,333
			Total	**2855**	**475,9**	**1739**	**173,9**	**681**	**68,1**	**836**	**139,3**	**2240**	**404,9**	**2118**	**352,9**	**12606**	**16808**
			N. taxa	**18**		**30**		**12**		**14**		**30**		**27**		**31**	

Fig. 4.147. Results of the analysis of the bulk samples (see analysed fractions in Fig.4.140) from sector B (CU: counted unit; for the abbreviations of ecological groups, see chapter 3.2.7).

Sector B, Layer II (probably equivalent to layer VII of sector D)

All the analysed samples from sector B were rich in remains and, with the exception of sample JH84-85, they mostly presented medium densities (100-400 r/l). They yielded a large number of taxa (between 12 and 31), both in charred and waterlogged state. The results are presented in Fig. 4.147.

The proportions of charred and subfossil remains are diverse (Fig. 4.148). Two samples in the western side of the sector (JH84-85 and JI90) present large proportions of charred remains (between 65 and 90%). The rest of the samples have a much larger waterlogged component (between 55 and 85%). When looking at the distribution of the ecological groups per sample, a similar parallel pattern is observed as in sector D (Fig. 4.149). Cereals prevail in the samples where the charred component was higher. Besides, two main groups can be observed within the eastern samples: KC87 and KC88 present a larger proportion of cultivars and plants from woodland edges and clearings; KB90, KC90 and KC91 have fewer remains of plants from the latter group and more weeds and ruderals. Furthermore, KC91 presents a relatively high proportion of aquatic and lakeshore plants.

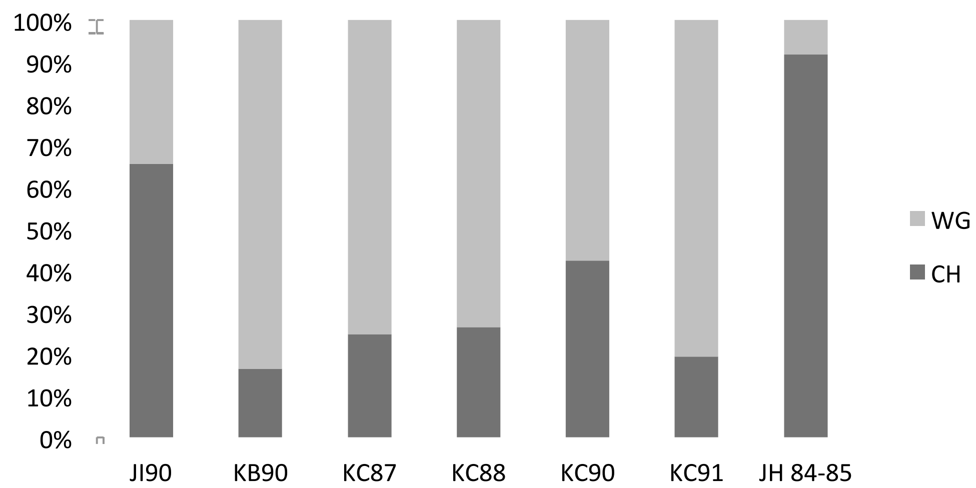

Fig. 4.148. Proportion of charred (ch) and waterlogged (wg) remains obtained from the bulk samples (see analysed fractions in Fig.4.140) of sector B.

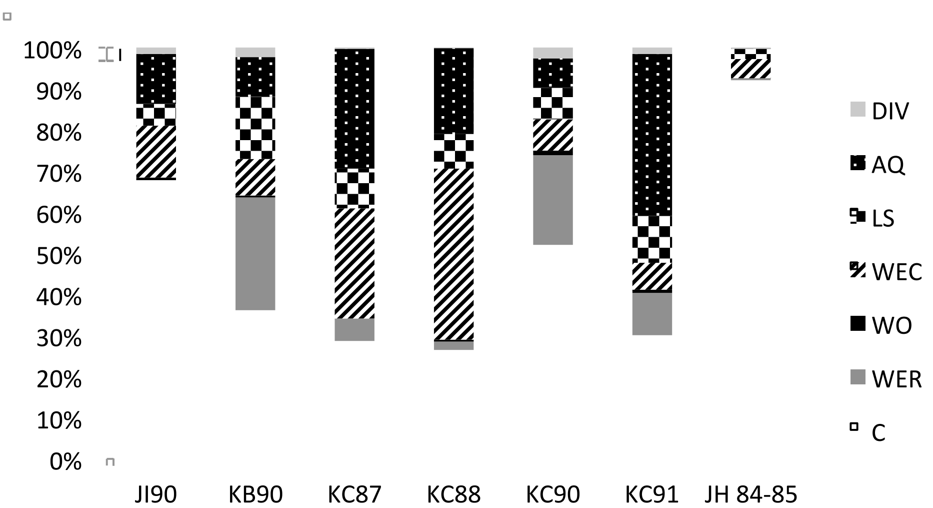

Fig. 4.149. Proportion among the number of remains per ecological group obtained from the bulk samples (see analysed fractions in Fig.4.140) of sector B of La Draga (for the abbreviations of ecological groups, see chapter 3.2.7).

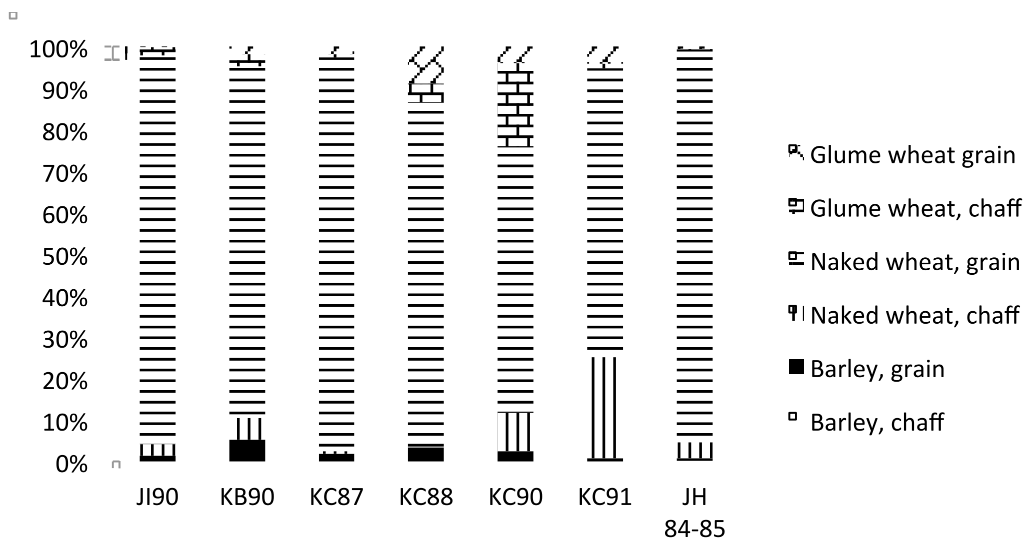

Fig. 4.150.Proportion among the different crop types recovered in the bulk samples(see analysed fractions in Fig.4.140) of sector B of La Draga.

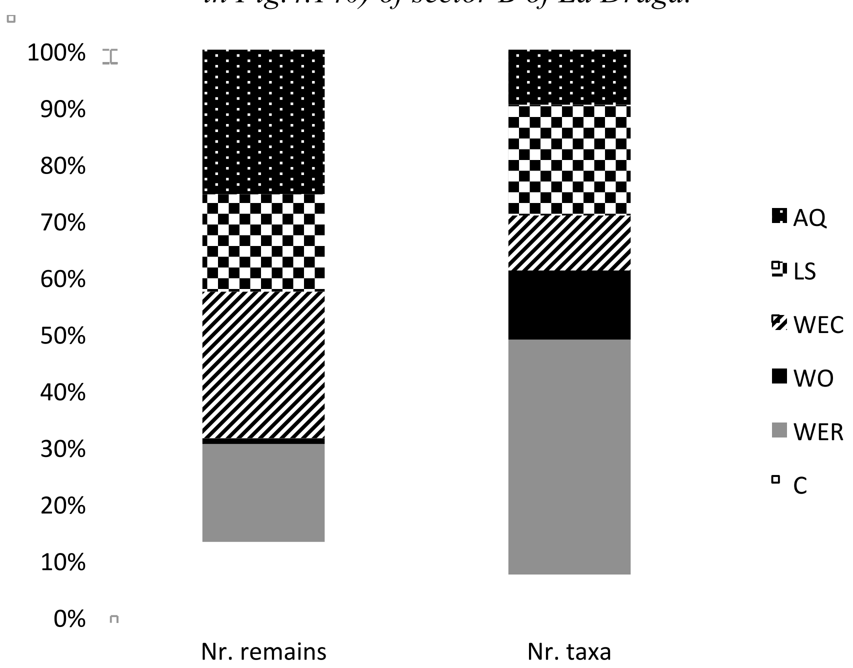

Fig. 4.151. Proportion of the number of remains and number of taxa per ecological group recovered in waterlogged state in the bulk samples(see analysed fractions in Fig.4.140) of sector B of La Draga (for the abbreviations of ecological groups, see chapter 3.2.7).

As already mentioned, the charred component of the samples is mainly consisting of cereal remains. No charred remains of opium poppy were found. Among the cereal remains, naked wheat grain is prevailing in all samples and only in sample KC90 a significant proportion of glume wheat (c.20%, mainly chaff) and in KC91 a larger percentage of naked wheat chaff (c. 20%) were identified (Fig. 4.150).

Unlike in sector D, no ear fragments or fragments of amorphous charred objects were found, but large grain aggregates were identified in KC87 and JI90.

The wild taxa that were recovered in charred state are, at least partly, rather similar to the ones observed in sector B: *Quercus* sp. (n=1), *Rubus fruticosus* (n=11), *Alnus glutinosa* (n=7), *Vitis vinifera* subsp. *sylvestris* (n=5), diverse Gramineae (n=8) and *Rumex* sp. (n=5). The total absence of legumes is quite significant.

Concerning the subfossil record, plants from woodland edges and clearings and aquatic areas were the better represented in number of remains, while the group of weeds and ruderals, pastures and grasslands yielded the larger number of taxa (Fig. 4.151).

It should be highlighted that, among the cultivars, not only waterlogged seeds of poppy were recovered but also some remains of chaff from naked wheat (with concentrations between 10-20 r/l in the western samples) and glume wheats (with concentrations between 2,7 and 8 r/l in the eastern samples). Poppy was found with densities around 30 r/l in four different samples.

Among the weeds and ruderals, *Verbena officinalis* and *Chenopodium album* were the best-represented taxa, especially *Verbena*, with concentrations between 27 and 55 r/l in four samples. Other taxa were also identified, such as *Carthamus lanatus, Polygonum aviculare, P. lapathifolium, Reseda phyteuma, Silene vulgaris/latifolia, Silybum marianum, Stellaria media* subsp. *media* and *Urtica dioica.*

Plants from pastures and grasslands were mainly recovered as single finds. Several taxa were identified: *Apium graveolens, Hypericum perforatum, Petrorhagia prolifera, Potentilla reptans, Silene gallica, Stellaria media* subsp. *major* and *Valerianella* cf. *dentata*.

Woodland taxa were also rather poorly preserved, especially in comparison with sector D. *Corylus avellana, Moehringia trinervia, Prunus avium, Pyrus malus* subsp. *sylvestris* and *Quercus* sp. were identified.

Among the plants from woodland edges and clearings, *Rubus fruticosus* was the best represented taxon, with densities between 15 and 60 r/l in most samples. *Crataegus monogyna, Physalis alkekengi* and *Prunus spinosa* were also ascribed to this group.

Lakeshore plants were well represented in the analysed samples. *Cladium mariscus* and *Vitis vinifera* were found in all samples but in relatively low densities (mostly below 25 r/l). Other taxa were identified as well: *Eupatorium cannabinum, Lycopus europaeus, Ranunculus sceleratus, Scirpus lacustris* and *Alisma plantago-aquatica.*

Finally, water plants were primarily represented by the presence of *Najas marina* in 6 of the 7 samples (13,7-139 r/l). *Nymbphaea alba, Potamogeton coloratus* and *Ranunculus aquatilis* were also identified.

Layer IV

The results from layer IV are rather rich (Fig. 4.152). Two samples yielded more than 1000 remains. They are all in charred state, except two seeds of *Rubus fruticosus*. Most of the charred seed and fruit items belong to cereals, except one pip of wild grape (*Vitis vinifera* subsp. *sylvestris*). Among the cereals, only grains were identified. Naked wheat is, by far, the best-represented taxon in all samples. Barley was found in four of the five sampled squares. Glume wheats are present in two of the five squares.

		Layer	Bulk samples from layer IV: sector D					
		Square	IJ78	IJ79	IJ79	IJ80	JB81	JD78
		Volume of the residues (ml.)				110		
		Analysed volume (ml.)				55		
Taxa	**Represented part**	**Preservation type**	**rNR**	**rNR**	**rNR**	**eNR**	**rNR**	**rNR**
Hordeum vulgare **(cf. incl.)**	**grain (MNI)**	ch	1	3	3	1	6	
Hordeum **sp. (cf. incl.)**	**grain**	ch			5	1	2	
Triticum aestivum/durum/turgidum	**grain (MNI)**	ch	9	10	1450	628	80	1
Triticum **(cf.)** ***dicoccum***	**grain (MNI)**	ch			5	5		
Triticum **(cf.)** ***monococcum***	**grain (MNI)**	ch				4		
Triticum **sp. unspecified**	**grain**	ch		2	1	503		
Cerealia, unspecified	**grain**	ch		3		3		
Rubus fruticosus **agg.**	**total CU**	wg			1		1	
Vitis vinifera **subsp.** ***sylvestris***	**total CU**	ch			1			
		Total general	**10**	**18**	**1466**	**1146**	**89**	**1**
		Sample volume (l.)	**10**	**10**	**10**	**10**	**10**	**10**
		Total nr. of taxa	**2**	**2**	**5**	**4**	**3**	**1**

Fig. 4.152. Results of the bulk samples (2mm fraction) from layer IV in sector D of La Draga (CU: counted unit; ch: charred; wg: waterlogged).

Layer III

The results obtained for layer III are rather similar to those from layer IV. Most of the identified remains are charred cereals (grains). Nevertheless, a wider diversity of taxa (n=5) were recovered in subfossil state (1,2% of the total of remains).

			Layer	Bulk samples from layer III: sector D						
			Square	JB80	JC79	JD80	JD81	JJ80	KA81	KC80
Ecological group	**Taxa**	**Represented part**	**Preservation type**	**rNR**	**rNR**	**rNR**	**rNR**	**rNR**	**rNR**	**rNR**
C	*Hordeum vulgare* (cf. incl.)	grain (MNI)	ch				6	13		
C	*Hordeum* sp.	FPostC	ch	1				1		
C	*Triticum aestivum/durum/turgidum*	grain (MNI)	ch	20	75	105	18	802	4	250
C	*Triticum* (cf.) *dicoccum*	grain (MNI)	ch					2		2
C	*Triticum* (cf.) *monococcum*	grain (MNI)	ch		1			2		
C	*Triticum* sp. unspecified	grain	ch	5						
C	Cerealia, unspecified	grain	ch	10						
WO	*Cornus sanguinea*	total CU	wg			1				
WO	*Cornus sanguinea*	fruit stone	wg			1				
WO	*Quercus* sp.	acorn base	wg				1			
WEC	*Rubus fruticosus* agg.	total CU	wg				1			
WEC	*Sambucus* cf. *nigra*	seed/fruit	wg				4			
WEC	*Sambucus* sp.	seed/fruit	wg				3			
LS	*Vitis vinifera* subsp. *sylvestris*	total CU	wg			1	3			
DIV	Rosaceae	fruit stone	wg				1			
			Total general	**36**	**76**	**107**	**40**	**820**	**4**	**253**
			Sample volume (l.)	**9**	**10**	**10**	**10**	**10**	**10**	**12**
			Nr. of taxa	**2**	**2**	**3**	**7**	**4**	**1**	**2**

Fig. 4.153. Results of the bulk samples (2mm fraction) from layer III in sector D of La Draga (CU: counting unit; ch: charred; wg: waterlogged; for the abbreviations of ecological groups, see chapter 3.2.7).

Regarding the cereal remains, mainly naked wheat was identified, together with some spare finds of barley and glume wheats (einkorn and emmer).

Concerning the subfossil record, several finds of *Rubus, Sambucus* and *Vitis,* as long with one single base of acorn (*Quercus* sp.), were recovered, all in squares JD80 and JD81.

Layer II

The results from layer II are rather parallel to those observed in layers IV and III (Fig. 4.154). The proportion of waterlogged remains is slightly higher than in the former layers, 5,1%. Otherwise, most of the record was preserved in charred form.

Once more, naked wheat grain is the best represented crop type (and it was present in all 15 squares), and only some spare finds of barley and einkorn were documented. Besides, two charred fragments of hazelnut shell were recovered.

Among the subfossil record, seven taxa were identified. *Vitis, Rubus* and *Sambucus* were the best represented taxa, along with *Fumaria officinalis, Cornus sanguinea, Corylus avellana* and *Prunus*.

			Layer	**Bulk samples from layer II: sector D**														
			Square	**JB79**	**JD78**	**JE79**	**JE81**	**JF78**	**JF79**	**JG79**	**JG80**	**JH78**	**KA79**	**KC81**	**KD81**	**KE81**	**KF80**	**KF81**
EG	Taxa	Represented part	Pres. type															
C	***Hordeum vulgare***	**grain (MNI)**	**ch**						4		2					2		
C	***Hordeum* sp., unsp.**	**FPostC**	**ch**										1					
C	***Triticum aest./dur./turg.***	**grain (MNI)**	**ch**	50	5	9	115	75	550	10	45	5	9	25	304	202	1	30
C	***Triticum monococcum***	**FPreC**	**ch**						1									
C	***Triticum monococcum***	**seed/fruit**	**ch**						1									
C	***Triticum* sp./new type**	**seed/fruit**	**ch**						1		1							
C	**Glume wheat, unsp.**	**grain (MNI)**	**ch**						1		1							
C	***Triticum* sp., unsp.**	**FPostC**	**ch**	5			8	15										5
WER	***Fumaria officinalis***	**seed/fruit**	**wg**						1									
WO	***Cornus sanguinea***	**total CU**	**wg**				5		1		1							
WO	***Corylus avellana***	**total CU**	**ch**													2		
WO	***Corylus avellana***	**total CU**	**wg**							1								
WEC	***Rubus fruticosus***	**total CU**	**wg**				22		6									
WEC	***Sambucus* cf. *nigra***	**seed/fruit**	**wg**				5											
WEC	***Sambucus* sp.**	**total CU**	**wg**			2	15											
LS	***Vitis vinif.* subsp. *sylv.***	**total CU**	**wg**				4		2		14							
DIV	**cf. *Prunus* sp.**	**fruit stone frag.**	**wg**								1							
		Total remains		**55**	**5**	**11**	**174**	**90**	**568**	**11**	**64**	**5**	**10**	**25**	**304**	**206**	**1**	**35**
		Sample vol. (l.)		**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**16**	**10**	**10**	**10**
		Nr. of taxa		**2**	**1**	**2**	**5**	**1**	**7**	**2**	**6**	**1**	**2**	**1**	**1**	**3**	**1**	**1**

Fig. 4.154. Results of the bulk samples (2mm fraction) from layer II in sector D of La Draga (CU: counting unit; ch: charred; wg: waterlogged;for the abbreviations of ecological groups, see chapter 3.2.7).

4.7.7.3. Discussion

4.7.7.3.1. Was the sampling strategy adequate enough to provide a rough characterization of the layers?

As already mentioned above, the analysis that was performed in this chapter is of rather preliminary nature. A large number of samples remain to be checked. Nevertheless, layers II, III and IV already presented a very repetitive pattern in most of their samples.

First of all, it should be emphasized that the volume of sediment that was processed was in most cases enough to get a high number of items per sample and over 1000 items per layer. Thus, evaluations at a layer scale are numerically possible. Secondly, the samples were taken from all over the area where the layer was documented, for which any spatial differences of some significance should have been identified.

Layer II was the most extensively studied layer (156 litres of sediment). Layer III was not so broadly sampled (71 litres of sediment) but it already presented a very homogeneous composition, just like layer IV (99 litres of sediment). Moreover, it should be highlighted that the differences between the three layers are minimal in terms of botanical composition. This, added to the fact that the archaeological material and structures identified in these layers were not abundant or clarifying, makes more efforts unnecessary. It is clear for the three layers that charred grain is present and that some fruits with lignified stones were preserved in waterlogged state.

Layer VII presents a completely different problematic. The analysed samples in sectors B and D yielded a large number of new taxa and types of remains which had not been identified in the profile samples or in the smaller systematic surface samples. For this reason, further analyses should be carried out in the near future, given the potential that these samples have of providing new information. Concerning the analysed volumes, it must be said that the volume of sample JH84-85 was probably wrongly measured or recorded, since some aberrant densities were obtained. Concentration values for this sample should not be taken into very detailed consideration.

4.7.7.3.2. Layer VII: contributions of the bulk samples to the general view and spatial evaluation of the layer

The analysed samples from layer VII in sector D, on the one hand, reinforce the spatial interpretation that was put forward for the charred record recovered in this area. Two concentrations of charred cereal remains were identified (see Fig. 4.109): one in JH80, with a larger component of naked wheat chaff; and one in KD80, with mainly naked wheat grain. Also the more preliminary results obtained for the northerly adjacent sector B seem to point towards this dichotomy: of larger concentrations of grain with some chaff in lines JH/JI of the grid and lower concentrations in the western sector (sometimes mixed with chaff). It becomes at this point necessary to analyse more samples from this area in order to confirm this pattern. If this was the case, it might indicate the same pattern than that presented for sector D.

The new findings in the eastern area of sector D were particularly interesting. The chaff remains of new glume wheat are among the oldest in Europe and the only findings of chaff which have been recovered in the Iberian Peninsula. Their presence is scarce and it is not possible, under the present state of research, to consider the role of this variety of glume wheat as a cultivar. The aggregates of grain fragments originated prior to charring could only respond to two activities: either grain milling or the production of bulgur. It is unlikely that the fragments of grain originated after milling were discarded as a by-product. There are ethnographic observations from Tunis where such by-products are usually consumed as a raw snack (Alonso et al. in press a). Therefore, these fragments might indicate that bulgur was produced at the site and the finds could just be residues from cooking activities. This would reinforce the interpretation of this area (around line KD) as an area for the accumulation of waste. A similar conclusion might be reached concerning the accumulation of glume wheat chaff in KC88. These might also be the discarded residues from the dehusking of glume wheat.

In addition, the waterlogged record brought out very interesting information, such as the rather important presence of pericarps of acorns in KC81. Only a small number of them were recovered in the two systematic samples that were analysed from this square. This would equally emphasize the interpretation of this area as an area of waste accumulation.

In sector D the preservation of uncharred material could have not been optimal due to the storage conditions of the samples. Nevertheless, a large diversity of taxa were identified. The larger proportion of subfossil items was found in the western samples. In this case, plants from woodland edges and clearings were more frequently found. Usually, accumulations of *Rubus fruticosus* are related to the presence of human faecal material (e.g. Jacomet, Brombacher & Dick 1989, Maier 2001, Maier 2011), but the sieving method was not appropriate for the recovery of such type of remains.

4.7.7.3.3. Layer VII: qualitative contribution of the bulk samples to palaeoeconomic issues

One of the main purposes of the analysis of these samples was to increase the number of identified taxa and to get a better representation of rare types of remains. Both goals were satisfactorily achieved.

On the one hand, it is of much interest to find ear fragments of naked wheat, since it might be informing us of the state in which the crop was stored. This topic will be dealt with in the general discussion (4.7.7.). Besides, the finding of the so-called, amorphous charred objects opens the door to new approaches to the consumed products within the site. Furthermore, the identification of a fragment of capsule of poppy within the site of La Draga might be the first clear evidence of the processing of these capsules at a household scale (they could be smashed in order to obtain the seeds and then the capsule fragments would just be discarded).

Concerning the identification of new taxa, most of these came from sector B (n=12), while three new taxa were identified in sector D (*Iris pseudacorus, Taxus baccata* and *Agrimonia eupatoria*). In sector B the new taxa are *Polygonum lapathifolium, Silene vulgaris/latifolia, Nymphaea alba, Amaranthus* sp., *Rumex* sp., *Silybum marianum, Stellaria media* subsp. *media* and subsp. *major*, *Potentilla reptans, Valerianella dentata, Moehringia trinervia* and *Crataegus monogyna.*

In sector D, it was also interesting to see some wild taxa with economic value better represented than in the systematic surface samples. These were *Quercus*, *Rubus* and *Corylus.*

4.7.7.3.4. Layers IV to II: general view of their archaeobotanical composition and the quality of the preservation conditions

As already mentioned above, the record from layers IV to II is rather rich but very homogeneous. The three layers show a major component based on charred cereal grains (mainly naked wheat). Only some waterlogged lignified fruit stones or fruit parts were preserved.

These data indicate that there are significant evidences of a later occupation of the La Draga site where the consumption of agricultural products would continue to be a common practice. Nevertheless, it is difficult to interpret the obtained data further than proposing that naked wheat was the main cultivated taxon during these later occupations.

The waterlogged record is typical of poor conditions for an anaerobic preservation (Murphy & Wiltshire 1994). Therefore, it is not representative of the original subfossil assemblage.

4.7.8. General discussion

4.7.8.1.Discussion Methodological discussion: was the multiple sampling strategy appropriate? Did we analyse enough samples? Did the diverse strategies produce complementary results? Is it possible to establish an optimal sample volume for La Draga?

At this point, it becomes necessary to perform a general evaluation of the methods and results obtained at a site level, integrating the three sampling strategies that have been separately presented and analysed.

First of all, it must be emphasized that the initial goals were mostly satisfied in our analysis: a multy-proxy approach to the stratigraphy and formation processes of the site was performed, a spatial analysis of the charred and waterlogged record was carried out and these results were completed with the data obtained with the bulk water-screened samples. Nevertheless, not all objectives were fully achieved, for which a list of drawbacks and future recommendations was done, largely based on previous works (Jacomet & Brombacher 2005) (Fig. 4.155.).

	Profile samples	Systematic surface samples	Bulk water-screened samples
Initial goals	stratigraphy + taphonomy	spatial analysis of layer VII	rough description + rare finds (large-seeded taxa)
Positive achievements	Detailed description of the layers + insights into formation processes of the site	spatial evaluation of the distribution of the charred and the waterlogged assemblage for VIIa and VIIb	sufficient volumes, first rough approach to the composition of layers II, III and IV. Significant rare finds in layer VII and increase of the number of identified taxa
Main drawbacks	Low volumes + insufficient representation of some layers such as IIa, but also II and III.	Low volumes	Layers VI and IIa were not analysed
Recommendations for future actions	Not using profile samples for multiple analyses, targeting the less well known layers and continuation of the extraction of profiles in future excavations, aiming to have a complete transect	Use of larger bags/jars (2-3 l) for future sampling (or use of two jars per subsquare)	Continuation of the strategy, especially for layer VII

Fig. 4.155. Evaluation of the sampling strategy at La Draga: goals, achievements, drawbacks and future actions.

Concerning the profile samples, it was observed that not all layers were adequately represented in the three profiles. Only layer VII and VI were (relatively) sufficiently sampled, while layers II, IIa and III were not, for which the results that were obtained cannot be considered as representative. One of the main problems, in some cases, was that the samples were too small to yield a sufficiently large number of items. Therefore, it was recommended to not use these profiles for multiple analyses, only for macroremains, and take another. On the other hand, the obtained results were of much interest for the site and the sampling strategy should continue in future fieldworks, aiming to achieve a transect from inland to the lake in order to reach a better understanding of the sedimentation processes at the site.

The systematic surface samples produced equally interesting results at a spatial level for layer VII (for both sublayers VIIa and VIIb). However, they only represent a small part of each square metre. In addition, it was observed that the samples did not reach the aimed volume (1 litre) and that, in some occasion, this volume might not produce a sufficient number of items. Consequently, it was recommended for future works to use larger containers (either bags or jars), of *c.* 2-3 litres, for the systematic sampling, and to particularly emphasize larger samples in those areas where the presence of organic material (leafs, twigs, moss, etc.) is not well attested, since they seem to contain lower densities of remains. It should be kept in mind that one of the goals of this strategy is to identify spatial patterns and single activity refuse deposits, and that the larger the samples, the larger the possibilities to mix residues from different activities. In order to test this hypothesis it would be of much interest to carry out the analyses of the 10 litre surface samples (processed with the wash-over method, besides the water-screened bulk samples that were analysed for this work) in order to see to what extent they yield the same or different patterns.

Finally, the results of the water-screened bulk samples demonstrated that 10 litres per square were an adequate measure to get the desired volume and quality of data for layers II, III and IV. On the other hand, it also proved that it was worth to increase the sieved volume for layer VII, where the diversity of remains was much larger.

The sieving methods proved themselves useful in their goals: the preservation of fragile items in the samples processed with the wash-over technique and the fast processing of large samples with the water-screening technique.

The frequent subsampling of the 0,35 mm fraction allowed the analysis of a larger number of samples. This was certainly adequate for our purposes in this project. On the other hand, at least one more subsample of around 15 samples (6 from the profile samples and 10 from the systematic surface samples) should be sorted in the near future. These are the samples which have the largest probabilities of yielding new taxa. It is recommended for future works, though, to sort <u>at least</u> 20 ml of the 0,35 mm fraction of the samples which are rich in charred remains, since the identification of charred weeds is of great need for the characterization of crop husbandry practices at the site.

4.7.8.2. The number of items and the botanical diversity obtained: final evaluation and brief comparison with other (later) Neolithic lakeshore sites from central Europe

It was repeatedly observed in the presentation of the results of the profile and the systematic surface samples that the optimal number of items per fraction (*c.* 400) was hardly ever reached. This was only possible in some cases when a concentration of charred cereal remains was found and only for the 2 mm fraction. Obtaining 400 items in the 0,35 mm fraction would have implied sorting all the residues, which was not possible within this project. The densities of remains per litre at La Draga make it unfeasible to target such high numbers of items per sample. At the same time, the low density of remains speaks against their representativity, for which it might be more efficient and productive to continue with the sampling strategy proposed in the previous chapter and analyse as many samples as possible, rather than investing time in the complete sorting of a smaller number. Nevertheless, it would be important to sort some of the 10 litre samples in order to compare the results with the smaller samples, both concerning the densities observed for the main taxa and the total number of taxa that were identified.

The comparison of the number of remains and the number of taxa obtained according to the type of sampling shows that the samples from profile samples are extremely limited in their potential information (Fig. 4.156). Few of them yielded more than 12 taxa and more than 120 items. The systematic surface samples produced similar results in many cases, but there was a larger number of samples which allowed the recovery of a larger number of remains and taxa. Not always, though, more remains equalled more taxa, especially in those samples where charred cereal remains prevailed. The larger water-screened samples yielded better results, especially those from sector B, for which the 0,5 mm fraction was also analysed. Nonetheless, the fact that only a few of them yielded more than 25 taxa could be indicating a potential threshold (which could be the optimal number of taxa per sample for future studies). Such numbers should be established through the analysis of several 10 litre samples processed with the wash-over method, rather than water-screening.

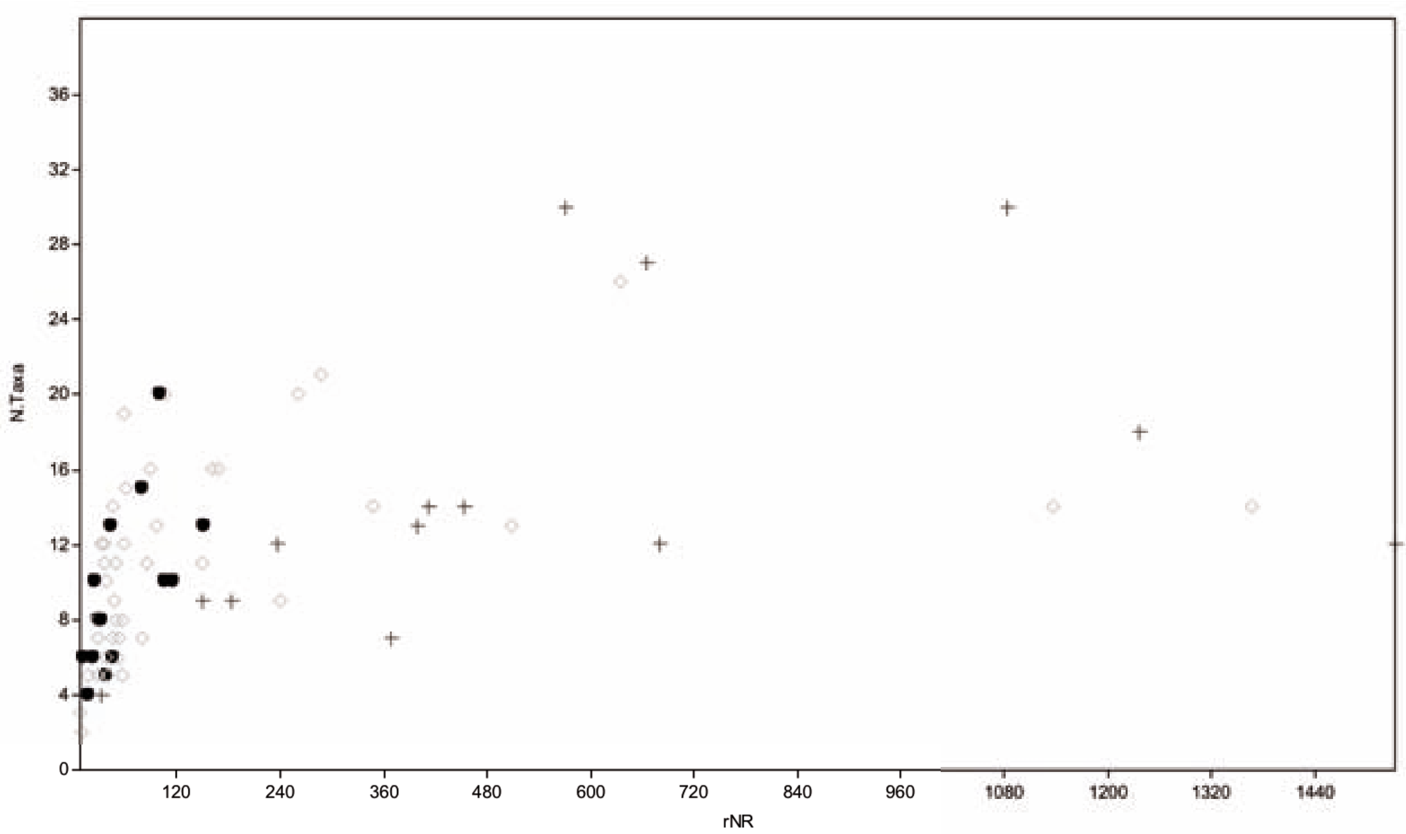

Fig. 4.156. XY Graph relating the real number of items (rNR) recovered in the samples from La Draga and the number of taxa obtained (dots: profile samples; diamonds: systematic surface samples; crosses: large water-screened samples; sample JH84-85 not shown).

A comparison with several sites from Central Europe associated with the LBK, Egolzwiler, Cortaillod, Pfyn and Horgen Cultures (between 5100 and 2800 BC cal) (Fig. 4.157: based on data obtained from Jacomet, Brombacher & Dick 1989, 226-227, Tab. 86; Knörzer 1998; and Hosch & Jacomet 2004, 117) shows that the number of taxa in waterlogged state that were recovered at La Draga was low compared to other lakeshore sites in which the material is preserved in waterlogged state. The results from La Draga (without including the results of the water-screened samples) were strikingly poor and only comparable to those obtained in the Horgen culture horizon of the site Zürich-Mythenschoss, which was an extremely eroded layer (Jacomet et al. 1989, 28). The number of taxa obtained in both levels of layer VII is comparable to the results of the earliest phases of Zürich-Kleiner Hafner (Egolzwil layer, dated to the onset of the lake-dwellings in the circumalpine region between 4300-4000 cal BC, and other early layers of Kleiner Hafner, such as 4AB and 4C, often consisting of charred materials). In addition, Kleiner Hafner is an island site, and therefore it was maybe more affected by erosion.

Similar results were obtained when comparing the densities of remains in each site. On the one hand, the average densities of charred remains found in level VIIa of La Draga (427,4 r/l) are high for most of the "ordinary" layers of the above-mentioned lake dwelling sites. Nevertheless, concentrations of between 1000 and 10000 r/l were obtained in several burnt stores of grain (Jacomet, Brombacher & Dick 1989, 69). Such concentrations were achieved in some samples of level VIIa such as JG80NE and JH80 (VIIb), which can only confirm their interpretation as a burnt store. On the other hand, the average densities of waterlogged remains (507.4 in level VIIa and 701.51 in VIIb) were only found in some burnt or clayey layers (Jacomet et al. 1989, 63 and 65, Abb. 27-30). Densities are much higher in most occasions in all of these sites (1000-15000 r/l in organic layers).

For all these reasons, one should not discard the possibility that, considering the large amount of lakeshore and aquatic plants recovered, the **erosion of the archaeological layer** in La Draga was relatively important and, consequently, the subfossil material was not well preserved in this area of the settlement. It is also possible that the vegetation cover and human impact around La Draga is not comparable to those in central Europe more than 1000 years later; however, this needs to be corroborated by more investigations. It is unlikely that the lower densities of remains found at La Draga are due to preservation issues derived from the age of the site, since 137 taxa (and in rather large quantities) were recovered in the Early Neolithic (LBK) well of Erkelenz-Kückhoven (Germany, dated to around 5100 BC cal). Recent analyses performed in five wells from the LBK period in West Saxonny (not shown in the figure) presented equally rich assemblages, of between 113 and 177 taxa (Herbig et al. 2013).

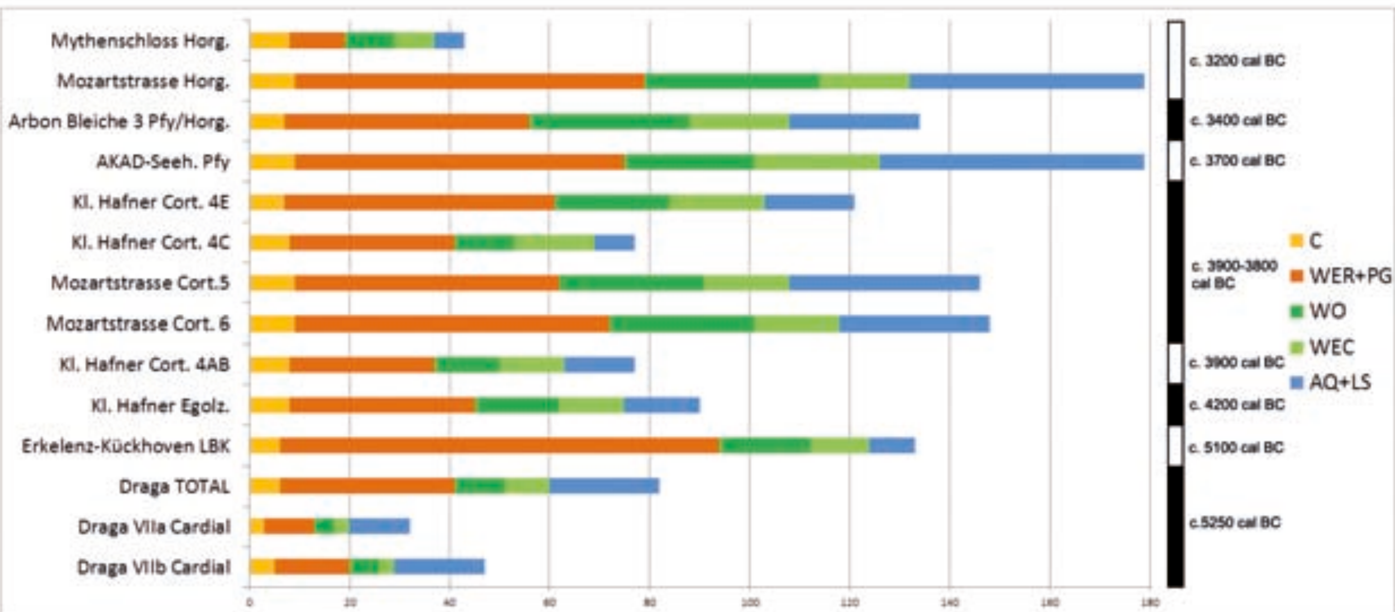

Fig. 4.157.Number of taxa (in subfossil state) classified per ecological group recovered at La Draga and other (later) Neolithic sites with waterlogged preservation from Central Europe.

4.7.8.3.Crops and crop processing, storing and consuming at La Draga

4.7.8.3.1. Layer VII

As repeatedly observed in the previous chapters, remains of crops were recovered in charred and in subfossil state at La Draga. All in all, six taxa were identified: *Hordeum distichum* (two-rowed hulled barley), *Triticum durum/turgidum* (tetraploid naked wheat), some spare finds of *Triticum aestivum* s.l. (hexaploid naked wheat), *Triticum dicoccum* (emmer), *Triticum monococcum* (einkorn) and *Papaver somniferum* (opium poppy). In the next lines I will proceed to a final evaluation per taxon or crop type (all naked wheat varieties will be analysed together).

Barley

Waterlogged remains of barley were identified both in levels VIIb and VIIa. In the profile samples, average densities of less than 1 r/l were found (and a maximum of 5 r/l in one sample from MP3). In the systematic samples, the average concentration was similar in layer VIIb (0,52 r/l) but it was totally absent in level VIIa. In the bulk water-screened samples, waterlogged remains of barley were never recovered, probably due to the fact that they are very fragile.

Charred remains (grains and chaff) of barley were not identified in the profile samples. They were not very abundant in the systematic surface samples, with average concentration values of around 3 r/l and a percentage of ubiquity of 19% in level VIIb. But they were much better represented in level VIIa, with around 50 r/l and ubiquity values between 21,1 and 57,9% (depending on the type of remain). The absence of barley in the profile samples can only be explained by the small size of the samples and their localized representativity. Remains of barley were also frequent in the bulk samples of sectors B and D.

In most samples, charred chaff of barley was not identified. No remains were recovered in the systematic surface samples of level VIIb and only in one of the bulk samples (JH80). These were abundant only in the systematic surface samples of level VIIa. In fact, they were only recovered in 3 squares of the western side of the excavated trench in sector D (JG79, JG80, JH80). This area was interpreted as a storage area. Ear fragments of barley were identified within this storage, in squares JG80 and JH80. No fragments of grain produced prior to charring were identified, which could indicate that there was no further processing of the crop after harvesting. Considering the obtained results (Fig. 4.134), it is most likely that barley was harvested and **stored in ear form**. The concentration values obtained would indicate that barley was only a small part of the stored crop.

All charred ear fragments were of two-rowed type (one could clearly observe a grain with a straight hilum and two attached sterile florets (see Fig. 4.110)). Therefore, it seems likely that the type of barley that was cultivated at La Draga was of two-rowed type.

In earlier work, the role of barley was considered as potentially significant within the economy of La Draga, given its ubiquity. Besides, only grains were identified, for which they were interpreted as residues of everyday human consumption (Antolín & Buxó 2011b, 162). These new results bring out complementary information to this situation. Barley was harvested in ear form and stored. Waterlogged rachis fragments of barley were identified in several squares away from the storage area (JI81, JJ80 and KA78) and charred grains were recovered in several squares (of both levels). One could conclude that these distribution of the different remains could match a *chaine operatoire* which would start with the harvesting of barley in ears, its direct transportation to the household, its storage, its processing on a day-to-day basis (waterlogged chaff remains) and, finally, its consumption and discarding of cooking residues (charred grains). The sample from square KA78 contained some dung remains; this is a hint on a possible use of chaff for animal foddering. Nevertheless, this should be a matter of future discussion, once these dung remains are analysed.

The values obtained would indicate that barley was only a small part of the stored crop. One could maybe speculate that it could have acted as a secondary crop, which could be consumed by humans in case of need. There are to date no evidences at La Draga of a large storage of barley.

Free-threshing wheat (including tetraploid and hexaploid naked wheat varieties)

Naked wheat is the best represented cereal-taxon at La Draga. Waterlogged chaff remains of naked wheat were recovered in one of the profile samples of level VIIb (with an average concentration of 2 r/l for the level) and in three samples of level VIIa (around 14 r/l in average). It was found with an average concentration of 2 r/l in the systematic soil samples of level VIIb and of 1,3 r/l in level VIIa. It was also identified in several of the water-screened bulk samples.

Among the waterlogged rachis fragments of naked wheat, a majority of remains were identified as tetraploid naked wheat. Only in one sample some nodes presented the characteristics of the hexaploid variety.

The charred remains of naked wheat were significantly more abundant. The grains appeared with average concentration values of 1 r/l in the profile samples of level VIIb and of 3,8 r/l in level VIIa. In the systematic surface samples, the average concentration values for level VIIb were of 23,1 r/l (57,1% of ubiquity) and more than 260 r/l (89,5% of ubiquity) for level VIIa. In all the bulk samples naked wheat grain was among the best represented type of remain.

Fragments of free-threshing wheat grain produced prior to charring were not identified in the profile samples, but they were identified in the systematic surface samples, both in level VIIb and in level VIIa. It is interesting to note that these (including those fragments which were not identified to species level) were 4,5% of the grain remains of square JG80 and 3,3% of JH80. This fragmentation had to be originated by some mechanical activity, and the fact that the fragments were recovered within a storage context which is interpreted as being *in situ*, should allow us to conclude that **the grain which was stored in this area had been threshed**. An alternative possibility is that some *bulgur* was stored in this area as well, but the number of fragments and the lack of large aggregates would speak against this second hypothesis. It must be kept in mind that broken grain tends to produce lumps when charred because there is no pericarp protecting all the exposed surface of the grains and the endosperm tends to swallow and stick to the nearby remains.

Charred chaff remains of naked wheat were also abundant. Two rachis fragments were recovered in the profile samples of level VIIa (average concentration around 1,5 r/l). Concentration values of 4,3 r/l were observed in the systematic surface samples of level VIIb and of 49,2 r/l in level VIIa (42,1% of ubiquity). These were also identified in several of the bulk samples. It is particularly noteworthy that the larger concentrations of chaff (*c*. 130-550 r/l) were found in squares JG80 and JH80, where the storage of grain was identified in level VIIa. Why would such concentrations of chaff remains be mixed with grain? Several possibilities occur to as, mainly derived from ethnographic models for grain storage:

1. The crop was threshed and winnowed but the by-products from winnowing were kept for later uses. They became mixed because of postdepositional factors.
2. The crop was stored in ear form, the so-called *primitive model* (Sigaut 1988, 19).

3. The harvested crop was threshed but not winnowed and stored with chaff
4. The harvested crop was threshed and winnowed and part of the winnowing by-products were used as isolating material for the storage of the grain.

The first hypothesis seems unlikely, given the taphonomic conclusions of our study. First of all, it seems that squares JG80 and both samples from JH80 present the characteristics of being *in situ*. Secondly, chaff remains are as restricted in their appearance as grain remains. A linear correlation (Pearson's correlation) was conducted between the concentration values per sample of level VIIa and the correlation value was of 5,7, which is a strong positive correlation. Therefore, the appearance of naked wheat chaff is positively correlated with the appearance of naked wheat grain. It is, consequently, unlikely that this correlation is the result of a postdepositional mixing of two or more separate storages.

The second hypothesis is more likely, given that it was considered that barley was probably stored in ear form and it was recovered in the same grain storage. Nevertheless, the important presence of grain fragments produced prior to charring would indicate that the grain had ben threshed, as mentioned above. The only ear fragment identified so far in sector D was recovered in JI80, while two spikelets of naked wheat with two grains were recovered in JG80. Such results do not support the hypothesis of ear storage. Besides, in some of the identified samples, there is even more chaff than what would correspond to ear storage (considering that the ears are of two-grained type). That would be the case of sample from level VIIa JH80 (VIIb). Therefore, the third and fourth hypothesis are the best-suited hypotheses, under the present state of research.

It is almost not possible to discern between hypotheses 3 and 4 at the present state of research. The stored crop could have been **threshed in the domestic space, on a low-scale basis** (for instance, using a stone (Alonso et al. forthcoming)), a first separation of the chaff could have been done manually and used as isolating material and the final winnowing could take place just before consumption. Otherwise, if threshing and winnowing had taken place on a larger scale, the chaff would have most likely been kept aside and used for animal foddering (for recent investigations on the use of chaff – and grain – to feed livestock see, for instance, Kühn et al. 2013) (Antolín et al. submitted).

In any case, naked wheat is the only cereal type which seems to constitute an important crop at La Draga. This was already observed in former works (Buxó, Rovira & Sauch 2000, Antolín & Buxó 2011b) and it has been confirmed in this study, where storage and waste disposal areas were identified, together with some final products of cereal origin (at least potentially) ready for consumption (*bulgur* and bread). If it was an important crop, what information do we have on the crop husbandry strategies for naked wheat at La Draga?

Fortunately, harvesting tools were preserved and recovered at La Draga. Several sorts of wooden hafts were found and all of those which were directly related with cereal harvesting presented the same shape (see Fig. 4.158): the hafts have an appendix at the end which would have been used to gather the stalks before cutting them. In order to cut the straw, a wrist movement of around 45º was necessary, since the blade was oriented towards a different direction that the mentioned appendix or hook. Consequently, experimental works have concluded that the harvesting at La Draga must have taken place at some distance from the ground (at least 12 cm) (Palomo et al. 2011). Other experimental works also concluded that this type of sickle would only be necessary when the plants were not densely sown (that is to say, by broadcasting) (Pétrequin et al. 2006). Therefore it is possible that they were **sown in rows by dibbling with the digging sticks** that have been identified at the site. Functional analyses are currently being conducted on the wooden tools of La Draga

(López-Bultó, PhD in progress, Universitat Autònoma de Barcelona; for some preliminary results see López, Palomo & Piqué 2012, Palomo et al. 2013).

The information on the conditions of growth of the plants is minimal due to the lack of charred weeds (Fig. 4.133). It would be of interest to conduct isotopes analyses on charred grains in the future in order to find out whether manure was being added to the fields either artificially (gathering dung from domestic animals and deliberately spread it on the fields) or naturally (by letting the animals to graze on the fields at certain times of the year). Nevertheless, the available record does give one significant information, which is that there are no evidences of shifting agriculture. The fact that the identified taxa are annuals would indicate that **the cultivation of the fields was permanent**.

The few available potential weeds in charred state are mainly legumes, which are usually climbing plants. The fact that only these taxa were recovered would support the interpretation of a high harvesting, as observed in experimental works (Reynolds 1985). It would be likely that in most cases, only the ears were harvested. Further evidence supporting this hypothesis is the fact that a relatively large number of fragments of straw were recovered (Fig. 4.110), but only a very low number of nodes were found (Fig. 4.160). Straw nodes have better chances of surviving the charring process (Boardman & Jones 1990). Therefore, their absence in the record probably means that they were not gathered (there is a considerable distance between the ear base and the first culm of the straw). It is important to remind that these fragments could belong, at least in part, to wild grasses. That would be suggested by the diameters observed. A total of 79 fragments were measured and these were of around 2 mm in average (0,6-5,4mm), being 54.4% of between 0,6 and 1,8 mm and 38% of between 1,8 and 3 mm. Both data are in accordance with the results and the interpretation of the charred storage (of cereal crops in ear form) of the lakeshore site of Hornstaad Hörnle 1A (Maier 1999). In this case, the culm diameters were slightly smaller (0,8-1,5) and the diversity and number of weeds higher. In conclusion, the available data seem to support a **high harvesting of the crop, between the ear and the first culm node**. This would agree with the existence of medium to low-densely sown fields and the use of the sickle types that were found at La Draga, as demonstrated in previous works in the lake Constance region (Schlichtherle 1992).

Fig. 4.158. Wooden sickle hafts from La Draga (1,2,3,4 and 5) (Palomo et al. 2011).

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Fig. 4.159. List of weeds from La Draga, ecological classification according to Ellenberg et al.(Ellenberg et al. 1992) *and to the Flora dels Països Catalans (FFPPCC) (de Bolòs et al. 2005), weed category (*sensu *Jones 1984: bfh: big,free,heavy; sfh: small,free,heavy), height of the plant (*sensu (Kreuz & Schäfer 2011)) *and real number of analysed remains (rNR).*

Fig. 4.160. Culm node of a cereal (KD81) from layer VII in sector D of La Draga (Author: F. Antolín).

If the crops were harvested high on the culm, then most of the straw was left on the fields. This would have created the opportunity for **domestic animals** to graze on them and **naturally manure** them. The fact that a large number of neonates from these herds was recovered at the site and the finding of dung in the samples would confirm that the animals were kept close to the house, at least during parts of the year, for which this possibility should not be discarded (Antolín et al. submitted). Mixed herds of goat/sheep, cattle and pigs were identified at the site (Saña 2011, Saña 2000).

Glume wheats

The presence of einkorn and emmer (as well as new glume wheat) is rather limited at La Draga. The average concentrations per sample are, in general, lower than the ones observed for barley or naked wheat (Fig. 4.161). Only waterlogged chaff remains were recovered in the profile samples, with average concentrations below 1 r/l. These concentration values were rather similar to the ones obtained for these remains in the systematic soil samples. In these samples, charred grains and chaff were better represented in level VIIa (over 20 r/l in sum). They were also present in the bulk samples, but mostly in low numbers. It was in these samples were new glume wheat was identified.

	Profile samples		**Systematic soil samples**					
	Waterlogged chaff		**Waterlogged chaff**		**Charred grain**		**Charred chaff**	
	Emmer	**Einkorn**	**Emmer**	**Einkorn**	**Emmer**	**Einkorn**	**Emmer**	**Einkorn**
VIIa	0,7	0,53	0,1		12,8	2	4,7	6,6
VIIb		0,64	0,2	2,1	0,5	0,1		0,3

Fig. 4.161. Average concentration values obtained for the different types of glume wheats according to the represented part (grain or chaff) and presented per type of sampling strategy. Levels VIIb and VIIa from sector D of La Draga.

The difficulty of understanding the role of glume wheats in the economy of the site of La Draga was already mentioned in previous works (Antolín & Buxó 2011b). The presented results do not allow straightforward conclusions. Glume wheats seem to appear in spikelet form at least in two systematic samples of level VIIa (JH79 and JH80 (VIIb)). Whether these spikelets arrived to the site in ear or in spikelet form is not clear. The mixing of spikelets of glume wheats with clean naked wheat grain was already observed in the sample JH84-85 (Antolín & Buxó 2011b). Therefore, they might have been grown together and the glume wheats could either be some sort of contaminant or some secondary crop. The lack of clear storages of glume wheat seem to discard the second possibility. There is only one bulk sample where a larger proportion of glume bases was found, which could be interpreted as some by-product from dehusking. Nevertheless, the number of analysed remains is rather low and more significant quantitative data should be recovered for further interpretations.

Opium poppy

Opium poppy is the best-represented crop at La Draga, especially considering the waterlogged remains. Average concentrations around 280 r/l were obtained for the samples from levels VIIa and VIIb in the profile samples. The average values for the systematic soil samples of level VIIb were lower, around 166,6 (0-885,5 r/l), but with a ubiquity of 100%. The average concentration for level VIIa was of 224,2 r/l (0-957,8 r/l) and a ubiquity of 95%. The main concentrations in level VIIb can be found in sample KC81, while the largest concentrations in level VIIa are in squares JH80 and JG81. Charred remains were very scarce in both levels (0,1 r/l, only found in one sample). Concentrations around 30 r/l (waterlogged remains) were observed in the bulk samples of sector B, even though they had been partially dried and not kept in proper storage conditions. It should be assumed, then, that large concentrations could have been found in this area as well.

The finding of one capsule fragment in charred state could respond to the processing of capsules in the house in order to obtain the grains. The capsule fragments would then be discarded and there would be chances for them to become charred. This is a very rare case, even for a lakeshore site where the preservation of charred remains is better than in dry sites. Therefore, as in many other previous studies (e.g.

(Jacomet, Brombacher & Dick 1989), we can conclude that poppy is dramatically underrepresented in dry mineral sites

The results obtained at La Draga are not far from the average concentration values of seeds of opium poppy from the lakeshore sites of the Alpine foreland, where the cultivation of poppy is fully assumed. For instance, in the Zürich region, average concentrations of between 250 and 3000 r/l per settlement phase were observed (Jacomet et al. 1989, 119). Also the high ubiquity of opium poppy in the systematic surface samples is comparable to the one observed in the rest of lakeshore sites where it was cultivated.

The different ways in which poppy could have been used at La Draga are, at the moment, unknown. The closest references were found in the La Marmotta site, another early Neolithic lake dwelling site which is located close to Rome, where the appearance of opium poppy was reported (Rottoli 1993). Apparently, some of these remains could have appeared within a particular ritual context (Merlin 2003). Unfortunately, no publications on this particular context are known to me. The contexts in which it appeared so far in La Draga are of domestic type, and they would rather suggest a more regular consumption of the plant.

Legumes

The role of legumes in the agricultural practices at La Draga will not be discussed in this work. The presented data do not allow new insights into this issue and previous findings were already discussed (Antolín & Buxó 2011b). In fact, only a small number of charred finds of *Vicia faba* and one *Pisum sativum* were recovered from sector A.

4.7.8.3.2. Layers VI to II

Layers VI to II were analysed in profile and water-screed bulk samples. Each layer will be briefly discussed in the next lines, given that no detailed evaluation of the agricultural practices is possible at this stage of research and with the available data.

Layer VI

Charred grains and chaff remains of naked wheat and waterlogged seeds of opium poppy were identified. The average concentration values were low. The most interesting features of this layer are the short episodes of burning which yielded some of these charred grains (see chapter 4.7.4.3.2.). They might respond to short episodes which might be interesting to analyse in the near future for a better understanding of the use of this area right after the first settlement phase.

Layer IV

Layer IV, like layer VI, was identified as a clayey layer. Nevertheless, the results of the bulk samples confirmed that an important quantity of charred grain was present in its sediments. Naked wheat was abundantly recovered, together with some glume wheats and barley. It is not clear, though, whether these remains were percolated from other layers.

Layer III

Only charred remains of naked wheat and one possible fragment of grain of barley were identified in the profile samples of layer III. In the bulk surface samples, hulled barley, emmer and einkorn were recovered as well. Naked wheat is the best represented taxon.

Layer II

The same pattern was observed in layer II. Only free-threshing wheat was identified in the profile samples. Naked wheat was equally well represented in the bulk samples, where spare finds of barley and glume wheats were also documented.

4.7.8.4.Wild fruit collection at La Draga: a unique approach in the Neolithic of the Iberian Peninsula

As already observed, the exceptional conditions of preservation present at La Draga not only allowed the recovery of interesting remains of cultivars, but also of a very large number of wild plants. As performed for other sites, in the next lines an evaluation of the potential uses of these taxa will be carried out. Further on, the more interesting taxa will be analysed in somewhat greater detail considering their distribution and concentration values within the site. Unfortunately, in many cases it was not possible to tell whether they had some specific use or not, especially when the seeds and fruits were not the consumed part of the plant. Further analyses (residues on potsherds, use-wear analyses on archaeological artifacts, etc.) could help elucidate this issue in the future. For the compilation of potential uses, several synthesis works were consulted (Leporatti & Ivancheva 2003, Tardío, Pardo-de-Santayana & Morales 2006, Mears & Hillman 2007, Hadjichambis et al. 2008) (Fig. 4.162).

		Fruits	Flowers	Young shoots	Aerial parts	Roots	Edib. rank.	Medic. Rank.
WER	***Ammi majus***			raw in salad				
WER	***Capsella bursa-pastoris***	Seeds eaten roasted and ground	eaten raw		Medicinal uses, basal leaves stewed, raw in salads		3	2
WER	***Carthamus* cf. *lanatus***				Basal leaves, raw in salad or stewed		1	1
WER	***Chenopodium album***	Edible when dried, parched and ground into flour.			Young leaves stewed		3	2
WER	***Euphorbia helioscopia* subsp. *helioscopia***				Latex used to curdle milk		1	2
WER	***Galium aparine* subsp. *spurium***				Medicinal use		2	3
WER	***Hyoscyamus niger***				Medicinal use		0	4
WER	***Lathyrus aphaca* type**						1	1
WER	***Polygonum aviculare***				Medicinal use		2	3
WER	***Polygonum lapathifolium***						1	1
WER	***Portulaca oleracea***				Tender leafs and stems raw in salad or stewed		4	3
WER	***Reseda phyteuma***						1	0
WER	**cf. *Scandix pecten-veneris***				tender basal leafs, stewed		2	1
WER	***Silene vulgaris/latifolia***				Leafs and young stems stewed, sometimes raw in salads or fried (S.vulgaris)		2	1
WER	***Silybum marianum***	seeds, raw, also medicinal value	to curdle milk, tender parts of the inflorescence, raw or stewed	peeled, raw or stewed	basal leaves, raw or stewed		3	5
WER	***Sonchus oleraceus/asper***				Basal leaves and tender stems raw in salads or stewed		2	2
WER	***Stellaria media***				Leaves and young stems stewed, infusion of aerial parts with medicinal value		2	3
WER	***Urtica dioica***			Tender leaves and stems raw or stewed	Leaves, medicinal use. Eaten boiled		5	5
WER	***Verbena officinalis***				infusion of aerial parts with medicinal value		1	2
WER	***Vicia villosa* type**	unripe seeds, raw as snack					1	0
PG	***Apium graveolens***	fresh in juice or infusion, with medicinal use		infusion, medicinal use	seasoning, raw in salads or stewed, leaves in infusion with medicinal use	fresh in juice or infusion, with medicinal use	3	3
PG	***Arenaria serpyllifolia***						2	2
PG	***Campanula* cf. *rotundifolia***						1	1
PG	***Hypericum perforatum***		flowered aerial part for herbal tea or making liqueur		aerial part in infusion with medicinal value		2	4

PG	***Leucanthemum vulgare***						2	2
PG	***Linum catharticum***						0	2
PG	***Potentilla* cf. *reptans***				infusion, medicinal value	infusion, medicinal value	1	2
PG	**cf. *Pulicaria dysenterica***						0	1
PG	***Silene gallica***						0	1
PG	***Valerianella* cf. *dentata***				Leaves eaten raw in salads			
WO	***Clematis vitalba***	With medicinal value	infusion, with medicinal value	young shoots, stewed	infusion, with medicinal value	infusion, with medicinal value	1	2
WO	***Cornus sanguinea***						2	1
WO	***Corylus avellana***	Eaten, sometimes unripe, often raw, dried or in cakes, stews or as condiment					5	2
WO	***Prunus avium***	eaten raw, for making liqueur; with medicinal value			hardened sap, chewed as chewing gum		4	2
WO	***Pyrus malus* subsp. *sylvestris***	raw, liqueur					3	2
WO	***Quercus* sp.**	fruits roasted, raw, boiled or grinded to flour to make bread		Twigs and leves of Q. ilex, to preserve olives	Barc and fruits of Q. petraea and robur used for medic. Purposes		2-5	2
WO	***Taxus baccata***	arils of the seeds eaten raw; with medicinal value					3	4
WEC	***Agrimonia eupatoria***		infusion, with medicinal value		Young aerial part for making liqueur, or infusions with medicinal value		2	3
WEC	***Crataegus monogyna***	eaten raw, for making liqueur or marmalade, infusion with medicinal value	infusion, with medicinal value	Eaten raw as snack	Leaves eaten raw as snack, infusion with medicinal value		3	5
WEC	***Fragaria vesca***	Eaten raw, jam, infusion with medicinal use		Leaves, infusion with medicinal use			3	3
WEC	***Origanum vulgare***		flowered aerial part for herbal tea. making liqueur or seasoning		infusion, with medicinal value		4	3
WEC	***Physalis alkekengi***	infusion, with medicinal value					2	2
WEC	***Prunus spinosa***	Fruits eaten raw after stored and for making liqueur, infusion with medicinal value	infusion, with medicinal value				3	2
WEC	***Rubus fruticosus* agg.**	eaten raw, for jam, or drank as liqueur or other beverages		macerated with fruits for making liqueur, eaten steamed or in soup	Medicinal uses, young leaves used cooked	Medicinal uses	5	3
WEC	***Sambucus* cf. *nigra***	Medicinal uses, jam	Medicinal uses, jam, herbal tea, liqueur				4	3
WEC	***Vicia sepium***	Green seeds eaten as a snack		Raw or steemed			1	0
LS	***Alisma plantago-aquatica***						1	3
LS	***Alnus glutinosa***	infusion of crashed cones with medicinal value					0	3
LS	***Apium nodiflorum* subsp. *nodiflorum***				tender leaves and stems in salads, boiled		no data	no data
LS	***Carex hirta* type**						1	1
LS	***Cladium mariscus***	Edible seeds					1	0
LS	***Eupatorium cannabinum***						0	3
LS	***Iris pseudacorus***					Medicinal uses	1	2
LS	***Lycopus europaeus***						1	3
LS	***Mentha* cf. *aquatica***				Aerial part as herbal tea or as a condiment		3	3
LS	***Phragmites australis***						5	2
LS	***Plantago major* subsp. *intermedia***	Medicinal use			Leaves, eaten raw, medicinal use		2	3
LS	***Ranunculus sceleratus***						1	1
LS	***Scirpus lacustris***	Edible seeds				Edible rizhomes after roasting	3	1
LS	***Vitis vinifera* subsp. *sylvestris***	Eaten raw or to make beverages and vinegar		Peeled and eaten raw as a snack			5	2
AQ	***Najas marina***						1	0
AQ	***Nymphaea alba***	fruits eaten raw	medicinal uses			medicinal uses	3	2
AQ	***Ranunculus aquatilis***						1	1
DIV	***Amaranthus* sp.**				Tender leaves and stems, stewed (A.blitus)			
DIV	**cf. *Dactylis glomerata***	Edible seeds					0	1
DIV	***Rumex* sp.**				Tender leaves, stewed (many species)			

Fig. 4.162. Ethnobotanically known uses of the plants that were identified in the seed and fruit record of La Draga, and edible and medicinal ranks for each taxon (www.pfaf.org).

A total number of 66 taxa with some economic use were identified at La Draga. Among the many different uses detected for the different parts of these plants, other than their seeds and fruits, it is interesting to notice the presence of two plants which could have been used to curdle milk: *Silybum marianum* and *Euphorbia helioscopia.* The production of milk at the site seems possible, according to the results of the archaeozoological analyses (Saña 2011). The production of derivates from milk was, therefore, feasible. Many other uses were probably given to these plants. Very significant is the case of *Clematis vitalba*: a roll made from its stem was identified at the site (Bosch, Chinchilla & Tarrús 2006). Nevertheless, the identification of seed and fruit remains from the site as by-products of other processes of production falls out of the scope of this work.There are 20 taxa which could have been gathered for their edible seeds and fruits at La Draga. The fruits of two more taxa could have been used for medicinal purposes. Most of the plants with edible seeds are those with higher edibility rank (except for some cases, like *Cladium mariscus, Vicia villosa* and *Vicia sepium*). Some other plants with high edibility rank did not appear in the reference works that were consulted, these were: *Portulaca oleracea, Urtica dioica, Origanum vulgare, Mentha aquatica* and *Phragmites australis*. If ever consumed, these plants would have probably not been gathered for their fruits. On the other hand, there are several wild plants which were relatively well represented in the samples from La Draga and which seemed not to have edible or medicinal value (or a low value). Among these, several taxa would be included, such as: *Verbena officinalis, Alisma plantago-aquatica, Lycopus europaeus, Ranunculus* sp., among others. These taxa were probably part of the local vegetation. Nevertheless, other uses of the plants should also be considered, like the use of their fibers for craftworks.

			Total VIIb			**TOTAL VIIa**				
			Profile samples	**Systematic surface samples**		**Profile samples**	**Systematic surface samples**		**Bulk samples**	
Ecological group	**Taxa**	**Preserv. type**	**Aver. concentr.**	**Aver. concentr.**	**% Ubiq.**	**Aver. concentr.**	**Aver. concentr.**	**% Ubiq.**	**Semiq.** (1:1-50; 2:50-100; 3:>100)	**Ubiq.** (1:1-2; 2: 3-5; 3:>5)
WER	*Capsella bursa-pastoris*	wg				0,7				
WER	*Chenopodium album*	wg				0,1	0,1	5,3	3	3
WER	*Silybum marianum*	wg							1	1
WER	*Vicia villosa*	ch							1	1
PG	*Apium graveolens*	wg		0,0	4,8		21,4	15,8	1	1
WO	*Corylus avellana*	wg		0,1	4,76		0,1	5,3	1	3
WO	Maloideae	wg		0,1	4,76					
WO	*Prunus* cf. *avium*	wg					0,1	5,3	1	2
WO	*Pyrus malus* subsp. *sylvestris*	wg	0,6	0,1	4,76				1	2
WO	*Quercus* sp.	ch		0,5	19		0,1	10,5	1	1
WO	*Quercus* sp.	wg	2,4	9,6	76	3,5	1,4	26,3	3	3
WO	*Taxus baccata*	wg							1	1
WEC	*Crataegus monogyna*	wg							1	1
WEC	*Fragaria vesca*	wg	1							
WEC	*Physalis alkekengi*	wg					2,9	5,3	1	1
WEC	*Prunus spinosa*	wg		0,0	4,76				1	3
WEC	*Rubus fruticosus* agg.	wg	1	4,4	33,33	1,6	8,2	78,9	3	3
WEC	*Rubus fruticosus* agg.	ch							1	1
WEC	*Vicia sepium*	ch		0,1	4,76					
LS	*Alnus glutinosa*	ch					0,1	5,3	1	2
LS	*Cladium mariscus*	wg	48,1	27,4	53,4	24,3	31,2	68,4	3	3
LS	*Scirpus lacustris*	wg		0,4	4,76		24,1	10,5	3	3
LS	*Vitis vinifera* subsp. *sylvestris*	ch					0,1	5,3	1	1
LS	*Vitis vinifera* subsp. *sylvestris*	wg	1	0,4	28,6		1,1	36,8	3	3
AQ	*Nymphaea alba*	wg							1	1
DIV	cf. *Dactylis glomerata*	wg				1				

Fig. 4.163.Average concentration and ubiquity of the wild taxa with seeds or fruits which are edible or have medicinal value, presented per sample strategy and level.

Concerning those taxa which are more likely to have been gathered for the edible or medicinal value of their seeds and fruits, a final synthesis of their average concentration values and ubiquity was carried out (Fig. 4.163). The profile samples presented a narrower botanical diversity than the systematic surface samples and, at the same time, these presented a narrower diversity than the bulk samples. Besides, the bulk samples allowed the observation of higher ubiquities for large-seeded taxa like *Prunus spinosa, Corylus avellana* and *Quercus* sp. In short, this evaluation would not have been complete if the three sampling systems would not have been applied.

In level VIIb, the best-represented taxa are *Quercus*, *Rubus fruticosus*, *Cladium mariscus* and *Vitis vinifera*. In level VIIa, these are *Apium graveolens, Quercus, Physalis alkekengi, Rubus fruticosus, Cladium mariscus, Scirpus lacustris* and *Vitis vinifera.* The bulk samples allowed the identification of other important taxa, on the basis of their higher ubiquity. These were *Corylus avellana, Prunus avium, P. spinosa* and *Pyrus malus.* Some taxa were much better represented in these bulk samples (*Quercus*, *Rubus, Cladium* and *Scirpus lacustris*).

Concerning the taxa from ruderalized areas and grasslands, it is difficult to disentangle the origin of the plants. These could have arrived to the site as weeds, or transported by humans or animals attached to their clothes or hairs, etc. The ones which present more clear evidences of having been object of human consumption are *Silybum marianum* and *Vicia villosa*. For the first case, it must be highlighted that seeds of this taxon were also recovered at the lakeshore site of La Marmotta site, in Italy. This site is slightly older than La Draga (5690-5260 BC). Besides this, it is significant to point out that the seeds appeared partly broken in both sites. According to M. Rottoli, this might be the result of the extraction of oil from the seeds for alimentary and medicinal purposes (Rottoli 2000-2001). As noted in Fig. 4.162, the seeds of this plant are edible. It is very likely, then, that this plant was well known and used by the population of La Draga. *Vicia villosa* was only identified in the bulk samples, but it was found in charred state. The fact that it is charred could be due to two factors, principally: it came as a weed and it was discarded during grain sorting or maybe it was gathered for food and the recovered item is a cooking residue. At the moment, it is difficult to discern whether one or both possibilities could have taken place. *Apium graveolens* is also a widely consumed plant in this region at present times and they could have well been gathered during the Neolithic as green salad. It might also be interesting to highlight the potential role of *Hyoscyamus niger* as a medicinal plant. It has recently been proposed that it was cultivated in LBK contexts of Germany (Herbig 2012, Herbig et al. 2013).

Taxa from woodland areas were most probably intentionally gathered. They could have arrived to the site with the gathered wood, but it is highly unlikely that they had not been consumed. Among these taxa, acorns (*Quercus* sp.) were the best-represented fruit, especially in the bulk samples, but also in the surface samples (rather high ubiquities). They were both preserved in charred and waterlogged state, but the subfossil remains were much more abundant. The rest of the taxa were preserved in waterlogged state. Hazelnuts (*Corylus avellana*) were not represented in the profile samples, and only punctually documented in the systematic surface samples. Quite the opposite, they were rather frequent in the bulk samples. Therefore, one could argue that they could have been gathered and consumed at the site. Their poor representation in the record could be due to the fact that the samples were not large enough, because of the management of residues at the site or because of taphonomic reasons (postdepositional displacement of the material). Wild apples (*Pyrus malus* subsp. *sylvestris*) were also not frequently identified but their consumption was probably frequent. Yew (*Taxus baccata*) was also badly represented at the site (only one find was recovered). All of these fruits would have been mostly gathered in autumn.

One of the most interesting finds concerning woodland taxa were the beads made of cherry stones (*Prunus avium*) (Fig. 4.164). These were already identified by this author when revising remains from old archaeological works, which were already published (Antolín & Buxó 2011b). These had been retrieved from the coarse-sieving fraction by the archaeologists. The fact that they were beads went unnoticed during fieldwork, but the observation of these beads under the binocular left few doubts. There were clear traces of the process of production (Antolín & Buxó 2011b). The stones were toasted and their surfaces are shiny and smooth (they could have been polished) (Oliva 2011). All of the identified beads from previous campaigns were perforated by abrasion (with a stone) in their proximal and longitudinal ends. Most of the finds presented in this work were of the same type, but one single case of one bead with lateral abrasion was found in square JI80 of sector D. It is particularly significant that *Prunus avium* was used for the manufacture of these beads. Charcoal fragments of this taxon were recently identified in both settlement phases of Sector D (Caruso & Piqué submitted). Similar beads were recovered from the circumalpine lake dwelling sites, mostly made of *Prunus spinosa* (e.g. Hosch & Jacomet 2004).

Fig. 4.164. Beads made of stones of Prunus avium. *La Draga (Author: F. Antolín).*

Despite seeds and fruits from woodland areas are well represented in La Draga, their concentration values are much lower than those observed in the Neolithic lakeshore sites of central Europe (Jacomet, Brombacher & Dick 1989, Hosch & Jacomet 2004), table 110: 140). It is unlikely that these differences are due to economic reasons. Therefore, taphonomic agents were probably determinant in the preservation of these remains at the site.

Plants from woodland edges and clearings were also rather well represented in the record. The best-represented taxon was *Rubus fruticosus*. Both charred and waterlogged remains were retrieved. Finds of *Rubus* were recovered from the three types of samples and high ubiquity values were obtained, especially in level VIIa. *Fragaria vesca* was only identified in the profile samples of level VIIb. Nevertheless, it is very likely that it was consumed. *Prunus spinosa* was found in the systematic surface samples of the same level and in several bulk samples. This taxon could have equally had a significant role at the site. *Physalis alkekengi* was only recovered in the systematic soil samples of level VIIa and in a few bulk samples. *Crataegus monogyna* was only identified in the bulk samples. Finally, one taxon was recovered in charred state: *Vicia sepium*. The case of *V. sepium* is totally analogous to that of *V. villosa* and it could have been consumed as well.

As observed with the woodland taxa, taxa from woodland edges and clearings are equally badly represented at La Draga when looking at their densities. *Rubus* seeds are usually found with average concentrations of around 100 r/l in lakeshore sites from central Europe (Jacomet, Brombacher & Dick 1989, Hosch & Jacomet 2004).

Finally, some lakeshore taxa could have had an economic use in La Draga. Some of them are very well represented, such as *Cladium mariscus*. But these taxa could have grown locally and it is difficult to interpret them in any other sense than as local vegetation. The fruits of *Nymphaea alba* have a good edibility value and they could have been consumed. On the other hand, several cones and catkins of *Alnus glutinosa* were recovered in charred state. The cones could have been used for making infusions but such practices are almost impossible to detect archaeologically. Finally, relatively high frequencies of finds of *Vitis vinifera* subsp. *sylvestris* might indicate that these fruits were also gathered and consumed.

The data from La Draga allowed the consideration of the frequent gathering of a large variety of fruits. This was possible because of the waterlogged conditions of preservation at the site. Otherwise, a very much reduced record would have been recovered. It should be pointed out that no signs of the existence of storages of any wild fruit were detected so far at the site. Future investigations might be revealing on this sense.

4.7.9. Summary and conclusions

The analysis that was presented for the site of La Draga brought out a large number of data of high quality, which had never before been available for this site. The application of sampling and soil processing techniques adapted from those applied for waterlogged Neolithic sites in central Europe resulted very positively.

The analysis of three profile columns allowed an accurate approach to the stratigraphy of the site and the type of preservation of each level. It was observed that layer VII might be more complex than observed during fieldwork and that short episodes might have taken place between the first settlement phase (layer VII) and the second (layer III). Anaerobic condicions only prevailed in layer VII.

The systematic surface samples taken from levels VIIa and VIIb allowed a closer approach to the differences between them and, even most importantly, to the spatial distribution of the archaeobotanical record. First of all, lakeshore influence was much more significant in the lower level VIIb, where the preservation of waterlogged material was also better. The upper level VIIa was mainly characterized by lakeshore vegetation and the documentation of a charred storage of grain. This was used to define a potential dwelling area and a potential area for the discarding of residues of everyday consumption.

Finally, the analysis of some bulk samples from sectors D and B allowed the obtention of data from a larger area, which seemed to follow (at least preliminarly) the same pattern observed in sector D. These samples also allowed the recovery of important plant remains which were underrepresented in the profile and systematic surface samples such as hazelnuts, acorns, and new taxa such as *Sylibum marianum, Iris pseudacorus* and *Nymphaea alba*.

The potential of the presented data will increase with time, when more representative data from nearby areas are obtained and more spatial patterns can be defined.

4.8. Bòbila Madurell

4.8.1. Chronology and phases

Two phases of occupation were identified in Bòbila Madurell, one dated to the Middle Neolithic phase (4200-3200 cal BC) and one to the Late Neolithic period (2900-2000 cal BC). For more details, see chapter 3.1.8.

4.8.2. Aims of the study

Bòbila Madurell is the most important open-air dwelling site of the Middle Neolithic of the region under study. Given the low number of archaeobotanical data that are available for the IVth millennium cal BC, the results that could be obtained from this site are of major significance. The potential of the site is enormous. The excavation of a very large area and a considerable number of archaeological structures (*c*. 80 storage pits) might allow the analysis of a large number of activities from different households, which would result in a unique approach to the type of appropriation of domestic resources by the Middle Neolithic farmers.

One previous report on the archaeobotanical remains of Bòbila Madurell was carried out by Leonor Peña-Chocarro and Lydia Zapata. Their results will not be included in this work, but a collective publication is under preparation.

4.8.3. Materials and methods

4.8.3.1.Sampling strategy at the site

The sampling strategy of the site was designed and supervised by the late V. López. He processed all the samples, and sorted part of them. He conducted the first identifications (samples 12/92 to 165/92 of the "Recording nr. LABEL" of Fig. III.19) but I re-analysed all the samples and carried out the identification of the remaining samples, which included all the richest assemblages. V. López did a very accurate work, but some uncertainties remained when the work was re-taken by me 20 years later. Private documents from him were made available by M. Kühn, Ö. Äkeret (from the IPAS, University of Basel) and P. González (from the Universitat Autònoma de Barcelona). Further information was obtained from the preliminary reports in the unpublished archaeological reports of the site (Mora & Martín 1992, Mora & Martín 1993).

A total number of 298 samples from two phases of occupation were obtained: 243 from the Middle Neolithic phase; 55 from the Late Neolithic phase (see the complete list in Fig. III.19 and III.20).

All storage structures were split in two **sections**, east and west, which where excavated separately in order to carry out a precise description of the stratigraphy. Both sections were dug in spits of 10 cm. Five kilograms of sediment were taken from each section and spit. The samples from the eastern section were always processed by flotation, while the samples from the western section were water-screened. This was done on purpose as a methodological approach to recovery techniques for archaeobotanical macroremains. Pit graves (see definition in chapter 2.5.1.5) were also sampled, usually keeping the sediment around the skeleton. The dwelling structures dated to the Late Neolithic period (C-1 and C-11) were sampled in those areas which were more susceptible of containing plant macroremains.

The samples from the eastern section of the storage structures were processed (mostly) through manual flotation (see a detailed list in Fig. 4.165 and Fig. 4.169). The soil was put into a bucket with water and the floating material was picked up with a strainer (unknown mesh size). This process was repeated until no more remains floated. Two deflocculating techniques were used to disgregate the clayey sediment: Calgonit and sodium hexametaphosphate $(NaPO_3)_6$. 0,048 kg of Calgonit were put in 25,5 litres of water. The sediment was then soaked for 2,5 hours, stirring every 30 minutes. Sodium hexametaphosphate only needed 30 minutes and one single stirring action after 15 minutes. In the preliminary works that were carried out by López, sodium hexametaphosphate was observed to be much faster and efficient. On the other hand, it was also more expensive.

Water screening was carried out with two sieves, one of 5 mm mesh and one of 0,5 mm.

For the Middle Neolithic, 239 samples were processed, of which 214 were clearly attributed to, at least, a recovery technique (water-screening, flotation or hand collection during fieldwork) and precisely dated to the Middle Neolithic on the basis of pottery tradition (Fig.4.165). Most of the samples were taken from several types of pits (some of which could have originally been used as storage pits), while a small number of samples were obtained from grave pits (Fig. 4.166).

The recovery techniques were not even for all structures, eight of them where only treated by water-screening, eight were floated, 22 were processed using both techniques and hand-collected material was available as the only archaeobotanical source for three further structures (see Fig. 4.165). The comparative evaluation between the different sieving methods was not systematically carried out within this work, especially because some of the data (weights, sieving methods, complete reference of the sample) were not always available.

The weight of sediment processed per archaeological feature was rather large, even though it was below 20 kg for around 20 structures (Fig. 4.168). The lower volumes were, in most cases, from pit graves. Pits were more intensively sampled.

For the Late Neolithic period, the available information is not as detailed as for the structures from the Middle Neolithic period. The processing technique is unknown and the weight of the sediment, in most cases, was also not specified (Fig. 4.169 and Fig. III.20). Most of the samples were obtained from the structure C-1, an underground dwelling structure with several features inside its limits. C-11, located nearby C-1, was interpreted as another dwelling structure. The feature 10.4 was identified as a possible storage structure.

Feature	Nr. samples	Total weight	Recovery technique	Period	Type of structure
11.1	3	unknown	water-screening	Late Middle Neolithic	pit
11.3	1	unknown	flotation	Middle Neolithic	pit grave
11.4	3	>10	flotation	Middle Neolithic	pit grave
11.5	2	unknown	water-screening	Late Middle Neolithic	pit
11.8	4	20	flotation	Late Middle Neolithic	pit
11.8	10	50	water-screening	Late Middle Neolithic	pit
G-12	1	5	flotation	Middle Neolithic	pit grave
G-13	1	-	hand-collected	Middle Neolithic	pit grave
G-14	4	unknown	flotation	Middle Neolithic	pit grave
G-15	7	>30	flotation	Middle Neolithic	pit
G-15	5	>20	water-screening	Middle Neolithic	pit
G-16	4	20	flotation	Middle Neolithic	pit
G-16	4	20	water-screening	Middle Neolithic	pit
G-17	1	unknown	flotation	Middle Neolithic	pit grave
G-17	1	5	water-screening	Middle Neolithic	pit grave
G-18	1	-	hand-collected	Middle Neolithic	pit grave
G-22	7	35	flotation	Middle Neolithic	pit
G-22	6	30	water-screening	Middle Neolithic	pit
G-23	3	15	flotation	Middle Neolithic	pit
G-23	8	40	water-screening	Middle Neolithic	pit
G-25	3	>5	flotation	Middle Neolithic	pit
G-25	3	15	water-screening	Middle Neolithic	pit
G-26	2	>5	flotation	Middle Neolithic	pit
G-26	1	5	water-screening	Middle Neolithic	pit
G-27	1	5	flotation	Middle Neolithic	pit
G-27	1	5	water-screening	Middle Neolithic	pit
G-4	1	unknown	water-screening	Middle Neolithic	pit grave
G-7	1	5	unknown	Middle Neolithic	pit grave
G-7	1	-	hand-collected	Middle Neolithic	pit grave
H-2	3	15	flotation	Middle Neolithic	pit
H-2	7	35	water-screening	Middle Neolithic	pit
H-4	5	25	flotation	Middle Neolithic	pit
H-4	7	35	water-screening	Middle Neolithic	pit
H-5	5	35	flotation	Middle Neolithic	pit
H-5	3	15	water-screening	Middle Neolithic	pit
H-6	5	25	water-screening	Middle Neolithic	pit
H-8	5	25	water-screening	Middle Neolithic	pit
J-13	5	25	flotation	Middle Neolithic	pit
J-13	10	>35	water-screening	Middle Neolithic	pit
J-24	4	20	flotation	Middle Neolithic	pit
J-24	3	>10	water-screening	Middle Neolithic	pit
J-9	1	5	flotation	Middle Neolithic	pit
J-9	1	unknown	water-screening	Middle Neolithic	pit
M-11	1	5	flotation	Middle Neolithic	pit grave
M-15	1	5	flotation	Middle Neolithic	pit grave
M-19	6	30	flotation	Middle Neolithic	pit
M-19	2	10	water-screening	Middle Neolithic	pit
M-20	1	5	water-screening	Middle Neolithic	pit
M-23	3	15	flotation	Middle Neolithic	pit
M-23	12	60	water-screening	Middle Neolithic	pit
M-24	6	30	water-screening	Middle Neolithic	pit
M-3	1	5	water-screening	Late Middle Neolithic	pit
M-7	1	5	flotation	Middle Neolithic	pit grave
7.3	13	unknown	flotation	Late Middle Neolithic	pit
7.3	4	unknown	water-screening	Late Middle Neolithic	pit
7.4	7	unknown	flotation	Late Middle Neolithic	pit
7.4	2	unknown	water-screening	Late Middle Neolithic	pit

Fig. 4.165. Number of samples per archaeological feature, total weight of the sediment and recovery technique applied. Middle Neolithic phase. Bòbila Madurell (see location in Fig. 4.178).

	number of features	number of samples	weight of sediment
pit	30	195	>780
pit grave	12	19	>40

Fig. 4.166. Number of archaeological features, samples and total weight of the sediment per type of feature. Middle Neolithic phase. Bòbila Madurell.

water-screening	8
flotation	7
both	20
hand collection	3

Fig. 4.167. Recovery techniques: number of archaeological features. Middle Neolithic phase. Bòbila Madurell.

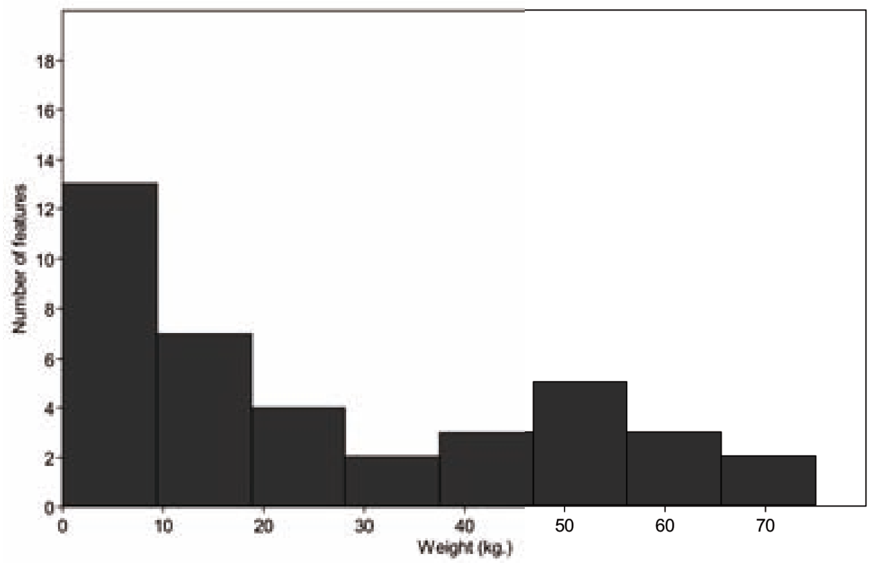

Fig. 4.168. Weight of sediment processed per archaeological feature. Middle Neolithic phase. Bòbila Madurell.

Feature	Nr samples	total weight	Processing technique	Period	Type of structure
C-1	16	>40	unknown	Late Neolithic (1st phase)	dwelling structure
C-1H	10	unknown	unknown	Late Neolithic (1st phase)	Pit in dwelling structure
C-1I	2	>5	unknown	Late Neolithic (1st phase)	Hearth in a dwelling structure
C-1.2	1	unknown	unknown	Late Neolithic (2nd phase)	dwelling structure
C-1B	3	unknown	unknown	Late Neolithic (2nd phase)	Pit in a dwelling structure
C-1F	3	unknown	unknown	Late Neolithic (2nd phase)	Pit in a dwelling structure
C-1L	3	unknown	unknown	Late Neolithic (2nd phase)	Pit in a dwelling structure
C-1_3A	1	5	unknown	Late Neolithic (3rd phase)	Pit in a dwelling structure
C-11	4	20	unknown	Late Neolithic	dwelling structure
10.4	1	unknown	unknown	Late Neolithic/Bronze Age	pit

Fig. 4.169. Number of samples per archaeological feature, total weight of the sediment and recovery technique applied. Late Neolithic phase. Bòbila Madurell (see location in Fig. 4.196).

In all the subsequent evaluations where densities of remains per sample or the total weight of sediment per context were used, an approximate value was calculated, assuming that each different sample was of 5 kg of weight, since that was the recorded volume in all the samples where this variable was noted.

Subsampling of the residues (see chapter 3.2.3. for details on methods and aims) was carried out on 4 samples of pit G-15 and 5 samples of pit G-16 (Middle Neolithic phase. A riffle box was used. Subsamples of between ½ and 1/16 were produced for the former series of samples and between ½ and 1/32 for the latter. The remaining subsamples were rapidly scanned for new taxa or rare finds.

4.8.3.2.Amalgamation of samples

As already mentioned, several structures, especially (storage) pits, were arbitrarily sampled in spits. Therefore, several samples could potentially be representing the same activity or behavioural episode. Amalgamation of samples into **contexts** becomes, then, necessary. In order to choose which samples were to be amalgamated two criteria were considered:

- the spatial location of the samples, only samples from nearby spits were amalgamated;
- a similar botanical composition: similar proportion among the cereal taxa, presence of the same wild taxa, etc..

One further criterium was used to *not* amalgamate samples: those which only contained a few crop remains (<50 r) and did not bring up new information to the sample (new taxa).

Even when the exact weight of sediment processed was not available for all samples, the quantity of remains per sample is probably comparable between samples, since, when weight data were available, 5 kg were always taken. Therefore, it is assumed that all samples were of the same weight. Ten sets of samples were amalgamated into contexts (see Figs. 4.170 to 4.172).

Most of the rest of the samples were presented per feature in amalgamated form (as contexts), mainly because they amounted to a very low quantity of remains (usually less than 10 after the amalgamation and/or with a very low number of remains identified to species level). These amalgamations were carried out in the following archaeological features: H-2, G-14, 11.8, J-24, 7.4, G-23, G-26, G-27, M-19, M-23, M-24, C-11, C-1F, C1B, C1_3A, C-1L, C-1H.

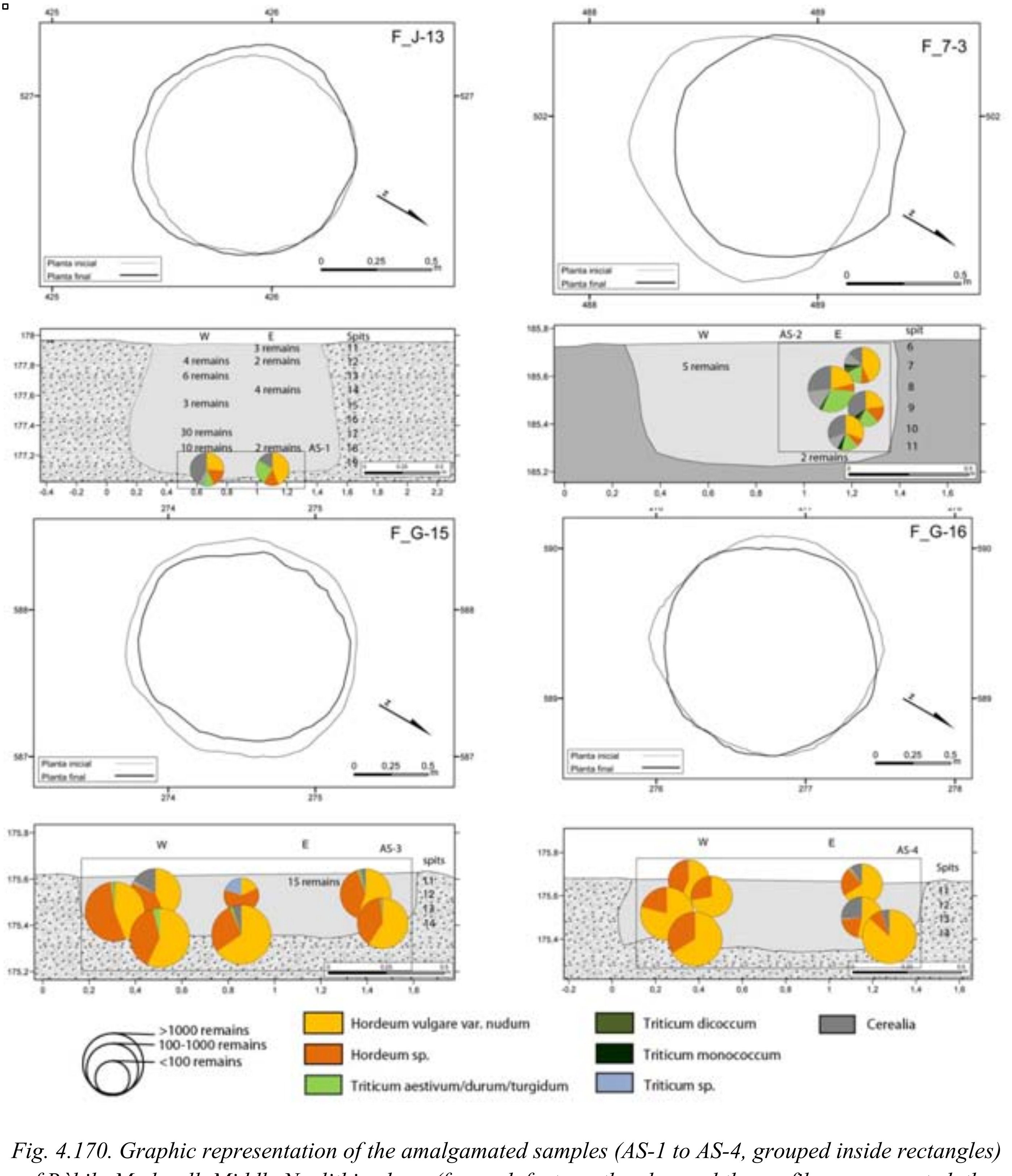

Fig. 4.170. Graphic representation of the amalgamated samples (AS-1 to AS-4, grouped inside rectangles) of Bòbila Madurell. Middle Neolithic phase (for each feature, the plan and the profile are presented, the depth of the profile can be observed to the left of the image, while indication on the location of the spits can be checked to the right of the image, see location of the features in Fig. 4.178).

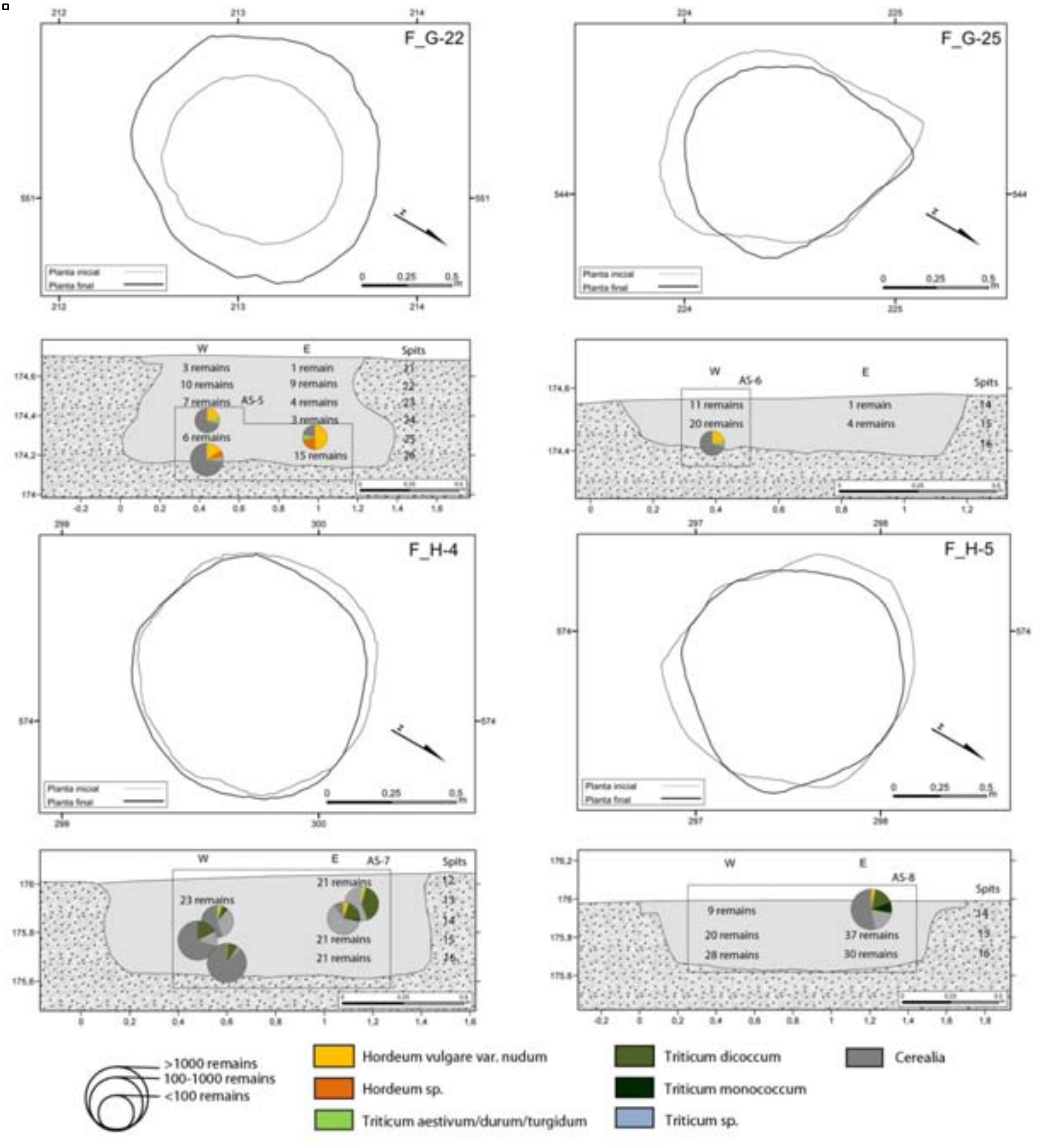

Fig. 4.171. Graphic representation of the amalgamated samples (AS-5 to AS-8, grouped inside rectangles) of Bòbila Madurell. Middle Neolithic phase (for each feature, the plan and the profile are presented, the depth of the profile can be observed to the left of the image, while indication on the location of the spits can be checked to the right of the image, see location of the features in Fig. 4.178).

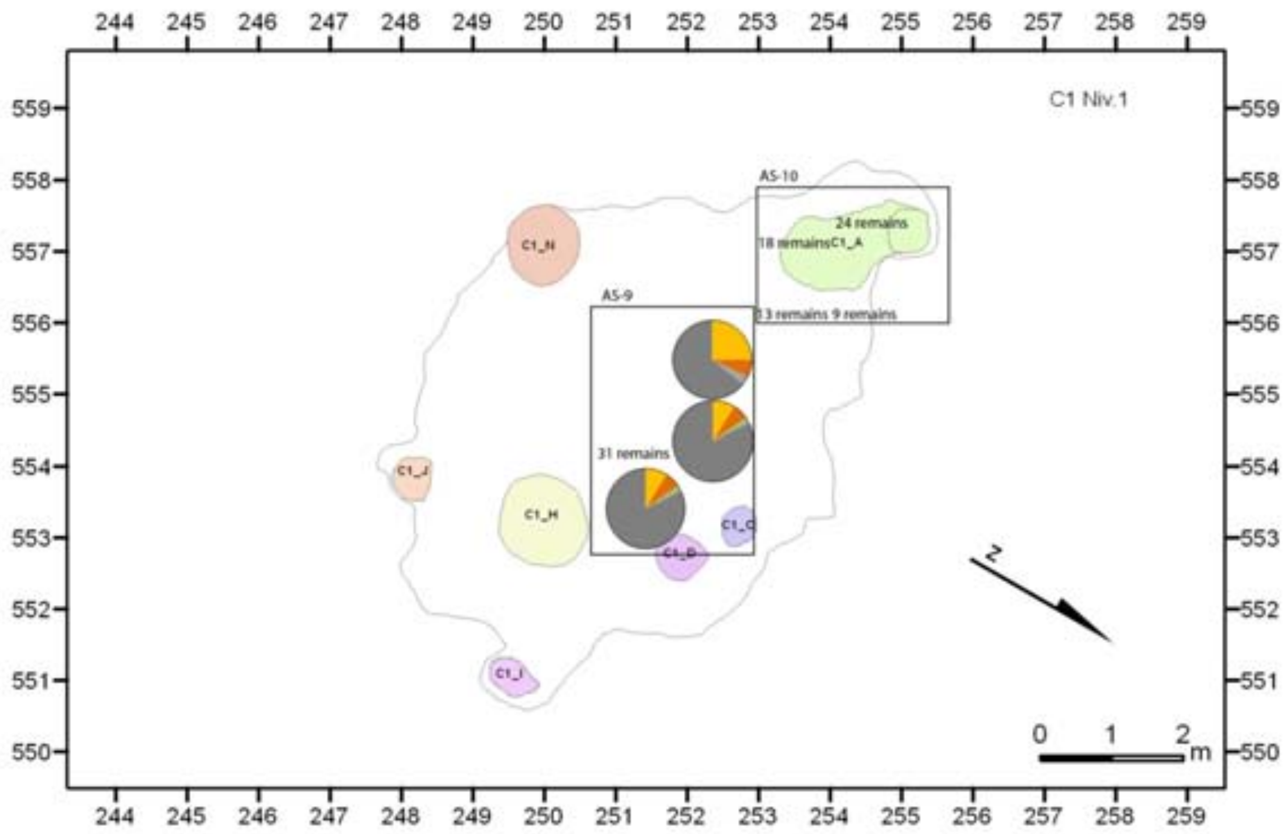

Fig. 4.172. Graphic representation of the amalgamated samples AS-9 and 10 (grouped inside rectangles) of Bòbila Madurell. Late Neolithic phase (see location in Fig. 4.178).

4.8.4. Results

A total number of 27490 items were retrieved from the analysed samples. Of these, 8845 were fully-analysed for this work. All remains were preserved in charred form. The results are presented in Fig. III.21. In the forthcoming chapters, the category "context" is used to define amalgamated samples or samples which are likely to represent single behavioural events.

4.8.4.1.The number of remains and the number of taxa per context

The distribution of the archaeobotanical remains was not homogeneous in the analysed contexts. Two of them presented a very large concentration of charred grain (pits G-15 and G-16, dated to the Middle Neolithic) (Fig. 4.173). The remaining samples presented less than 100 remains in their majority (around 35 samples) and only seven more yielded between 100 and 550 remains (Fig. 4.174).

Most of these remains were recovered in pits (=26422), a smaller fraction was found in dwelling structures (n=963) and the lowest amount was recovered in grave pits (n=24). 7 of the 12 grave pits yielded some crop remains, but in most cases they only provided one taxon and less than 5 items.

The vast majority of remains were recovered in the Middle Neolithic phase (n=26446), while the Late Neolithic assemblage was also remarkable (n=963).

The number of taxa per context was also very low. The maximum number of taxa obtained was 6, while most of the samples (n=32) only allowed the identification of one or two taxa (Fig. 4.175).

There seems to be some correlation between the quantity of sediment processed and the number of items recovered. Only in contexts where more than 40 kg of sediment were processed, assemblages of more than 100 remains were obtained. The number of taxa is low in all cases, but it seems to increase when the quantity of sediment processed is larger (Fig. 4.176).

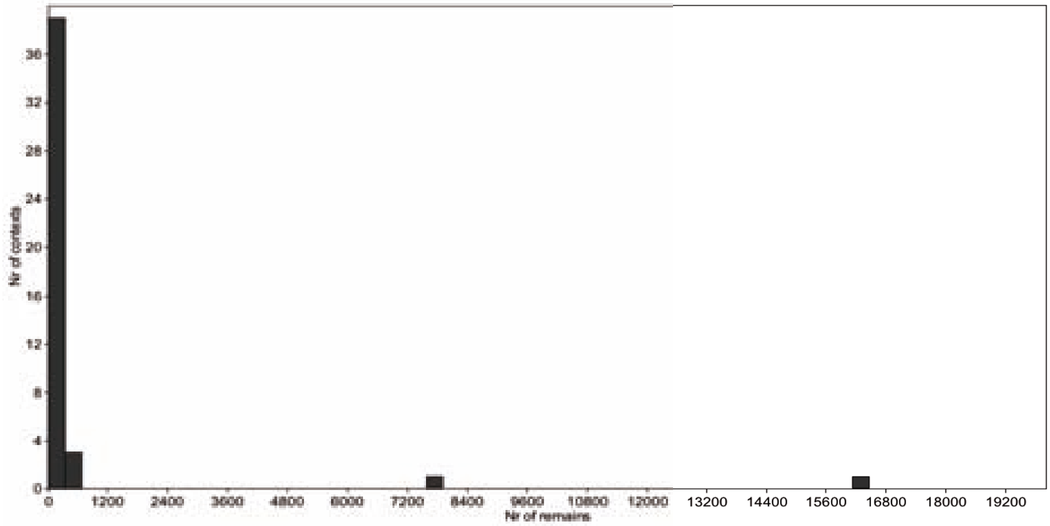

Fig. 4.173. Histogram showing the number of items per context in Bòbila Madurell.

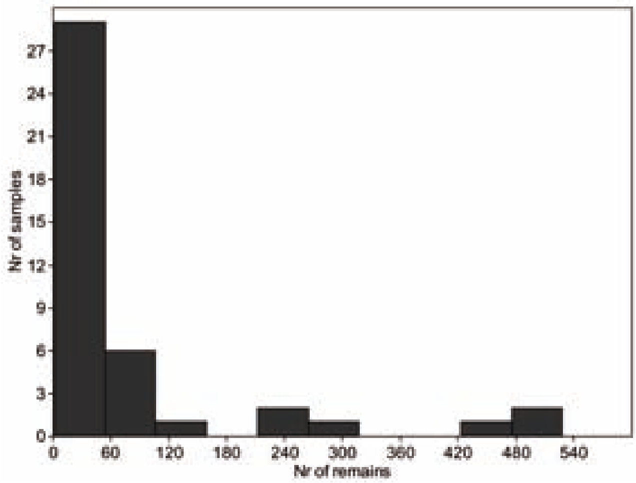

Fig. 4.174. Histogram showing the number of items per context in Bòbila Madurell, without contexts G15 and G16.

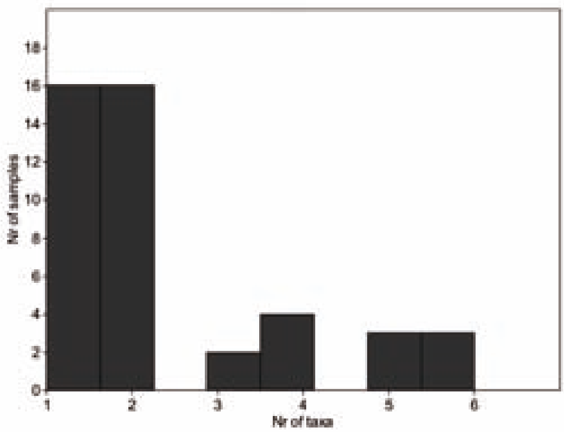

Fig. 4.175. Histogram showing the number of taxa per context in Bòbila Madurell.

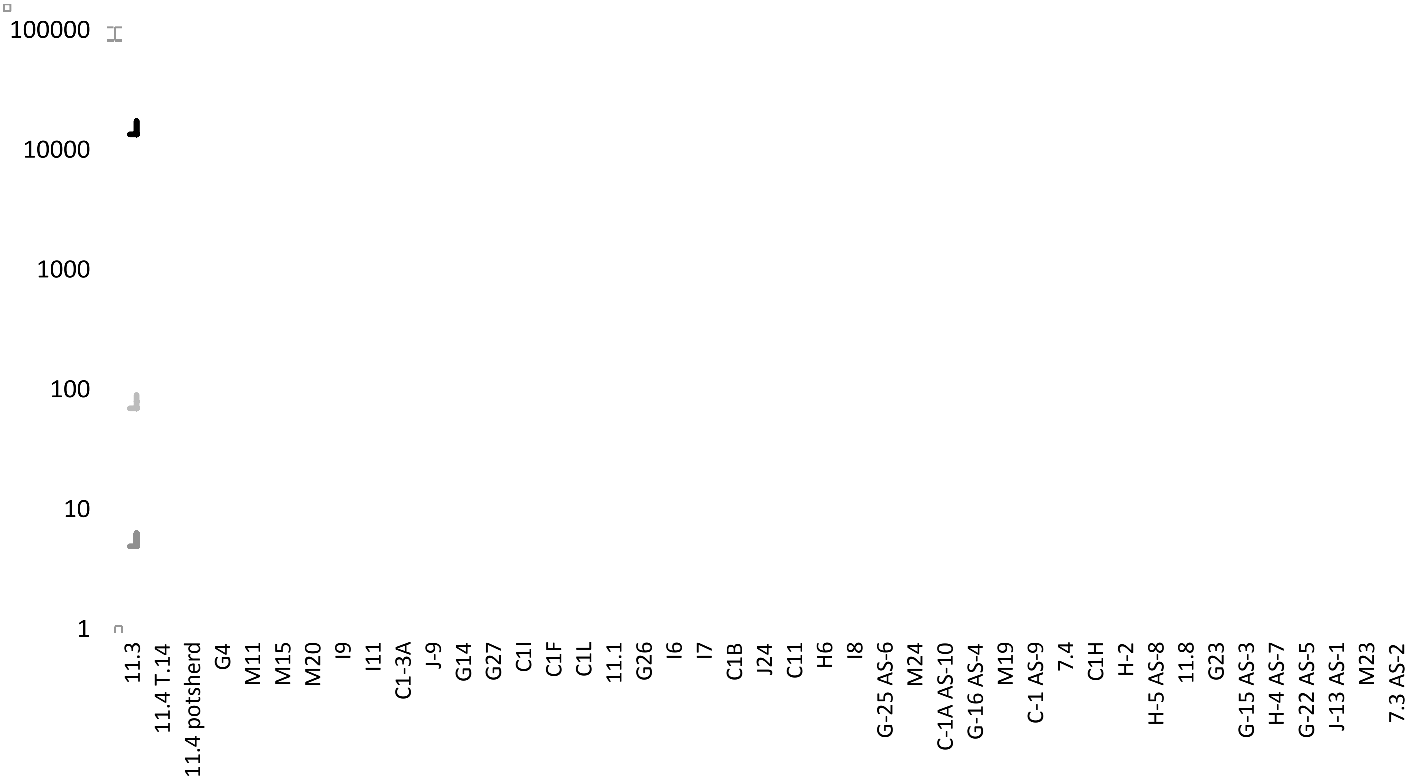

Fig. 4.176. Weight of sediment, number of items and number of taxa per context in Bòbila Madurell site.

4.8.4.2.The density of remains per context

The average density of remains per kg of sediment is of 27,84 for the Middle Neolithic Phase and of 5,07 for the Late Neolithic. Nevertheless, most of the samples presented densities below 1 r/l (n=22) or between 1 and 4,99 r/l (n=12). A few contexts (n=7) had between 5 and 20 r/l and only two of them were of above 100 r/l. The larger concentrations were found in contexts which were sampled several times (of 40 or 60 kg of sediment). No small contexts with very high concentration values were observed.

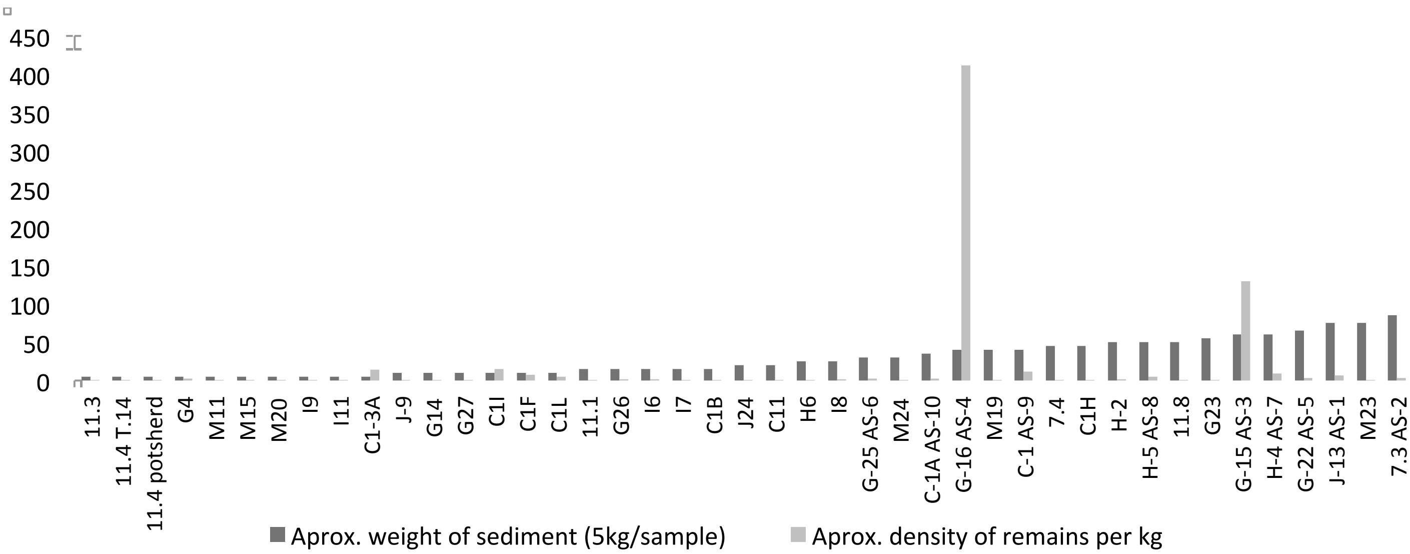

Fig. 4.177. Approximate weight of sediment per context and density of remains per kilogram of sediment in Bòbila Madurell site.

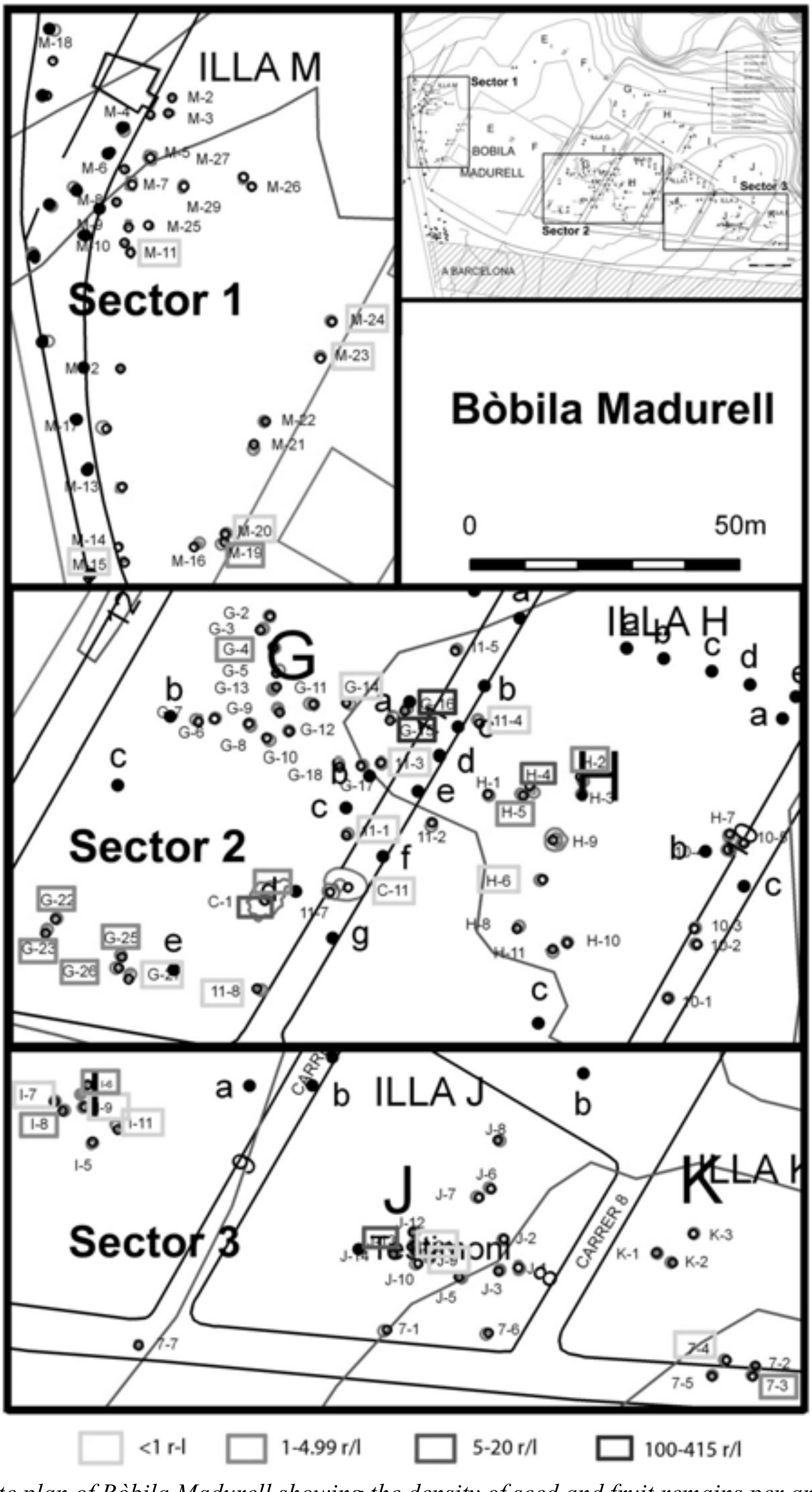

Fig.4.178. Site plan of Bòbila Madurell showing the density of seed and fruit remains per archaeological context.

The spatial distribution of the contexts with higher densities is rather dispersed. Even though the largest (and the majority of) concentrations are in "sector 2" of Fig. 4.178, structures with medium concentrations (1-5 r/l) or higher are found in each visible grouping of structures, including the dwelling structure C-1 (Fig. 4.178).

Grave pits present very low densities, usually below 1 r/l, while the higher concentrations are found in some of the storage pits and one sample from the dwelling structure C-1 (AS-9).

4.8.4.3.The botanical spectrum and the representation of the different ecological groups

Seventeen taxa were identified considering the two settlement phases (see Fig. 4.179; for details see Fig. III.21). These taxa were grouped into cultivars, weeds and ruderals (and plants from grasslands) and plants from maquis formations. Eight potential cultivars were identified, including five cereals (*Hordeum vulgare, Hordeum vulgare* var. *nudum, Triticum aestivum/durum/turgidum, Triticum dicoccum, Triticum monococcum*) and three legumes (*Lens culinaris, Pisum sativum* and *Vicia* sp.). Almost no cereal chaff remains were recovered. One single grain of hulled barley was identified but it will not be considered any further since it is a single find and the identification of grains of hulled barley is not always 100% reliable. It is worth noticing the presence of the so-called "new" glume wheat type grains. These were identified following the criteria proposed by M. Kohler-Schneider (Kohler-Schneider 2003), but their identification is not reliable, due to the absence of chaff remains. Therefore, this group of remains were purely recorded as "new" glume wheat for the sake of noticing the presence of these odd-shaped grains. Besides, the identification of some potentially cultivated legumes is only based on the size of the seeds. These could also be wild large-seeded legumes.

Among the weeds and ruderals (and plants from grasslands), four taxa were identified: *Calepina irregularis, Heliotropium* sp., *Medicago* sp. and *Polycnemum arvense*. Only one taxon from maquis vegetation was identified, *Pistacia lentiscus*. Finally, the four remaining taxa were not possible to group: *Prunus* sp., *Sambucus* sp., Trifolieae and *Vicia* sp. (small).

Taxon	Represented part	TOTAL MN	Ubiquity (%) 30 contexts	TOTAL MN/LN	TOTAL LN	Ubiquity (%) 9 contexts
Cultivars: cereals						
Hordeum vulgare	seed/fruit	1	3.33			
Hordeum vulgare var. *nudum*	Total remains	16497	73.33	13	101	77.78
Hordeum sp.	Total remains	7724	50.00	13	80	88.89
Triticum aestivum/durum/turgidum	Total remains	436	53.33	10	22	55.56
Triticum "nudum"/dicoccum	seed/fruit	1	3.33			
Triticum dicoccum	Total remains	136	13.33			
Triticum monococcum	Total remains	32	20.00		5	22.22
Triticum dicoccum/monococcum	Total remains	11	6.67			
Triticum sp./new type	Total remains	11	6.67			
Triticum sp.	Total remains	295	53.33	9	14	44.44
Cerealia	Total remains	1365	66.67	18	707	100.00
Cultivars: legumes						
Lens culinaris	seed/fruit				1	11.11
cf. *Pisum sativum*	seed/fruit	1	3.33			
Potential cultivars: legumes						
Vicia/Lens	cotyledon	1	3.33	1		
Vicia/Pisum	Total remains	4	13.33			
Vicia sp. (large)	Total remains	3	10.00		1	11.11
Vicieae	seed/fruit			1		
Weeds/ruderals/grasslands						
Calepina irregularis	fruit				1	11.11
Heliotropium sp.	seed/fruit			1		
Medicago sp.	seed/fruit	2	3.33			
Polycnemum arvense s.l.	seed/fruit	1	3.33		1	11.11
Maquis formations						
Pistacia lentiscus	seed/fruit	2	3.33			
Diverse/unknown						
Papilionaceae (large)	cotyledon	1	3.33			
Poaceae	Total remains	2	6.67		26	11.11
cf. *Prunus* sp.	fruit stone fragment				1	11.11
Sambucus sp.	seed/fruit	2	3.33			
Trifolieae	seed/fruit				1	11.11
Vicia sp. (small)	fragment	1	3.33			
Vicia/Lathyrus (small)	Total remains	1	3.33			
Bread/fruit flesh/unidentified	Amorphous object	1	3.33		1	11.11
Unidentified				1	2	11.11
Unidentifiable				15		
	Total remains	26446		81	963	
	Aprox. weight of sediment	950		65	190	
	Aprox. density of remains per kg	27.84		1.25	5.07	
	N. taxa	10		4	9	

Fig. 4.179. List of identified taxa, ecological group in which they have been classified, total number of items recovered and percentage of ubiquity in Bòbila Madurell site.

4.8.4.4.Evaluation of the representation of the taxa within the ecological groups

Cultivated plants: cereals and legumes

Cereals were the best represented group in all settlement phases at the site. In the Middle Neolithic they were found in 93,33% of the contexts and in the Late Neolithic in 100%. They were more abundant in pits but also in the dwelling structure C-1 (dated to the Late Neolithic phase). Especially significant are the concentrations of grain in pits G-15 and G-16 (Middle Neolithic phase). Only one rachis segment of barley was found in the dwelling structure C-11, dated to the Late Neolithic. Naked barley was always the best represented taxon, followed by naked wheat. The latter taxon seems to be better represented for the Late Neolithic when looking at the relative proportions obtained between the three identified taxa (emmer and einkorn were grouped as glume wheats) (Fig. 4.180). When observing the indices of relative abundance (Figs. 4.181 to 182), one can see that the ubiquity values were rather high for both naked barley and naked wheat in all phases. The glume wheats, on the other hand, were much more rarely present in the samples. It is worth noticing that emmer disappears in the Late Neolithic.

Naked barley and naked wheat were recovered together in nearly all of the structures with more than 35 crop items, except in C-1F and C-1L (pits within a dwelling pit), dated to the Late Neolithic phase (Fig. 4.183). Nevertheless, naked wheat only had a significant proportion (over 10%) in a small number of these structures (n=3). In two of these structures (7.3 and G-23, dated to the Middle Neolithic phase), naked wheat was slightly better represented than barley. The assemblages recovered in pits G-15 and G-16 almost only yielded naked barley, while the assemblages of pits H-4 and H-5 were dominated by glume wheats (all dated to the Middle Neolithic phase). The majority of samples had a considerable number of cereal grains that were not possible to identify to species level. That is particularly visible in the samples from the Late Neolithic period.

Not only complete grains were recovered, but also some fragments of grain produced prior to charring, more specifically of naked barley (n=9) and naked wheat (n=1). These were found in features 7.3, G-15 and G-16. Two fragments of some bread-type remains (amorphous charred objects) were recovered in M-20 (Middle Neolithic) and C-1F (Late Neolithic).

It is worth mentioning that cereal grains were recovered in 7 of the 12 grave pits that were sampled. Only spare grain remains were found, but both naked wheat and naked barley were identified.

Legumes were much rarer than cereals in the record. One pea (*Pisum sativum*) was identified for the Middle Neolithic period and one lentil for the Late Neolithic phase. Remains of potentially cultivated legumes were recovered in a larger number of structures, but they always appear with ubiquities below 20%. No particular concentrations were found.

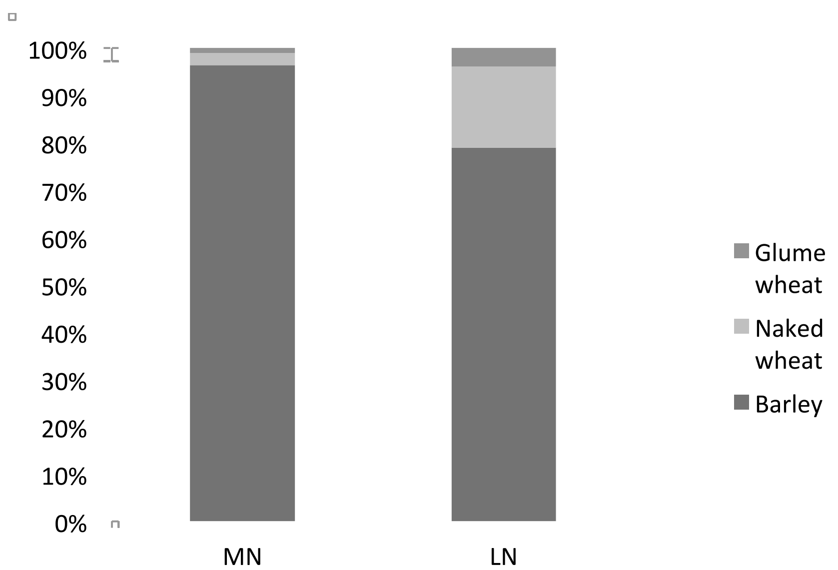

Fig. 4.180. Relative proportions among the different cereal taxa for the different settlement phases of Bòbila Madurell (MN: Middle Neolithic; LN: Late Neolithic).

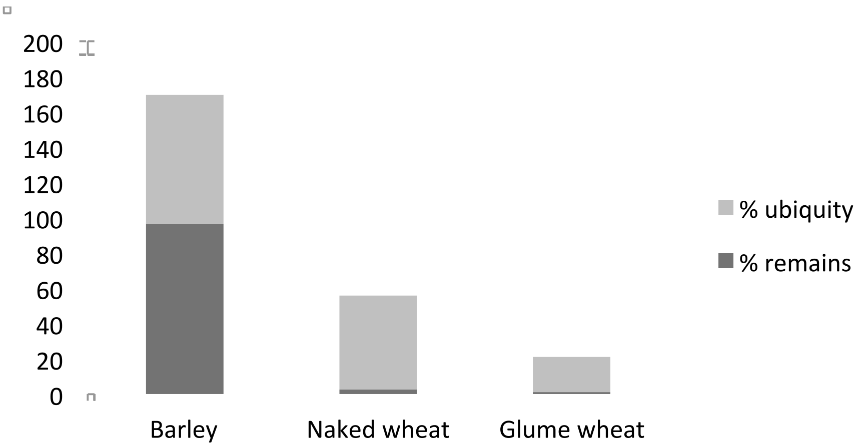

Fig. 4.181. Index of relative abundance of the three identified cereal taxa in the Middle Neolithic phase of Bobila Madurell.

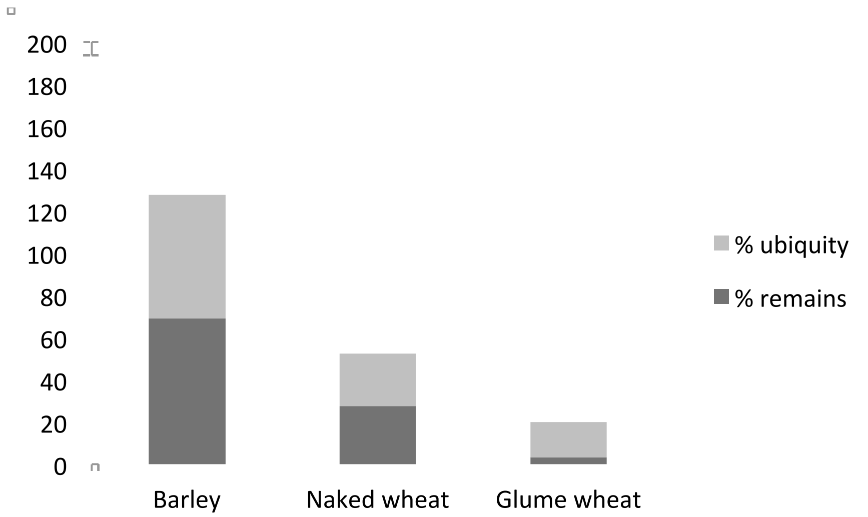

Fig. 4.182. Index of relative abundance of the three identified taxa in the Late Neolithic phase of Bobila Madurell.

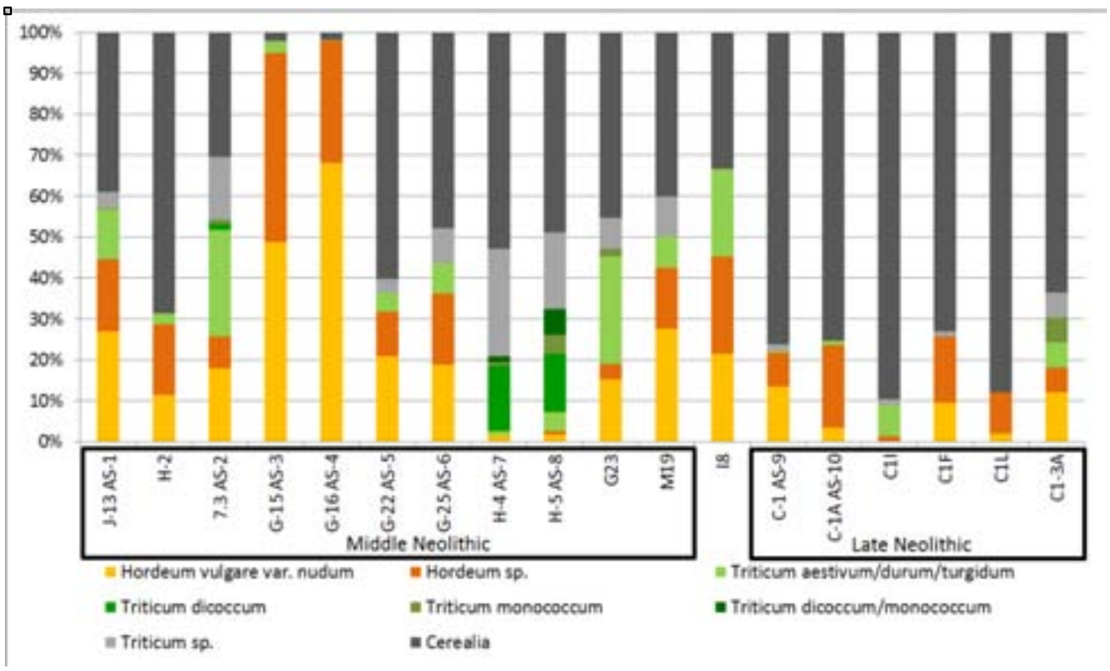

Fig. 4.183. Relative proportions among the different cereal taxa presented per context in Bòbila Madurell. Only contexts with more than 35 crop items are shown.

Wild plants

The representation of wild plants in the seed and fruit record of Bòbila Madurell was rather meagre. Nevertheless, two groups were distinguished: plants from ruderalized areas and grasslands and plants from maquis formations.

Among the group of plants from ruderal areas, four taxa were identified, as mentioned above. At least one of the taxa was represented in both of the settlement phases. They all appeared in cereal-rich samples, except for the seed of *Heliotropium* sp., which was recovered within a poor sample. *Medicago* sp. was identified for the first settlement phase, *Polycnemum arvense* for the first and second phases, and *Calepina irregularis* only for the Late Neolithic phase.

Only *Pistacia lentiscus* was identified among the taxa from maquis formations. Two fruit stones were recovered in pit 7.3 (Middle Neolithic).

4.8.4.5. The taphonomic description of the samples

In the following lines, a taphonomic evaluation of the cereal remains recovered in Bòbila Madurell is presented. Only those samples which yielded relevant results for each of the analysed variables are presented for their subsequent discussion.

The degree of fragmentation: general evaluation

The overall degree of fragmentation of the assemblage was rather high, ranging between 55 and 95% of grain fragments (Fig. 4.184). The fragmentation was mostly of irregular type (91%) (Fig. 4.185), even though in some samples the regular type of fragmentation reached nearly 20% (G-22) (Fig. 4.186). As already mentioned above, only ten of these fragments were produced prior to charring. The size of the fragments was generally large, with percentages between 50 and 90% of fragment types 3 and 4 (Fig. 4. 187). The largest proportions of small fragments were recovered in C-1_3A (pit within a dwelling structure, Late Neolithic phase) and pit G-22 (Middle Neolithic phase). The complementarity among the different types of fragmentation was low in those cases where this variable was possible to observe (Fig. 4.188).

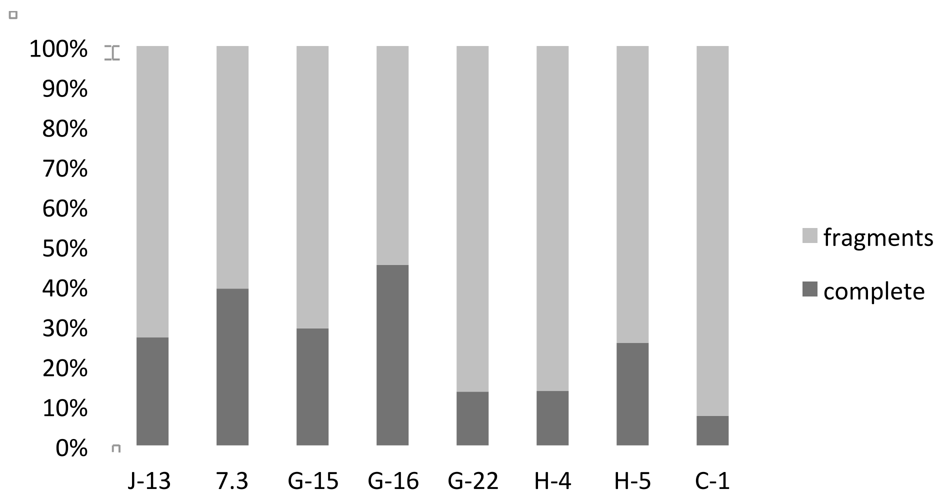

Fig. 4.184. Proportion of fragments and complete cereal grains per archaeological context in Bòbila Madurell (only contexts with enough remains to carry out this analysis are shown; all contexts attributed to the Middle Neolithic except C-1, which is dated to the Late Neolithic phase).

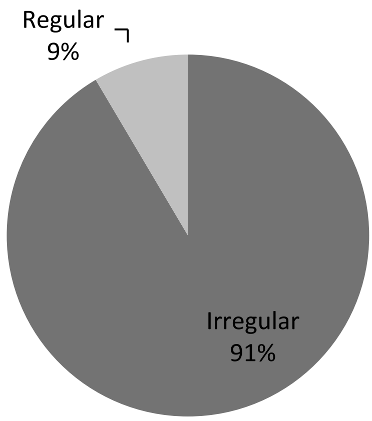

Fig. 4.185. Proportions of regular and irregular fragments of cereal grain in Bòbila Madurell site.

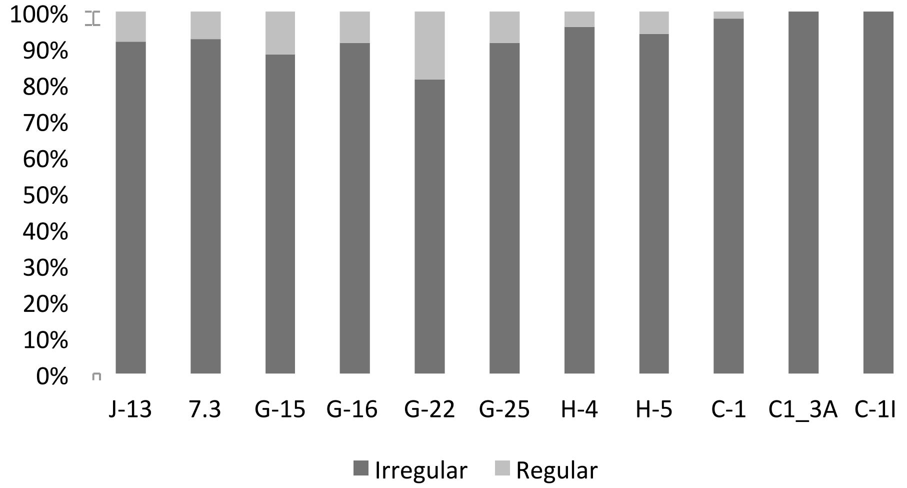

Fig. 4.186. Proportions of regular and irregular fragments of cereal grain per context in Bòbila Madurell site (only contexts with enough remains to carry out this analysis are shown; all contexts attributed to the Middle Neolithic except C-1, C1_3A and C-1I, which are dated to the Late Neolithic phase).

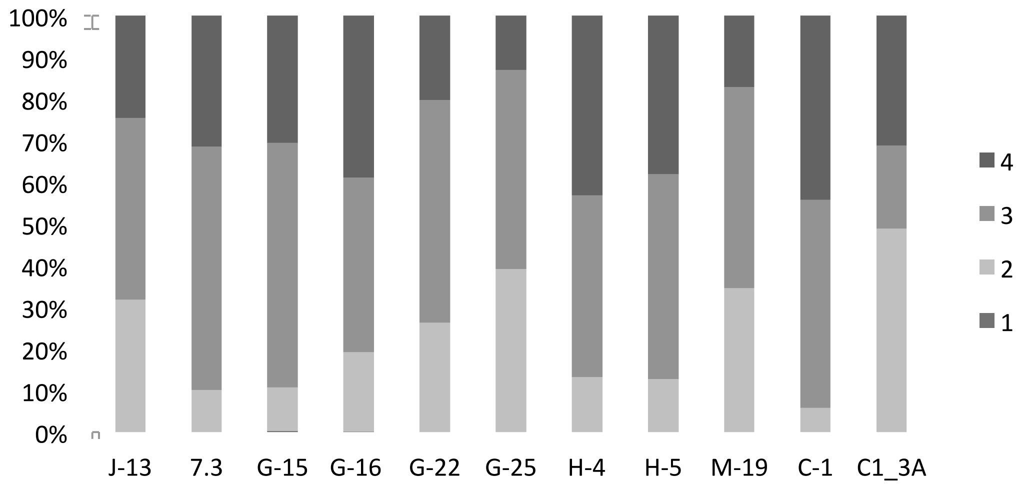

Fig. 4.187. Proportions among the different degrees of fragmentation of cereal grains in Bòbila Madurell site (only contexts with enough remains to carry out this analysis are shown; for references to the degree of fragmentation see Fig. 3.30; all contexts attributed to the Middle Neolithic except C-1 and C1_3A, which are dated to the Late Neolithic phase).

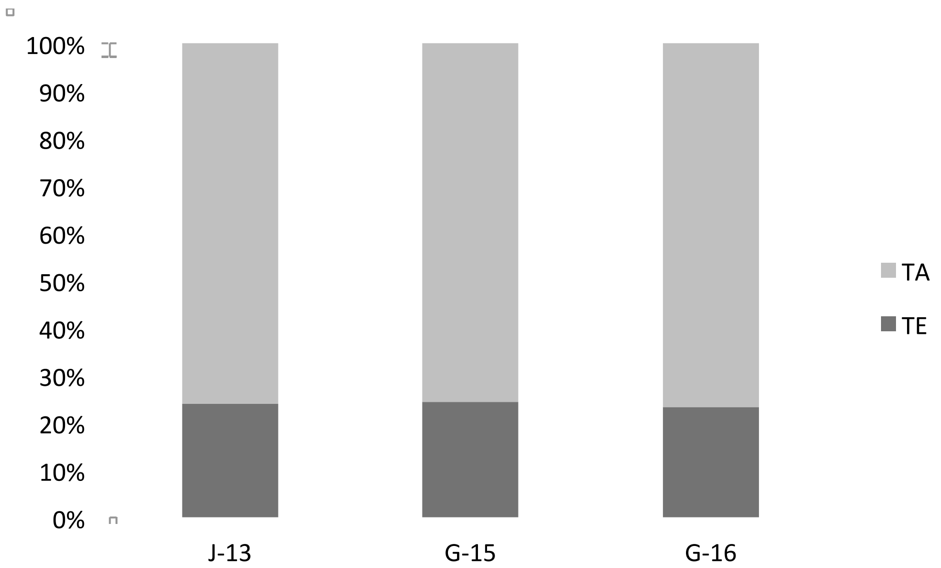

Fig. 4.188. Proportion among complementary fragments of naked barley grains in Bòbila Madurell (only contexts with enough remains to carry out this analysis are shown; TA: transversal apical; TE: transversal embryonal, see Fig. 3.29; all contexts dated to the Middle Neolithic phase.

State of preservation of the surface of the items: general description

The state of preservation of the surface of the grains was, in general, bad. In most contexts, between 70 and 99% of the items were significantly degraded and only in the features G-15 and G-16 intact and semi-intact remains were together nearly 50% of the assemblage. The assemblage from C-1 was particularly intensively affected.

Most grains lacked the embryo and only one presented signs of germination. Percentages of grains lacking the embryo were between 80 and 100%.

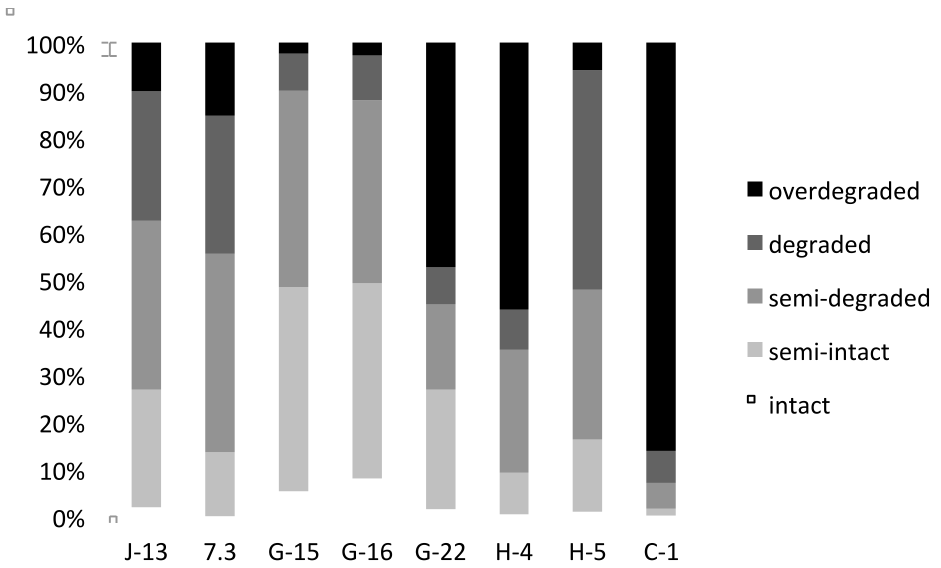

Fig. 4.189. State of preservation of the surface of cereal grains in Bòbila Madurell (only contexts with enough remains to carry out this analysis are shown; all contexts attributed to the Middle Neolithic phase except C-1, dated to the Late Neolithic phase).

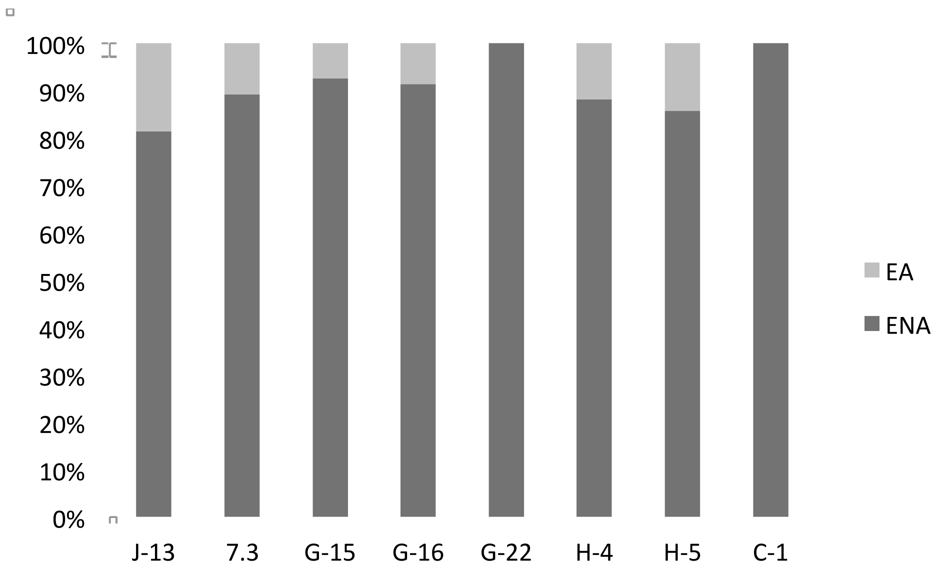

Fig. 4.190. Embryo adherence on cereal grains in Bòbila Madurell site (only contexts with enough remains to carry out this analysis are shown; all contexts attributed to the Middle Neolithic phase except C-1, dated to the Late Neolithic phase).

Effects of charring on grain morphology and surface

Charring effects were only possible to evaluate at a quantitative level for naked barley (Fig. 4.191). Around 10-20% of the grains were popped and 5-10% had protrusions. Very small percentages of grains with concave flanks were found (below 5%) except for the assemblage in C-1, where 18% of the grains presented this shape. Very few remains presented deformations due to charring inside a confined space or other types of deformations (below 3%).

Hordeum vulgare var. nudum	**Popped grains**		**Grains with protrusions**		**Grains with concave flanks**		**Deformation produced in a confined space**		**Deformation**	
	NR	%	NR	%	NR	%	NR	%	NR	%
J-13	30	20.41	15	10.20	2	1.4	1	0.68	1	0.68
R-130 (7.3)	8	14.55	3	5.45	2	3.6				
G-15	124	13.42	47	5.09	1	0.1				
G-16	311	17.10	191	10.50	5	0.3	2	0.11	13	0.71
G-22	4	9.52	6	14.29	1	2.4	1	2.38		
C-1 AS-9	1	1.67	5	8.33	11	18			1	1.67

Fig. 4. 191. Effects of charring on naked barley grains in Bòbila Madurell site.

4.8.5. Discussion

4.8.5.1. Was the sampling strategy adequate? Did the sampling in spits and sectors bring out interesting insights?

The horizontal sampling of the site was systematically undertaken and it allowed the obtention of a very significant amount of data for more than 50 archaeological features dated to the Middle and Late Neolithic periods. This is a unique case for the region, especially for the earlier phases. Comparable results were only obtained at such a large scale in sites of similar characteristics dated to the Bronze Age or later periods, such as Minferri (Juneda, Les Garrigues) (Alonso 1999, Alonso et al. in press b).

The accurate vertical sampling (in spits) that was carried out in Bòbila Madurell allowed the identification of potential behavioural episodes. Our results seem to indicate that a single episode is represented in most of the pits.. Only at the dwelling structure C-1, two different assemblages were defined on a spatial basis (AS-9 and AS-10, see Fig. 4.172).

The excavation of most of the structures in two sections (east and west) was meant to compare two different soil processing techniques (flotation and water-screening). This evaluation was difficult to conduct twenty years after the processing of the samples and it was not within the targets of this project. Nevertheless, the results in Figs. 4.170 and 4.171 showed that both sectors usually gave very similar results. Therefore, both methods seem to have been equally successful.

More problematic for the present analysis was the fixed amount of sediment that was processed per spit. The definition of a constant volume per sample is an easy instruction for archaeologists to follow but it may not be optimal for the subsequent archaeobotanical analyses. It was already observed above that contexts of more than 40 kg of sediment seemed to yield higher amounts of remains (Fig. 4.192). Consequently larger samples would have potentially yielded better results for at least part of the analysed contexts. This fixed quantity of volume might also affect the final record on another level. Small concentrations (of, for instance, 0,5 litres of volume) could have not been properly identified in samples of 5 kg of weight.That might explain why small samples with high concentrations of remains (which may represent short events in the past) were not identified in our record. Flexible sampling strategies seem to be optimal in most archaeological sites, thus combining the systematic samples with judgement samples which can give insight to particular features of high interest (*sensu* Jacomet & Brombacher 2005).

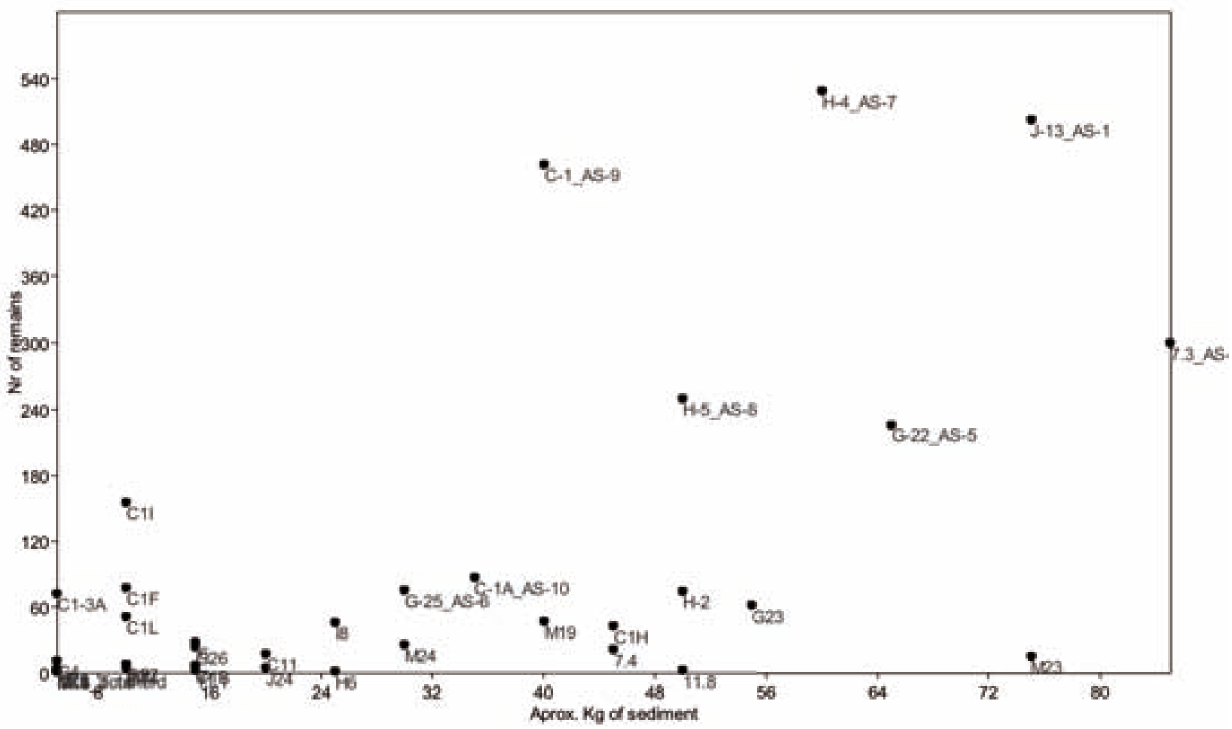

Fig. 4.192. Relation between the approximate quantity of sediment per context and the number of items recovered in Bòbila Madurell site.

4.8.5.2.Depositional and post-depositional history of the assemblages of charred grain: assessing the representativity of the samples

As in preceding chapters, I will focus the taphonomic analysis on those samples which have 35 remains or more. First, the charring conditions will be analysed and then the post-depositional effects will be discussed.

Concerning the charring conditions, these seem to have been rather homogeneous for all the Middle Neolithic contexts (Fig. 4.193). The characteristics of the assemblages seem to indicate that they were exposed to temperatures around 250°C and low heating rates. However, the materials recovered in the dwelling structure C-1 (dated to the Late Neolithic), seem to have been exposed to higher termperatures and, therefore, they might have had a very different origin. It must be kept in mind that all the features from the Middle Neolithic phase were pits. For the Middle Neolithic contexts, the charring conditions would have allowed the preservation of rachis remains. In the Late Neolithic assemblage, these could have started to disintegrate after reaching 300° C. In any case, the charring history seems appropriate for the conduction of further evaluations of the composition of the samples.

Hordeum vulgare var. *nudum*	**% Popped grains**	**% Grains with protrusions**	**% Grains with concave flanks**	**Heating treatment**
J-13	20.41	10.20	1.36	250 LHR
7.3	14.55	5.45	3.64	250 LHR
G-15	13.42	5.09	0.11	250 LHR
G-16	17.10	10.50	0.27	250 LHR
G-22	9.52	14.29	2.38	250 LHR
C-1 AS-9	1.67	8.33	18.33	300-350 LHR

Fig. 4.193. Evaluation of the heating treatment of the cereal-rich samples of Bòbila Madurell.

Concerning the conditions of charring, it is also interesting to notice the presence of some deformations produced by the charring of the grains in a confined space. These were only identified in significant numbers in two pits: G-15 and G-16. The percentage of aggregates is rather low (below 1%). Therefore, it seems that the exposure to heat took place in a rather open environment (for instance, a pan).

SAMPLE	**Dominant crop**	**Fragmentation**	**Fragments type 1-2**	**Type of fracture**	**Complementarity**	**Degradation oft he surface**	**Embryo**	**Density**	**In situ charring**	**Type of refuse**
J-13	nb(nw)	medium	low	irreg	low	high	low	low	no	secondary
7.3	nw(nb)	medium	low	irreg		high	low	low	no	secondary
G-15	nb	high	low	irreg	low	medium	low	medium	no	secondary
G-16	nb	medium	low	irreg	low	medium	low	medium	no	secondary
G-22	nb(nw)	high	low	irreg		high	low	low	no	unknown
H-4	gw	high	low	irreg		high	low	low	no	unknown
H-5	gw	high	low	irreg		high	low	low	no	unknown
C-1	nb	high	low	irreg		high	low	low	no	unknown

Fig. 4.194. Taphonomic evaluation of the samples from Bòbila Madurell: charring and type of refuse (nb: naked barley; nw: naked wheat; gw: glume wheat).

After the analysis of the different variables under consideration for the post-depositional characterization of the samples, it was concluded that none of them was charred *in situ* (the high proportion of fragments but their low complementarity indicates so) but that some of them could have been intentionally deposited in one or few actions (Fig. 4.194). These are the assemblages recovered in pits J-13, 7.3, G-15 and G-16 (dated to the Middle Neolithic phase). Besides, the materials were (irregularly) fragmented and eroded in most cases. Since the size of the majority fragments was rather large, it is likely that they were not exposed to postdepositional agents for a long time before they were deposited inside the pits. The observed percentage of remains with a highly degraded surface on some of the assemblages (pits G-22, H-4 and the dwelling pit C-1) seems to indicate that some of them could have suffered more severe post-depositional agents.

These conditions of preservation are not optimal, but they are still sufficient for a general characterization of the palaeoeconomy at the site, especially for the Middle Neolithic phase, which is significantly better represented.

4.8.5.3.Main cultivars at Bòbila Madurell and insights to crop husbandry practices. Evaluation at a spatial level

It was already pointed out that up to eight potential cultivars were identified in Bòbila Madurell: seven for the Middle Neolithic phase and five for the Late Neolithic phase. Among these, cereals were the best-represented ones. Naked barley seems to be the most important crop in both phases (Figs. 4.181 and 4.182). It appears together with naked wheat in most samples. It is possible that both crops were grown as a maslin or that some crop rotation existed (naked barley after naked wheat, for instance; for a further discussion on this topic within later Neolithic contexts of central Europe, see e.g. Jacomet, Brombacher & Dick 1989, Willerding 1996, Brombacher & Jacomet 1997).Nevertheless, pure assemblages of naked barley were also identified (in pits G-15 and G-16). All the analysed samples belonged to clean crops in the last stage of processing. Weeds and chaff remains were barely non-existent.

For a final evaluation of the economic role of cereals in Bòbila Madurell site, a **spatial** representation of the obtained results becomes necessary (Figs. 4.195 and 4.196). Most of the available data are from the Middle Neolithic phase, and a spatial approach makes more sense for this period, since sufficiently grain-rich samples were obtained from all over the excavated surface. Some characteristic patterns emerge from this representation and previous observations concerning the density of remains per structure (see Fig. 4.178). First of all, it is interesting to see that structures with medium to high densities of remains are found in each concentration of pits (excluding grave pits). This would speak in favour of a repetition of a similar phenomenon, for instance, everyday refuse disposal by different households. It is unfortunately not possible under the present state of research to relate these concentrations of pits to particular households or even to put forward a relative chronology between them. It is significant to note, on the other hand, that barely any of these structures intersect with one another, for which it is possible that they were either contemporary or they belonged to different generations of the same household (which, for instance, could have facilitated the persistence in the memory of their members of where old storage pits were located). Secondly, quite a similar pattern is observed in the excavated surface. The most frequent type of assemblage presents a combination of naked barley and naked wheat (normally naked barley prevails but some structures show fluctuations in the percentages). Therefore, besides the issue of how many households and generations might be represented in our record, this common pattern seems to characterize the economy of the site.

Two sets of samples present a different composition from this general pattern. On the one hand, two nearby assemblages presented a very large **concentration of grains of naked barley** (in pits G-15 and G-16).

These were the samples with a higher density of remains at the site and they probably respond to a single action. One possibility would be that this was an *in situ* burnt storage. The previous taphonomic analysis seemed to conclude otherwise. These assemblages probably got charred outside the structure and were then deposited/discarded inside. Therefore, this seems to be an accident which could have occurred during the toasting of the grain. It must be reminded that most of the grains lacked the embryo, which could be the result of some insect infestation during a long-term storage. The toasting of grain after long-term storage before putting the grain into smaller ceramic vessels has been ethnographically recorded (Ferchiou 1985). The presence of large storage vessels suitable for this kind of short-term storage were also recorded at the site (Masvidal, González & Mora 2005). In conclusion, these large accumulations of grains lacking embryos, which were exposed to low heating temperatures, might respond to accidents during roasting.

Furthermore, two samples, which were located close by, presented a different crop composition: pits H-4 and H-5. **Glume wheats** dominated these assemblages. The state of preservation of the surface of the grains was among the worst cases of the site. This fact, together with the severe fragmentation of the remains, did not allow the identification of most the remains to species level. Along with these evidences, the fact that these assemblages were also lacking chaff and weed remains indicates that they probably were residues of the culinary processing of the grain for human consumption.

The identification of these assemblages of glume wheat grain in such a localized area of the site opens many questions without a satisfactory answer. Do they belong to a single household which was only growing glume wheats? Was this a risk-reducing strategy? Were all households producing free-threshing and non-free-threshing cereals? Were these crops imported as a supplement after a bad yield? The localized situation of both of these structures probably indicates that this was a localized phenomenon. It is unlikely that glume wheats were one of the main crops at the site. In order to further investigate whether these cereals were locally grown, isotopic analyses might be more elucidating.

Finally, it should be shortly discussed if the few grain remains that were recovered in **grave pits** might have been part of food offerings. The evidences are too scarce, but one of these grains was found inside a potsherd (grave pit 11.4). It is possible that these grains were slightly toasted before depositing them in bowls and that only the charred remains survived until the present. This possibility is difficult to demonstrate with other evidences, since cereal grains do not produce phytoliths and lipid residues on potsherds usually over-represent lipids of animal origin. Other analyses on microremains (such as starch remains) might be essential for this question.

Pulses were poorly preserved in the analysed samples. They were always recovered together with charred cereal grain and in small samples. It is not possible to state their importance in the diet in Bòbila Madurell site, but it seems to be somewhat lower to that of the cereals, especially for the Late Neolithic phase. It must be reminded that we lack of domestic contexts for the Middle Neolithic period. These might yield more significant data concerning pulses, since it is more likely to detect accidentally charred remains during cooking activities.

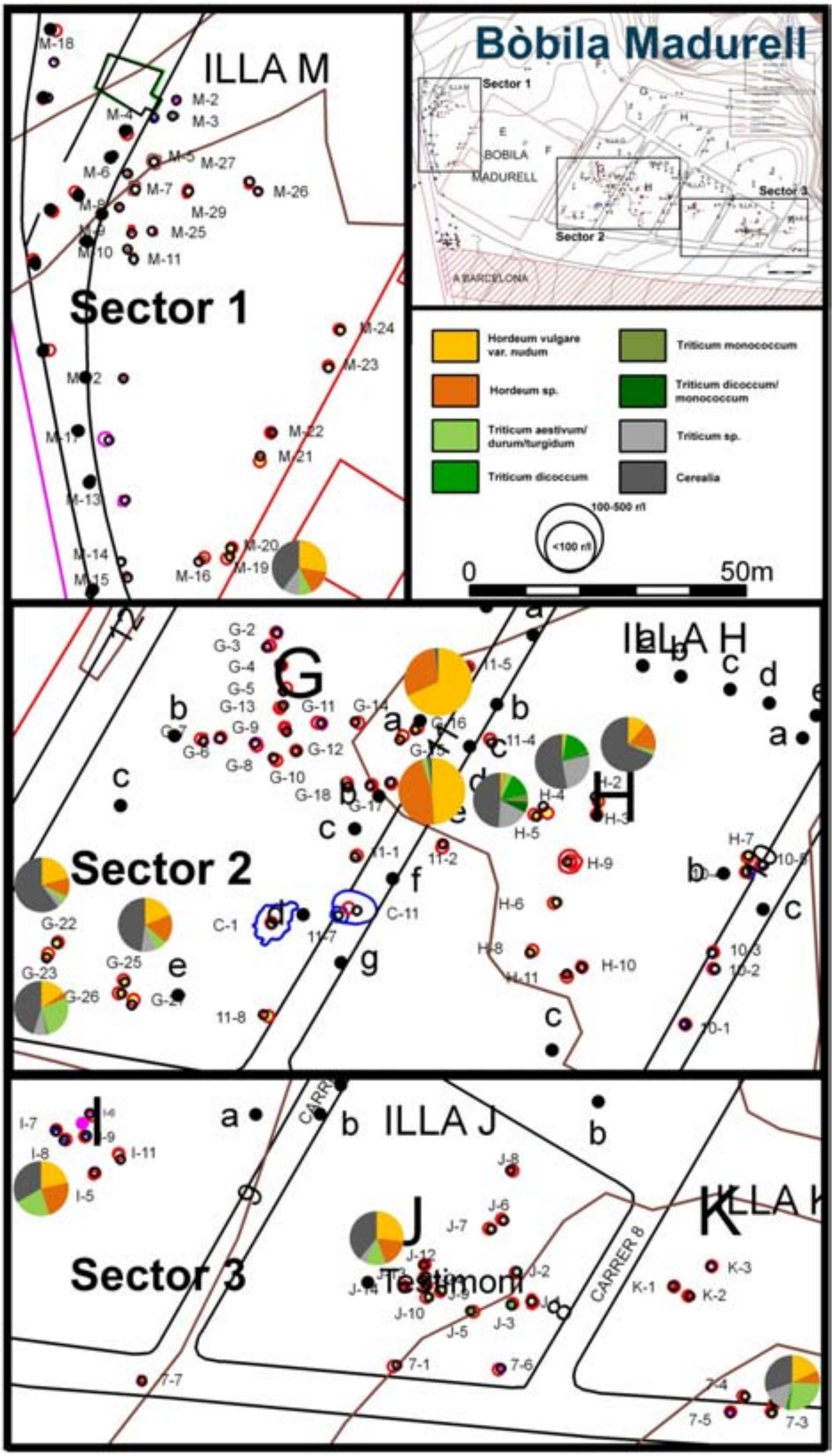

Fig. 4.195. Spatial representation of the proportion among the different cereal taxa per context in the Middle Neolithic phase of Bòbila Madurell.

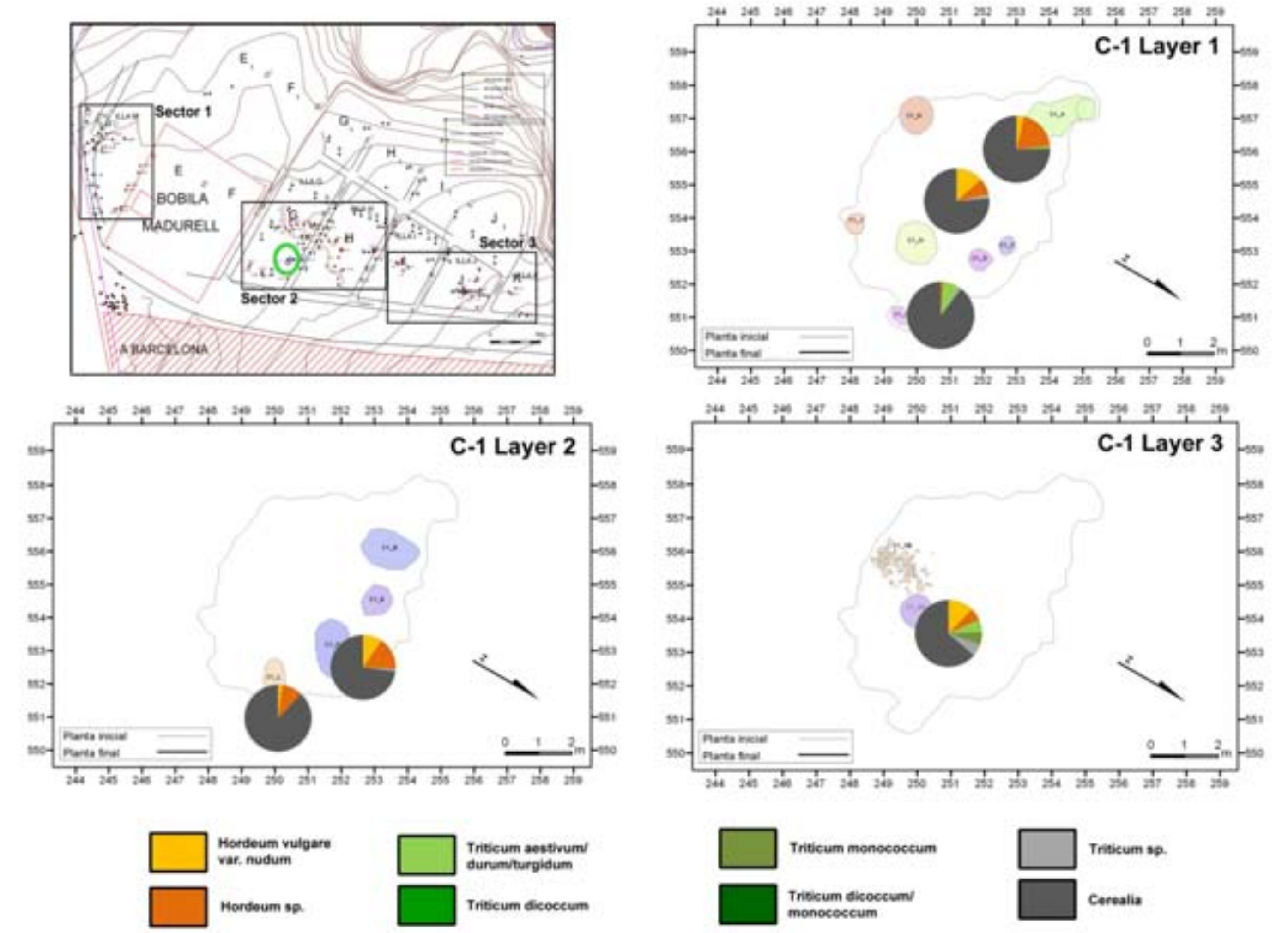

Fig. 4.196. Spatial representation of the proportion among the different cereal taxa per context in the dwelling structure of the Late Neolithic phase of Bòbila Madurell.

The weed assemblage of Bòbila Madurell is very meagre. For the Middle Neolithic, only *Medicago* sp. and *Polycnemum arvense* were identified; for the Late Neolithic *Calepina irregularis* and *P. arvense*. Both *Calepina* and *Polycnemum* are short plants (Fig. 4.147). If these were weeds, they would indicate a low harvest. This would be partly confirmed by the results of the usewear analyses on lithic tools from the site, at least for the Middle Neolithic phase (Clemente & Gibaja 1998, Gibaja 2002a, Gibaja 2003).

None of these weeds would be typical of shifting agriculture, since they are both annuals. The fact that they both have short to intermediate flowering periods would indicate less intensive husbandry practices, while the early flowering period of *Calepina* (before June) and the germination period of *Polycnemum* in Autumn are typical of Autumn-sown fields. Nevertheless, we are far from having a representative weed assemblage for the site. One can only conclude that, if anything, the weeds from the Late Neolithic phase would be typical of less intensively managed fields which were sown in Autumn.

Taxon	**Height**	**Life cicle**	**Flowering period**	**Germination period**
Polycnemum arvense	Low	Annual	VI-IX	Autumn
Calepina irregularis	Low	Annual	IV-VI	unknown

Fig. 4.197. Ecological characterization of the weed spectrum from Bòbila Madurell.

4.8.5.4. Wild fruits in Bòbila Madurell: were they an important economic resource?

One of the most striking features of the archaeobotanical record of Bòbila Madurell is the absence of wild fruits. Were they not being gathered and consumed? Were they not being processed at the site? Only two stones of *Pistacia lentiscus* were recovered in pit 7.3, dated to the Middle Neolithic. The fruits of *Pistacia* do not have a high alimentary or medicinal value according to the PFAF database (value=2). There are not many uses recorded for its fruits, other than in Cyprus (present in several traditional recipes of cakes, sausages and oil) and Greece (consumed as pickles) (Hadjichambis et al. 2008, Hadjikoumis 2012). It seems that they were also used for making oil in the Iberian Peninsula in times of need when olive oil was not available (Torres-Montes 2004,37. Other potentially gathered fruits could be *Sambucus* sp. and *Prunus* sp., but their representation at the site is also very low and their identification too imprecise. The available data do not allow further conclusions on wild plant use at the site.

4.8.6. Summary and conclusions at a site level

The results obtained for Bòbila Madurell are of great value for the characterization of agricultural practices during the Middle Neolithic in the region under study. A large assemblage was recovered and several patterns were observed. Naked barley and naked wheat seem to be the main crops at the site. Glume wheats were detected, especially in two underground pits. They probably had a minor role at the site, but they could constitute an important resource in times of need. Crop husbandry practices were not possible to define for the Middle Neolithic phase. For the Late Neolithic period, the available weed spectrum is very meagre, but it might point towards somewhat more extensive agricultural practices and autumn-sown crops. Further data would be necessary to confirm this hypothesis. It seems that naked barley and naked wheat were at least occasionally cultivated as monocrops. Some evidences have been put forward to propose that naked barley was stored in large underground pits and eventually toasted and put into smaller vessels for everyday consumption. The role of wild fruits in the economy of the site was not possible to characterize. They were nearly absent from the record.

4.9. C/Reina Amàlia, 31-33

4.9.1. Chronology and phases

The site of C/Reina Amàlia, 31-33 is considered as one permanent dwelling site dated between 4700 and 4360 cal BC (based on the available radiocarbon dates). Three phases were identified on a stratigraphic basis. The foundation of the site (UE 95, from feature III, and feature XX, two hearths), would be followed by a second phase (UE 59 and UE 46, both from feature III, a hearth, and feature XV, a burial) and a final burial episode (feature XIV). No rupture is observed during these three episodes (González, Harzbecher & Molist 2011). For further information, see chapter 3.1.9.

4.9.2. Aims of the study

The site of C/Reina Amàlia 31-33 offers the possibility to carry out an in-depth analysis of one dwelling structure and the surrounding features, which could have had different functions (storage pits, grave pits, hearths, etc.). Such an approach has a very good potential for the identification of domestic storage or crop processing activities, as well as targeting domestic refuse management practices.

4.9.3. Materials and methods

4.9.3.1.Sampling strategy at the site

The sampling strategy was designed and carried out by the archaeologists. Judgement samples were taken from most of the structures, especially when archaeobotanical material was visible during fieldwork. Thirty samples and 472 litres of sediment were obtained and processed for this study (see the complete list in Fig. III.22). Anna Rodríguez (from the IPHES, Universitat Rovira i Virgili) processed 89 litres of sediment (UE 107, UE 131, UE 133, UE 134 and UE 136) for a preliminary report. These materials were incorporated to the present study and the identification work was finalized. In some occasions, several samples were taken from the same stratigraphic unit but at different depths. These were amalgamated when possible following the same criteria as mentioned in chapter 3.2.8.

The archaeologists consider that the site was occupied during *c.*400 years, but two settlement phases can be distinguished from the available radiocarbon dates, even though no real hiatus was identified: 4700-4500 cal BC and 4500-4300 cal BC. The sampling strategy allowed a good representation of both phases. A similar number of samples were obtained, from a rather comparable number of features, and more than 200 litres of sediment were processed for each phase (Fig. 4.199). For the first phase (4700-4500 cal BC), most samples came from two hearths and one burial context (Fig. 4.199). For the next phase, storage pits were more extensively sampled, while only a small sample from a burial context was processed. Most of the sediment sampled from the second phase of occupation came from two hearths (Fig. 4.200).

The average volume per sample was 16,86 litres. Only eleven samples were larger than the average and six were of more than 20 litres (Fig. 4.201).

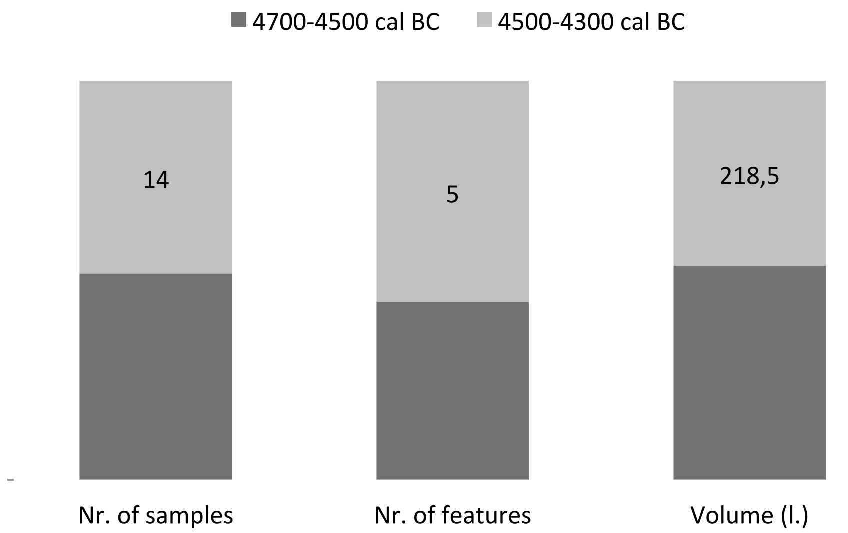

Fig. 4.198. Number of samples, features and total volume processed per settlement phase in C/Reina Amàlia, 31-33.

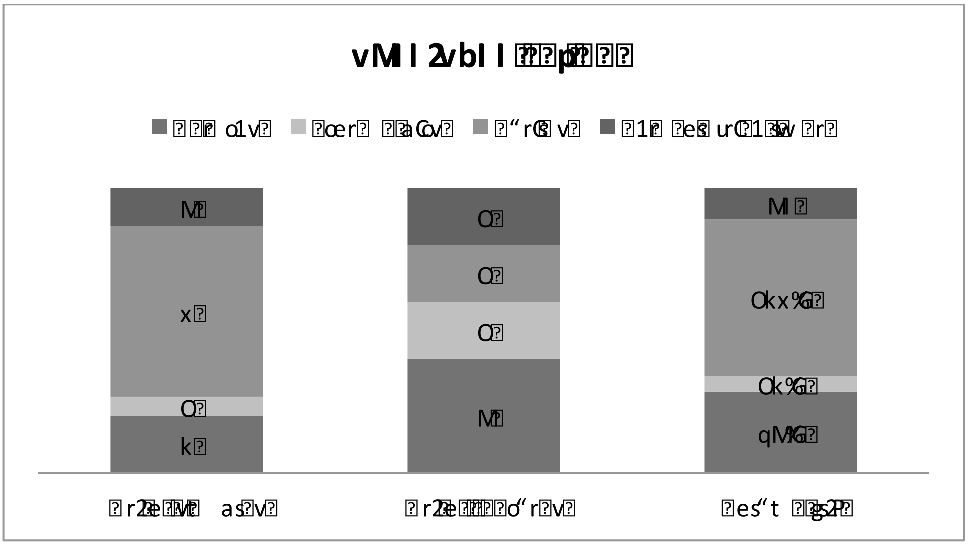

Fig. 4.199. Number of samples, features and total volume processed per type of feature during the first settlement phase in C/Reina Amàlia, 31-33.

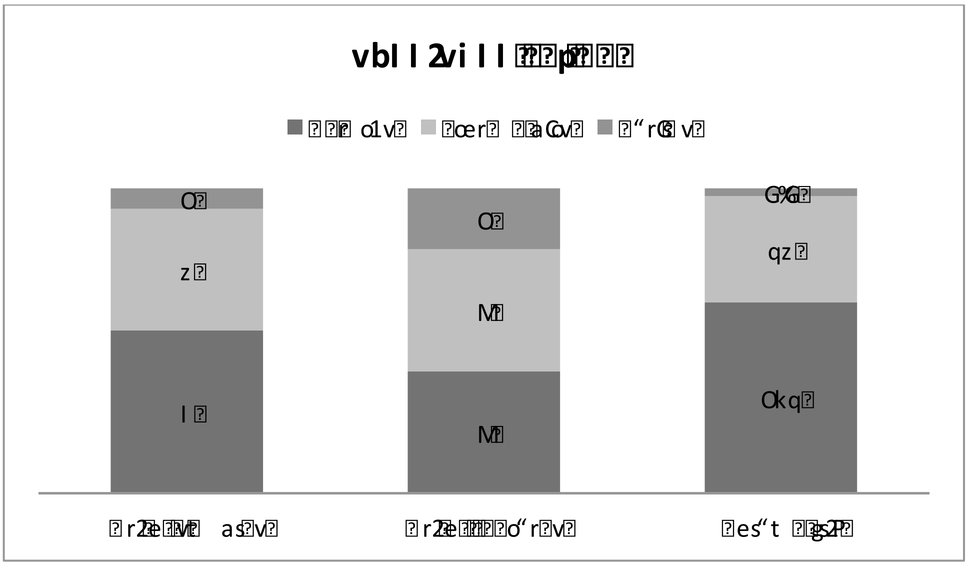

Fig. 4.200. Number of samples, features and total volume processed per type of feature during the second settlement phase in C/Reina Amàlia, 31-33.

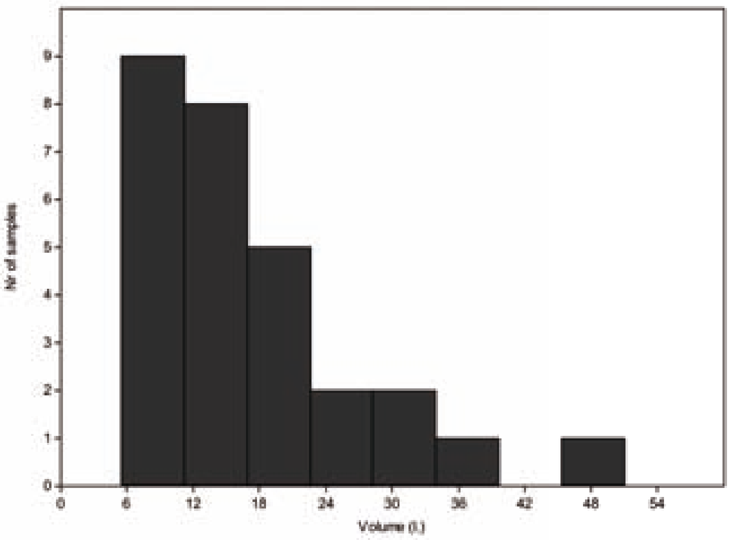

Fig. 4.201. Histogram presenting the volume processed per sample in C/Reina Amàlia, 31-33.

4.9.4. Results

A total number of 589 seed and fruit remains were recovered in C/Reina Amàlia 31-33 (see the complete table of results in Fig. III.23). All of them were in carbonized state, except for 3 imprints on daub.

4.9.4.1.The number and density of remains, and the number of taxa per context

The number of remains obtained per sample was rather diverse. Only samples of more than 80 litres of volume yielded significant amounts of remains (>35). The number of taxa per sample was also very low (1-3) and it only increased when very large amounts of sediment were processed (Fig. 4.202). The density of remains per context was very low (<1r/l) in most cases. It was only slightly above it in feature XI (3,73 r/l). No small samples with high densities of remains were identified (Fig. 4.203). All of the samples which produced archaeobotanical remains were found either inside the dwelling structure or in the several structures found at the northern side of it (Fig. 4.204). Samples from the southern and eastern structures were not available (E-IV, V, VI, VII, VIII, IX and X), presumably because no charred material was observed during their excavation.

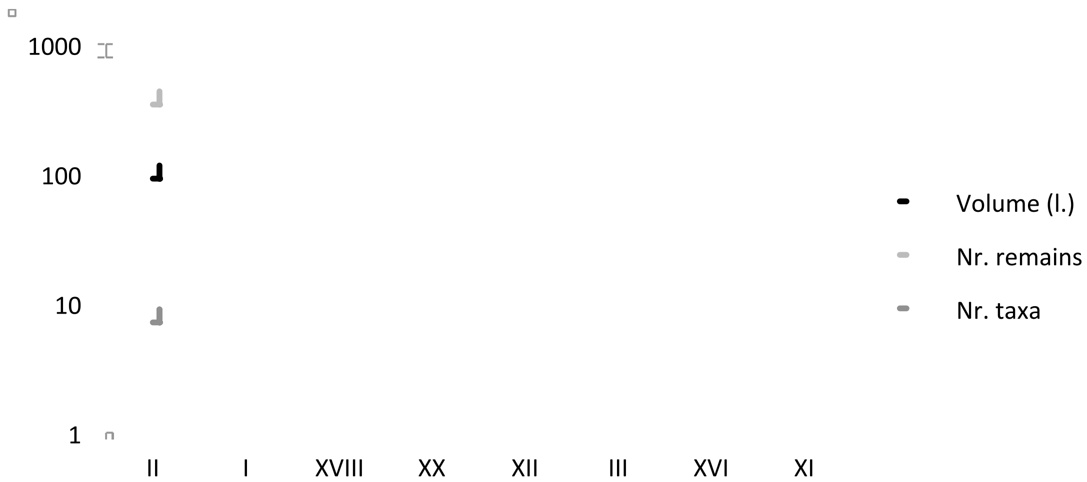

Fig. 4.202. Relation between the number of remains, the number of taxa and the volume per feature in C/Reina Amàlia, 31-33.

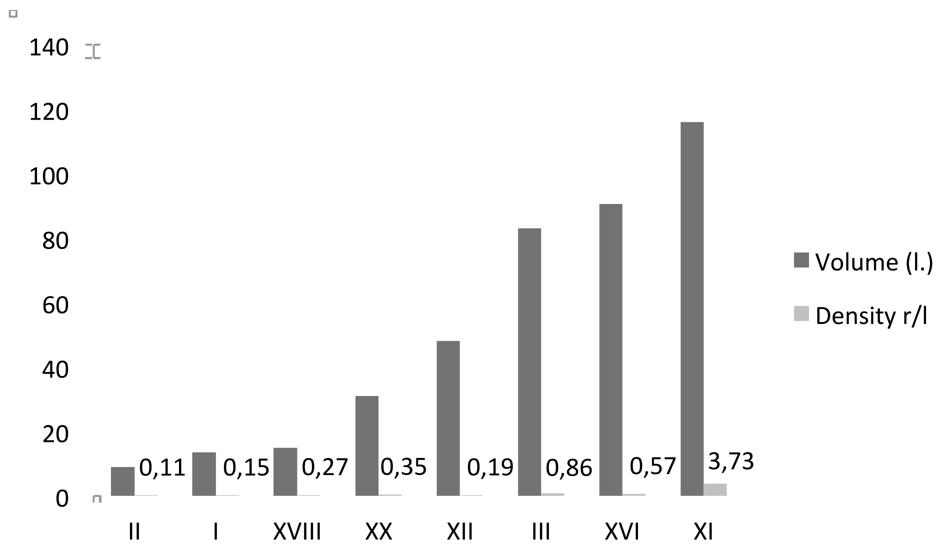

Fig. 4.203. Relation between the volume of sediment and the density of remains (also shown numerically) per context in C/Reina Amàlia, 31-33.

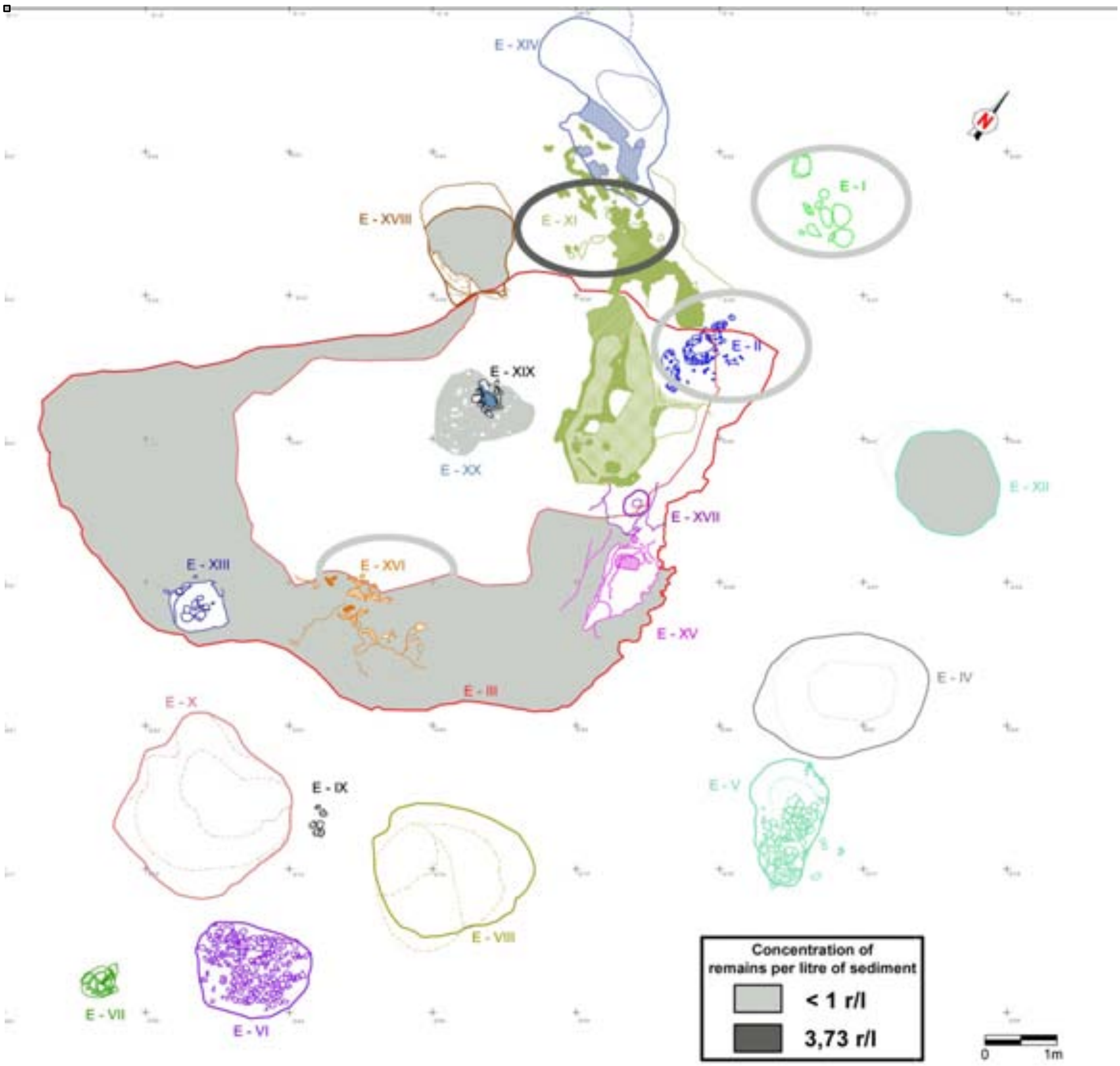

Fig. 4.204. Spatial representation of the density of remains per archaeological feature in C/Reina Amàlia, 31-33 (adapted from an image provided by J. González).

4.9.4.2.The botanical spectrum and the representation of the different ecological groups

Sixteen taxa were identified at the site. Only three ecological groups were differentiated: cereals (four taxa: *Hordeum vulgare, Hordeum vulgare* var. *nudum, Triticum aestivum/durum/turgidum, Triticum dicoccum*), weeds and ruderals (five taxa: *Euphorbia helioscopia, Heliotropium europaeum, Polygonum aviculare, Sherardia arvensis, Solanum nigrum*) and maquis formations (1 taxon: *Pistacia lentiscus*). The six remaining taxa were not possible to ascribe to any of these groups (*Carex* sp., Lamiaceae, Papilionaceae, *Phalaris* sp., *Poa* sp., cf. *Setaria* sp.) (Fig. 4.205).

Taxon	Represented part	4700-4500 cal BC	4500-4300 cal BC	Total site
Cultivars: cereals				
Hordeum vulgare	**Total remains**		**5**	**5**
Hordeum vulgare* var. *nudum	**Total remains**	**4**		**4**
***Hordeum* sp.**	**FPostC**	**1**	**2**	**3**
Triticum aestivum/durum/turgidum	**Total remains**	**4**	**54**	**58**
Triticum dicoccum	**seed/fruit**	**2**		**2**
***Triticum* sp.**	**FPostC**	**4**	**52**	**56**
Cerealia	**FPostC**	**98**	**295**	**393**
Weeds and ruderals				
Euphorbia helioscopia	**fragment**	**1**		**1**
Heliotropium europaeum	**seed/fruit**	**1**	**5**	**6**
Polygonum aviculare	**seed/fruit**	**1**		**1**
Sherardia arvensis	**seed/fruit**		**1**	**1**
Solanum nigrum	**seed/fruit**		**3**	**3**
Maquis formations				
Pistacia lentiscus	**fruit stone**	**1**		**1**
Diverse/Unknown				
***Carex* sp.**	**seed/fruit**		**6**	**6**
Cyperaceae	**seed/fruit**	**2**		**2**
Lamiaceae	**seed/fruit**		**1**	**1**
cf. *Papilionaceae* (small)	**cotyledon frag.**	**1**		**1**
***Phalaris* sp.**	**seed/fruit**	**1**		**1**
***Poa* sp.**	**seed/fruit**		**1**	**1**
Poaceae	**FPreC**		**1**	**1**
cf. *Setaria* sp.	**seed/fruit**		**1**	**1**
	Total remains	**142**	**447**	**589**
	Volume (l.)	**218.5**	**188**	**406.5**
	Density r/l	**0.65**	**2.38**	**1.45**
	Nr. taxa	**10**	**9**	**16**

Fig. 4.205. List of identified taxa, ecological group in which they have been classified, total number of items recovered per phase and per site in C/Reina Amàlia, 31-33.

4.9.4.3.Evaluation of the representation of the taxa within the ecological groups

Cultivated plants: cereals

Cereals were the best-represented group in both phases and in all samples except feature I (accumulation of stones with an unknown function), where they were absent. In both phases, cereal remains are more than 90% of the total assemblage (Fig. 4.206). In the first phase (4700-4500 cal BC), most of the items were not identifiable to genus or species level. Only ten remains were identified to species level: naked barley (n=4), naked wheat (n=4) and emmer (n=2). They were all found in the same two features: III (a hearth) and XVI (a burial). On the second phase (4500-4300 cal BC), a larger number of items were identified to species level (n=59), but most of the remains were only classified as cereals (n=295). In this case, naked wheat was the best represented taxon (n=54), followed by hulled barley (n=5), while no emmer or naked barley grains were recovered. It is significant to notice that only two charred grains of barley were identified. The rest of the identified remains were glumelle imprints on a daub fragment (Fig. 4.207). Most of the remains were recovered in feature XI, but also in XVIII: an oven and a storage pit, respectively. A taphonomic analysis was not possible due to the low number of recovered items, but it is clear that the preservation was bad and that depositional and post-depositional agents damaged the remains quite significantly.

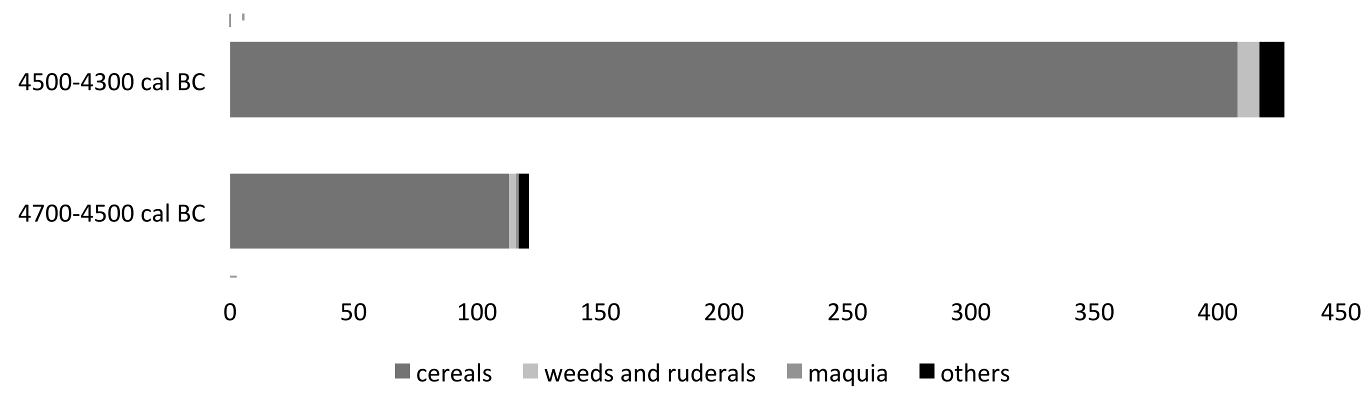

Fig. 4.206. Number of remains per ecological group recovered in each phase in C/Reina Amàlia, 31-33.

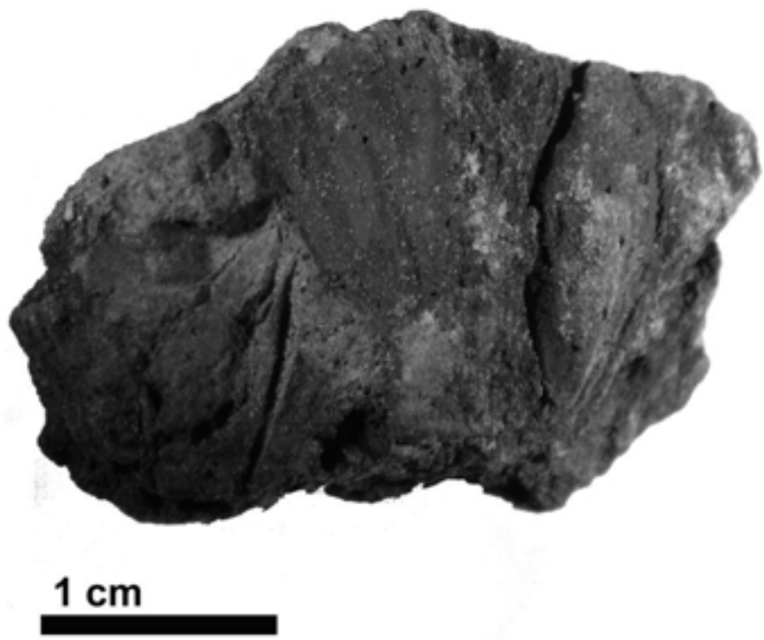

Fig. 4.207. Daub fragment with glumelle imprints of hulled barley. C/Reina Amàlia, 31-33.

Weeds and ruderals

The weed spectrum recovered was rather meagre. Three seeds were recovered in the first phase (structure III): *Euphorbia helioscopia, Heliotropium europaeum* and *Polygonum aviculare*. Nine seeds were found in the second phase (structure XI), of three different taxa: *Heliotropium europaeum, Sherardia arvensis* and *Solanum nigrum*.

Maquis formations

Only one fruit stone of *Pistacia lentiscus* was identified in the first settlement phase, in structure III (a hearth).

4.9.5. Discussion

4.9.5.1. The sampling strategy

The sampling strategy practiced at the site allowed a spatial approach to the distribution of archaeobotanical remains within a single household. The presented results show that all of the sampled structures but one yielded positive results. In this sense, it was an appropriate strategy. On the other hand, not all structures were sampled and it is therefore not possible to demonstrate that they did not contain any plant macroremains. It was also observed that very large samples are needed for obtaining assemblages with a sufficient number of items (>35 crop items at least) (Fig. 4.202). In this case, samples of around 80 litres of sediment might have been necessary. Therefore, most of the samples might have been too small. These observations might be valid for any future archaeological excavation on the plain of Barcelona, where other similar contexts have already been excavated but, in general, inconsistently sampled.

4.9.5.2.Plant food economy in C/Reina Amàlia, 31-33

As mentioned above, all the samples presented rather low densities of remains. It is for this reason very unlikely that single events are representedin our data. Quite the opposite, it seems more plausible that these are residues from everyday consumption which were gradually deposited on the different structures. Even the remains of the funerary structure XVI are most probably percolations from the nearby structure III, given their similarly bad state of preservation. The concentration of these remains at the northern side of the dwelling space might indicate either a cooking area (structures II and XI were hearths) or a waste disposal area (or both).

The available data do not allow a reliable approach to agriculture and crop husbandry at the site. Nevertheless, the obtained results point towards two facts. Firstly, free-threshing cereals seem to prevail in the record, mainly naked wheat. Secondly, there is evidence for the use of crop processing by-products as temper.

The charred grains of free-threshing cereals most likely represent everyday cooking refuse, for which their representation in the record might be taphonomically biased (depending on the type of processing that was performed on each species). Emmer is present during the first phase of occupation, but only in low amounts. It is difficult to state its importance in the economy of the site.

On the one hand, the use of crop-processing by-products such as chaff remains as daub temper could be indicating that part of the crop processing was carried out in the domestic space, that is to say, on a low scale. On the other hand, the absence of charred chaff remains on the record does not confirm that such activities were being conducted in this part of the site.

No cultivated pulses were identified but that could be due to taphonomic reasons, for which we cannot present a satisfactory interpretation of their economic role.

Some ruderal plants were found in direct association with the cereal remains. Since these were not found in closed assemblages, one cannot know whether they were really weeds or just wild plants which got mixed with the crop assemblages. Nevertheless, it is worth observing their general botanical and ecological characteristics (Fig. 4.208). It must be noted that most of them would be classified as “small, free-headed, heavy”, following the classification proposed by G. Jones (1984). Consequently, they would be typical of the last stages of processing (fine-sieving by-product). The spectrum would support permanent field cultivation (presence of annuals) and spring sowing (plants with long flowering periods and which germinate in spring/summer). This would be compatible with floodplain cultivation practices. The identification of *Carex* sp. and *Phalaris* sp., might also point towards this husbandry model. Likewise, the absence of plants with vegetative reproduction, which are typical of less intensively managed fields, would be a characteristic feature of weed floras from such type of fields. More data and more representative samples should be obtained for a more reliable conclusion.

	Life form	Flowering time	Height	Method of propagation	Germination time
Euphorbia helioscopia	annual	I-V(XII)	1-4 dm	seed	summer
Heliotropium europaeum	annual	VI-X	1-4 dm	seed	spring
Polygonum aviculare	annual	IV-VIII	0,5-8 dm	seed	spring
Sherardia arvensis	annual	IV-IX	1-4 dm	seed	
Solanum nigrum	annual	V-XI	1-6 dm	seed	spring/summer

Fig. 4.208. Ecological characterization of the weed spectrum from C/Reina Amàlia, 31-33.

Finally, the representation of other wild fruits is very meagre at the site. Only one stone of *Pistacia lentiscus* was identified. As already stated in the previous chapter, the fruits of *Pistacia* do not have a high alimentary or medicinal value according to the PFAF database (value=2). According to present ethnographic references, its fruits could have been used in cakes, sausages, to make oil or to consume as pickles (Torres-Montes 2004, 37; Hadjichambis et al. 2008, Hadjikoumis 2012).

4.9.6. Summary and conclusions at a site level

The results obtained in C/Reina Amàlia, 31-33 are rather meagre but very interesting, given the archaeological contexts. We could observe that free-threshing cereals were the best-represented crop type at the site. Most of the remains concentrated at the northern side of the dwelling pit and are related to hearths. Therefore, it seems that these are cooking residues. Chaff remains were identified as imprints on daub, for which it seems that they were being used as temper. Some weeds were found in the cereal-rich samples and they would be compatible with floodplain agriculture (low soil disturbance, spring sowing and wet environment). Nevertheless, these results might be totally biased and this question should be targeted in future studies in the area. Wild edible fruits were nearly absent from the record, like pulses. No conclusions were put forward for these resources.

4.10. Gavà Mines

4.10.1. Chronology and phases

The Gavà Mines are a major mining complex which was destined to the obtention of variscite (for more information, see chapter 3.1.10). The start of the subterranean mining activities took place at some point around 4200 cal BC (mines 8 and 83) (Borrell, Bosch & Vicente 2010). Most of the available dates, though, concentrate between 4000 and 3600/3400 cal BC, when the mining activities are thought to be more intensive (Villalba, Edo & Blasco 1998).

The last evidences of use of the mines are the funerary contexts of Mine 28, dated to the end of the IVth millennium cal BC (Villalba et al. 1986), and Mine 8, which is actually dated to the early IIIrd millennium cal BC (Villar, Ruiz & Subirà 2011).

4.10.2. Aims of the study

The study of deposits coming from a mining complex like Gavà offers the possibility to approach agricultural and wild fruit gathering practices, together with waste management strategies, of communities which are considered to be specialized craftwork artisans. This might be of particular interest when comparing the results to those obtained in other sites where these activities are not documented. Many questions remain open: were they cultivating their own fields? Was it performed at a household scale? Was it a communal work that allowed some members of the community to work permanently on the mines?

4.10.3. Previous works

The first archaeobotanical data obtained for Gavà Mines were among the first studiesof this sort in the NE of the Iberian Peninsula. These were carried out by G. Kraus-Kashani, in collaboration with the archaeologists of the site, who conducted the recovery of the materials (by dry-sieving and hand collection during fieldwork) already in the late seventies (Villalba et al. 1986). Later on, further analyses were performed by M. Català and R. Buxó (Buxó, Català & Villalba 1991). More recently, N. Alonso and myself published new data from more recent excavations (Alonso & Antolín 2010). These later materials will be presented later on, since they are part of this project. All the analysed contexts belong to the Middle Neolithic period, but mostly to the latest centuries of this phase (3600-3300 cal BC).

		Mine 11	**Mine 28**		**Mine 28 - GAL C**	**Mine 8**	**Mine 6**	**Mine 7**	
Taxa	**Represented part**	**charred**	**imprints**	**charred**	**charred**	**charred**	**imprints**	**imprints**	**TOTAL**
Hordeum vulgare	seed/fruit		2		4	12	3	6	**27**
Hordeum vulgare var. *nudum*	seed/fruit		1	2	5	6			**14**
Hordeum sp.	seed/fruit				1				**1**
Triticum aestivum/durum/turgidum	seed/fruit		1		1	2			**4**
Triticum dicoccum	seed/fruit				2	1			**3**
Triticum monococcum	seed/fruit					1	1	2	**4**
Triticum sp.	seed/fruit		1				3		**4**
Cerealia	seed/fruit					1			**1**
Avena sp.	seed/fruit					1			**1**
Chenopodium sp.	seed/fruit					1			**1**
Galium sp.	seed/fruit				1				**1**
Vicia sp.	seed/fruit			4		1			**5**
Olea europaea var. *sylvestris*	seed/fruit			18	158	1			**177**
Vitis vinifera subsp. *sylvestris*	seed/fruit				2				**2**
Leguminosae	seed/fruit			2					**2**
Liliaceae	seed/fruit				100				**100**
Rosaceae	seed/fruit				1				**1**
Indeterminats	seed/fruit	1		1					**2**
	Total remains	**1**	**5**	**27**	**275**	**27**	**7**	**8**	**350**

Fig. 4.209. Results from the seed and fruit analysis of Gavà Mines performed by G. Kraus-Kashani (Villalba et al. 1986) *and R. Buxó (Buxó, Català & Villalba 1991).*

Five cultivars were identified, but only cereals (*Hordeum vulgare, Hordeum vulgare* var. *nudum*, *Triticum aestivum/durum/turgidum, Triticum dicoccum* and *Triticum monococcum*). All of them were both identified as imprints and in charred form, except for emmer, which was only preserved in charred form. The use of chaff as temper in daub and the presence of cereal pollen at the site (Riera 2010), together with the identification of several sickle blades (Gibaja 2010), might be considered good indicators of a local agricultural production. Wild fruits were also identified at the site, mainly *Olea europaea* var. *sylvestris*, but also *Vitis vinifera* subsp. *sylvestris*. Most of the fruit stones of wild olive were found on direct association with a multiple burial. This was interpreted as the result of some ritual where branches of olive trees could have been burned and then the charred fruit stones could have been spread over the corpses (Buxó, Català & Villalba 1991).

4.10.4. Materials and methods

4.10.4.1. Sampling strategy at the site

Thirty-two samples were obtained from 8 different mine shafts: 5/11 (n=2), 11 (n=9), 16 (n=6), 21 (n=1), 22 (n=1), 23 1), 83 (n=4), 84 (n=6) and 85 (n=2) (for the complete list see Fig. III.24). These were taken by the team of archaeologists, especially from those contexts where the presence of charred archaeobotanical material was visible during fieldwork. For this reason, samples where mostly taken from those contexts which are not typical mining refuse deposits. These usually lack archaeobotanical remains.

The average volume per sample was of 16,22 litres. Most of the samples were of less than 20 litres of sediment (Fig. 4.210).

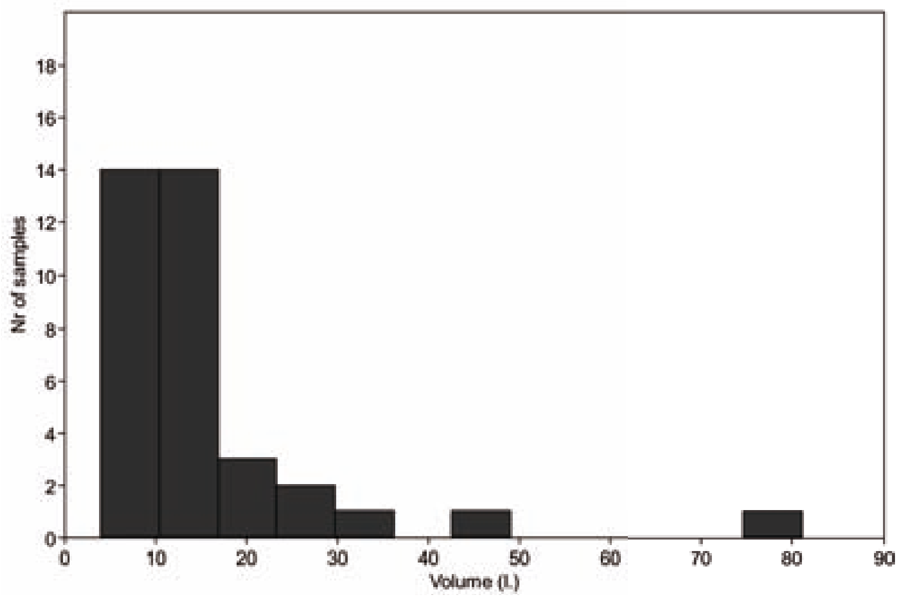

Fig. 4.210. Histogram presenting the volume of sediment processed per sample in Gavà Mines.

4.10.5. Results

A total number of 76 seed and fruit remains were recovered in Gavà Mines (see the complete table of results in Fig. III.25). All of them were in charred state.

4.10.5.1. The number and density of remains, and the number of taxa per context

The obtained number of remains per sample was very low (<35) in all cases. Even when large samples were taken, the number of items was scarce (Fig. 4.211). The densities of remains per sample were equally low (Fig. 4.212). Given these results, the data coming from contexts from the same mineshaft were amalgamated. When looking at the obtained amalgamated results (Fig. 4.213) it is possible to observe that only in those cases when more than 100 litres of sediment were sieved, more than 35 items were recovered.

Fig. 4.211.Relation between the number of remains, the number of taxa and the volume per context in Gavà Mines.

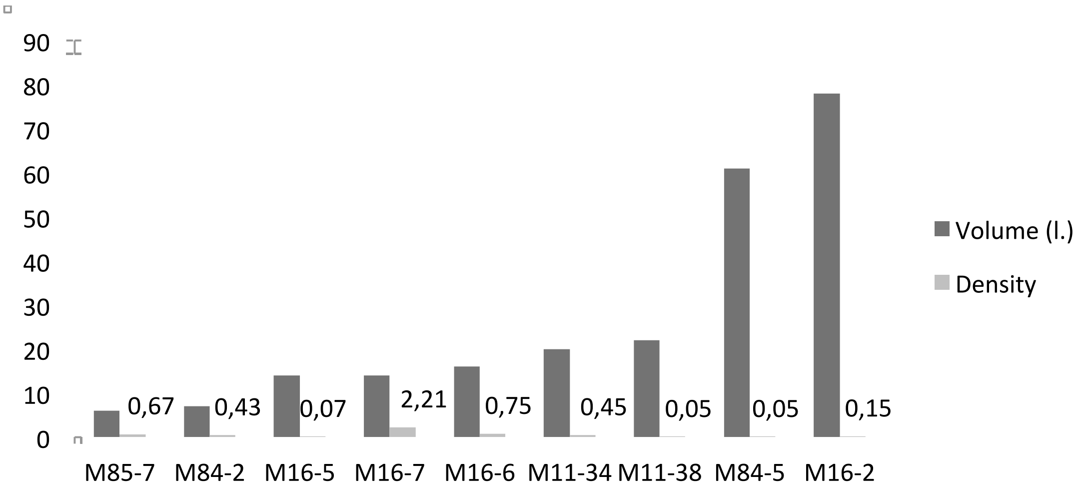

Fig. 4.212.Relation between the volume and the density of remains (numerical values also presented) per context in Gavà Mines.

Fig. 4.213.Relation between the number of remains, the number of taxa and the volume per mineshaft in Gavà Mines.

4.10.5.2. The botanical spectrum and the representation of the different ecological groups

Four taxa were identified in the analysed samples (Fig. 4.214): two cultivated cereals (*Hordeum vulgare* var. *nudum* and *Triticum aestivum/durum/turgidum*), one cultivated pulse (*Lens culinaris*) and one wild plant of diverse ecology but mainly from humid grasslands and ruderal areas (*Phalaris* sp.). These taxa are not equally represented in all the mine shafts. The cultivated cereals were only identified in Mine 16, together with *Phalaris* sp. And the seed of *Lens culinaris* was recovered in mine 84.

Taxa	Represented part	Mine 11	Mine 16	Mine 84	Mine 85	TOTAL
Hordeum vulgare var. *nudum*	Total remains		7			**7**
Hordeum sp.	Total remains		5			**5**
Triticum aestivum/durum/turgidum	Total remains		7			**7**
Triticum sp.	Total remains		3		1	**4**
Hordeum/Triticum	FPostC		25			**25**
Lens culinaris	seed/fruit			1		**1**
Phalaris sp.	Total remains		3			**3**
Poaceae	FPostC	9	5	2	3	**19**
Unidentified	fragment	1	1	3		**5**
	Total general	**10**	**56**	**6**	**4**	**76**
	Volume (l.)	**42**	**122**	**68**	**6**	**196**
	Density r/l	**0.24**	**0.46**	**0.09**	**0.67**	**0.39**
	Nr. of taxa	**1**	**3**	**2**	**1**	**4**

Fig. 4.214. List of identified taxa, ecological group in which they have been classified, total number of items recovered per mine shaft in the Gavà Mines site.

Cultivars were the best represented ecological group at a quantitative level. Remains of cereals were found in mines 16 and 85 (but probably some of the unidentified fragments of Poaceae from mines 84 and 11 could belong to cereals as well). Only free-threshing cereals were identified and only grains were recovered. Pulses were only represented in one single mine (mine 84) and by one single remain of lentil (*Lens culinaris*).

Three caryopses of *Phalaris* were identified in Mine 16. This taxon could have acted as a weed but it could have grown in any ruderalized area.

4.10.6. Discussion

4.10.6.1. The sampling strategy

The sampling strategy allowed the recovery of new archaeobotanical data but in very low amounts. Volumes of more than 100 litres of sediment per mine shaft are necessary to obtain a sufficient number of items. Therefore, larger average volumes per sample should be taken (probably around 40-50 litres). Another possibility would be to water-screen all the sediment and keep the 2 mm fraction (besides taking samples to be processed with a flotation machine). That way, a larger number of economically significant plant remains could be retrieved, together with other archaeological materials.

4.10.6.2. Plant food economy in the Gavà Mines

It is very difficult at the present state of research to present a comprehensive interpretation of the scanty archaeobotranical data that have been obtained to date from the Prehistoric Mines of Gavà. The identification of cereal remains in at least six different mine shafts gives a new perspective to the site. This pattern probably reflects that cereals were routinely consumed at the site and that the dwelling area, though never archaeologically documented, would probably be very close to the mining area. The results from Mine 16 would indicate that a combination of free-threshing cereals would be grown at the site, but previous findings would demonstrate that other cereals were available to the population, too. The use of crop processing by-products as temper in daub would probably confirm that the cultivation and processing of the cereals were at a local scale. Pulses would also be grown at the site but their representation is very meagre and their economic role is not possible to establish.

Weedy taxa are very scarce and one can only draw the attention to the presence of *Phalaris,* which could be diagnostic of the cultivation of the floodplain areas next to Llobregat River. Nevertheless, these is only a tentative interpretation that needs further investigation and supporting data.

These potential evidences of local cultivation of the cereal are of major significance for the understanding of the economy at the site. This would confirm the permanent settlement of the area and the economic independence of the group which was dwelling in the area. Their economy would not be purely focused on the extraction of variscite for trade. That would be one more of the activities that these groups were carrying out in their annual task calendar.

No wild fruits were detected in our samples but the gathering of wild olives and grapes was documented in previous works. Both taxa probably grew in the vicinities of the site and they could have been gathered either for their alimentary consumption. A particular ritual sense was given to an assemblage of olive stones which was found in direct association with the burials of Mine 28 (Buxó, Català & Villalba 1991). The fact that *Olea* was the most important taxon among charcoal remains in Mine 28 might indicate that these stones could have arrived to the site along with the fuel (Piqué 2010). It should be pointed out, though, that the explanations provided for the presence of charred olive stones in a funerary complex lack of a proper experimental work that can explain how these fruit stones ended up charred, without mesocarp and exocarp, in such a context where no cremated bones were present.

4.10.7. Summary and conclusions

The results presented for the Prehistoric Mines of Gavà bring out new evidence which seems to support the interpretations of the previously obtained data. The cereal diversity was somewhat more restricted than that obtained in previous works but it seems to point towards the preferential cultivation of free-threshing cereals, especially naked wheat and naked barley. Our analyses also confirm that pulses were also consumed at the site. Therefore, a rather diversified crop assemblage was present and the available evidences (imprints in daub fragments, use-wear analyses on sickle blades, pollen analyses) seem to indicate that the cultivation of these crops was local. Local gathering of wild fruits was also documented. All these evidences were used to argument that agriculture, wild fruit gathering and mining activities were all equally important in the economy of the site, together with other activities, such as animal husbandry.

4.11. Can Sadurní Cave

4.11.1. Chronology and phases

Twenty-seven different archaeological strata have been identified in this cave site. The strata are dated between approximately 11000 cal BC and the last century (Fig. 3.14) (for a recent compilation see Edo, Blasco & Villalba 2011).

Even though seed and fruit remains have been identified in Early, Middle and Late Neolithic layers (Antolín et al. 2013, Antolín 2008b), this study will only focus on three contexts or layers: layer 10 (dated to 4180-4037 cal BC (Edo, Blasco & Villalba 2011)), layer 11 (dated to 4470-4340 cal BC (Edo, Blasco & Villalba 2011)) and layer 18 (dated to 5392-5304 cal BC (Martín et al. 2010)). These are the best studied contexts from the site and, consequently, a more complete archaeological evaluation of the data is possible. For more information on the site, see chapter 3.1.11.

4.11.2. Aims of the study

The analysis of the archaeobotanical materials obtained from three different layers (18, 11 and 10) from Can Sadurní Cave does not only offer the possibility to take a diachronic approach to plant food production at the site, but also an interesting insight to particularly different archaeological contexts, including a funerary deposit and two layers which have a close connection with animal penning practices.

4.11.3. Previous works

The first archaeobotanical analyses at the site were performed by G. Kraus-Kashani. This author only analysed a small amount of materials recovered by dry-sieving and hand-collecting from the archaeological campaigns between 1978 and 1983 (including materials from the Early Neolithic onwards). These were never published but they were made available by the archaeologists of the site. The analyses were continued by R. Buxó and some preliminary qualitative data were published in a few papers (Blasco et al. 1999, Blasco et al. 2005). It was in 2007 when I started to take charge of the sampling strategy of the site, the flotation of the samples and the sorting of the residues. Until that moment, these tasks had been carried out by the team of archaeologists and some inconsistencies were detected (Antolín 2008b). Some of the results from this project were already published in a relatively large number of papers (Antolín & Buxó 2011c, Antolín & Buxó 2011a Antolín et al. 2013, Antolín et al. 2013, Saña et al. in press). All the data from layers 18, 11 and 10 will be included in the corresponding chapters of this study, since they were revised and amplified for this study.

4.11.4. Materials and methods

The sampling strategies applied in Can Sadurní Cave were rather diverse over the years and they were also affected by non-strictly scientific factors. A detailed description of the evolution of the different strategies can be found elsewhere (Antolín 2008b). First of all, it must be said that only a sector of the cave site and one trench outside the cave were excavated (see Fig. 3.13). Besides, it should be pointed out that a grid square was established in order to dig each cultural layer in squares of 1 m^2, which is a rather common technique in this sort of sites. Each cultural layer was also divided into spits of 10 cm of depth. Therefore, different samples from the same layer were taken according to squares and spits, which are arbitrary divisions of the layer. Such sampling strategy could facilitate the identification of spatial patterns of distribution of the remains.

During the first archaeological works (1978-1983), dry sieving of the sediment from some pilot squares was carried out. The archaeobotanical materials that were observed were recovered and analysed. From 1993 until 1998 100% of the sediment was processed with a flotation machine. This mainly affected layer 11. From 1998 until 2006 it was not possible for the team to continue doing flotation on site, for which only the sediment from the pilot squares and the area of the sondage were processed in their entirety. This was once more changed in 2007, when it was decided to take at least 10 litres of sediment per square (which was applied on layer 10), keeping the recovery of 100% of the sediment from the pilot squares. Until this moment, the volume of sediment was never measured, for which it is difficult, if not impossible, to get density values for the old samples. Finally, in 2011 the excavation of layer 11 started and it was decided that 100% of the sediment of all squares should be processed with a flotation machine. Nearly 7500 litres of sediment were processed since then, but the analysis of the samples is currently on-going. Consequently, these data were not included in this work.

For this study, only the samples taken from layers 18, 11 and 10 until the year 2010 were included (Figs. 4.217 and 4.218).

Layer 18 was sampled and sieved by the archaeologists in its entirety between 1998 and 2004. Most of the recovered materials were analysed in previous works. The flots of two samples (G8-IIIc-18 and H8-IIIc-18) had been subsampled (1/8). For this study, the sample from square G8 was completely analysed and the 0,5mm fraction of H8 as well. The main priority was to recover as many potential weeds as possible for the characterization of the crop husbandry practices at the site. Some newly found materials from square I8 were also incorporated into the final results. In 2008, a short rescue excavation was necessary on square I7. One more surface sample (of 1 litre of volume) was taken and the contents of several potsherds were individually sampled (with very small resulting samples, of around 10 and 50 ml), following the observations made after the first archaeobotanical analyses (Antolín 2008b). In total, 11 samples were taken. The contents of potsherds were processed with the wash-over method in order to treat the samples as gently as possible. The total amount of processed volume was very low (1,162 litres).

Layer 11 was sampled between 1995 and 1998. The new samples from the 2011 and subsequent campaigns were not included since their study is currently on-going. Consequently, it will not be possible to offer any reference data on the density of remains per litre of sediment for this layer.

Layer	Nr. samples of unknown volume	Nr. samples with known volume	Nr. of squares	Volume of sediment (l.)
10	8	19	25	217
11	22		11	
18		11	4	1.162

Fig. 4.217. Number of samples taken per layer, total number of sampled squares and total volume of sediment processed from layers 10, 11 and 18 of Can Sadurní Cave.

Layer 10 was rather extensively sampled between 2007 and 2010. The volume of the samples was always measured during this period. An amount of 217 litres of sediment were processed (43,5 l from square E6 and around 10 litres for each of the rest). Some samples from previous campaigns (1993-1996) were also included in the analysis.

The complete list of samples can be checked in Fig. III.26.

The results obtained per layer will be presented separately for a clearer comprehension of the data in order to proceed to a combined discussion, which is aimed to facilitate a diachronic perspective.

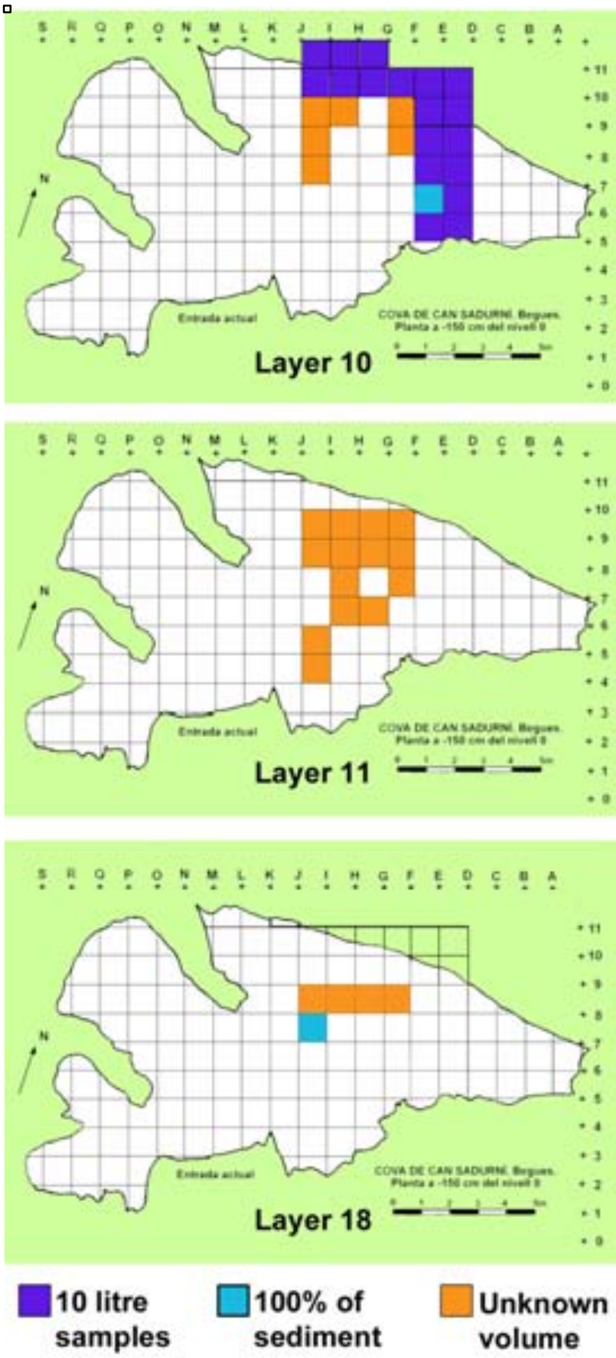

Fig. 4.218. Sampling strategy per square and layer at Can Sadurní Cave.

4.11.5. Results: layer 18

7424 remains were incorporated to the previously available data for this layer, which amounts to 49332 remains in total. The amalgamated results per square and, when possible, per ceramic vessel (the materials associated to fragments from the same pot were amalgamated, indicated as P1, P2, etc.), are presented in Fig. III.27.

4.11.5.1. The number of remains and the number of taxa per context

The number of remains obtained per square was very high, around 10000 for F8, G8 and I8 and around 25000 for H8. The total number of items from square I7 is not yet known, since it was not fully excavated. The number of taxa per square was, on the other hand, rather low (4-12 taxa). The largest botanical diversity was found in H8, where the largest concentration of remains was documented (Fig. 4.219). The samples that were obtained from potsherd fragments equally display a low number of taxa, which was somewhat higher when a larger number of items were analysed (Fig. 4.220).

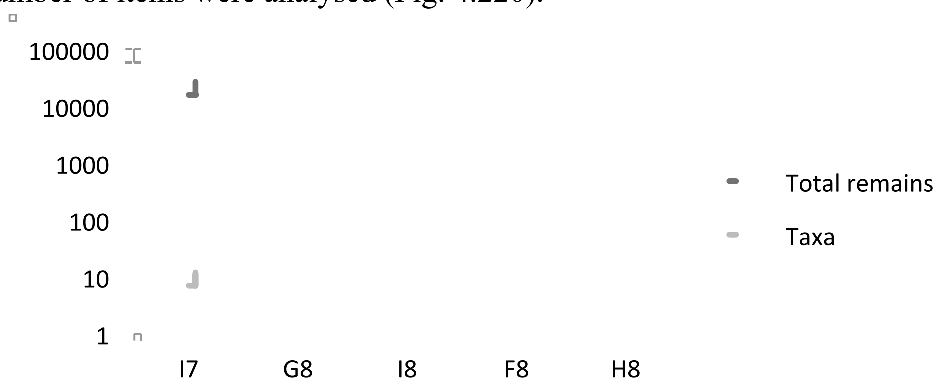

Fig. 4.219. Number of remains and number of taxa per grid square. Layer 18, Can Sadurní Cave.

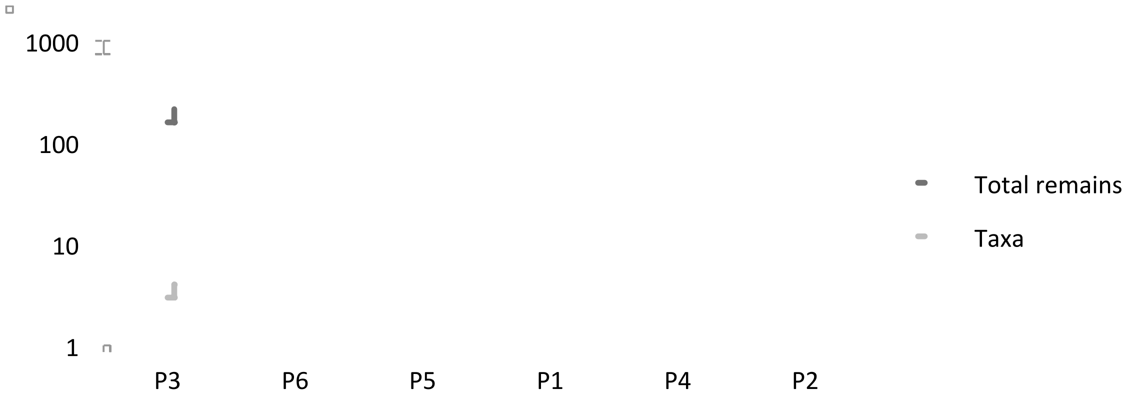

Fig. 4.220. Number of remains and number of taxa per potsherd. Layer 18, Can Sadurní Cave.

4.11.5.2. The density of remains per context

As mentioned above, it was not possible to calculate the densities for any of the samples which were retrieved and processed before 2006. Therefore, only the samples from the square I7 were used for this evaluation. The concentration of the surface sample presented around 1000 r/l, while most of the potsherds contained between 3000 and 6000 r/l (Fig. 4.221).

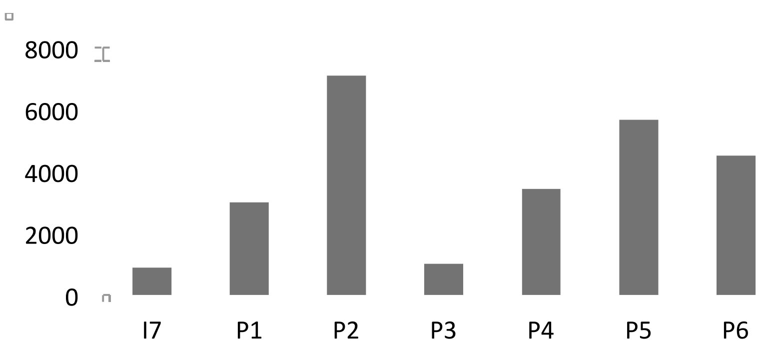

Fig. 4.221. Densities of remains per litre in the samples obtained from square I7. Layer 18, Can Sadurní Cave.

4.11.5.3. The botanical diversity and the classification of the taxa into ecological groups

A total number of 20 taxa were identified in this layer (Fig. 4.222). Five taxa were included into the group of cultivars (*Hordeum distichum, Hordeum vulgare* var. *nudum, Triticum aestivum/durum/turgidum, Triticum dicoccum, Triticum monococcum*). Five taxa were grouped as weeds and ruderals (*Avena* sp., *Chenopodium* *album, Chenopodium hybridum, Solanum nigrum* and *Verbena officinalis*). *Rubus idaeus* was the only taxon which was considered typical of woodland edges and clearings. *Arbutus unedo* was put to the group of maquis formations, and *Pinus* sp. and *Quercus* sp. were grouped in woodland/shrubland formations of diverse type (but it should be kept in mind that they could also grow in maquis formations, especially in the case of *Pinus*, taking into consideration that only *Pinus halepensis* was identified in the charcoal record analysed for this phase (Antolín et al. 2013, Antolín et al. 2013). Six taxa were not possible to ascribe to any ecological group (Asteraceae, Cyperaceae, *Lathyrus* sp., cf. *Linum* sp., *Polygonum* sp., cf. Umbelliferae). Some "odd-shaped" glume wheat grains were found. Part of these were identified as coming from 2-grained spikelets of *Triticum monococcum*. Another group of grains was identified as "*Triticum* sp./new type", since they presented the characteristics proposed by M. Kohler-Schneider to identify this cereal (Kohler-Schneider 2003).

Taxa	Represented part	Total
Cultivars: cereals		
Hordeum vulgare	MNI	**355**
Hordeum vulgare var. *nudum*	MNI	**90**
Hordeum cf. *distichum*	rachis fr.	**1**
Hordeum sp.	grain fr.	**47**
Triticum aestivum/durum/turgidum	MNI	**4050**
	node	**1**
Triticum dicoccum	MNI	**5864**
	glume base	**148**
Triticum dicoccum/monococcum	glume base	**91**
Triticum monococcum	MNI	**1846**
	glume base	**154**
Triticum monococcum (2-grained type)	grains	**10**
Triticum sp./ new type	grain	**8**
Triticum sp.	grain (incl. fr.)	**44228**
	glume base	**6**
Cerealia	Total remains	**550**
Weeds and ruderals		
cf. *Avena* sp.	frag. of caryopse	**1**
Chenopodium album	seed/fruit	**1**
Chenopodium hybridum	seed/fruit	**1**
Solanum nigrum	seed/fruit	**9**
Verbena officinalis	seed/fruit	**1**
Woodland edges and clearings		
Rubus idaeus	kernel	**1**
Maquis formations		
Arbutus unedo	fragment of fruit	**5**
Woodland/shrubland: diverse		
Pinus sp.	fragment of cone scale	**3**
Quercus sp.	acorn fragment	**1**
Diverse/Unknown		
Asteraceae	seed/fruit	**1**
Cyperaceae	seed/fruit	**1**
Lathyrus sp.	fragment of cotyledon	**1**
cf. Linum sp.	seed/fruit	**1**
Papilionaceae	fragment of cotyledon	**4**
Poaceae	seed/fruit	**1**
Polygonum sp.	fragment of fruit	**1**
Solanaceae	seed/fruit	**3**
cf. Umbelliferae	seed/fruit	**1**
Unidentified fruit	fragment of fruit stone	**2**
Unidentified	Total remains	**185**
	Total remains	**54197**
	Taxa	**20**

Fig. 4.222. List of identified taxa, ecological group in which they have been classified, total number of items recovered in Layer 18 of Can Sadurní Cave.

4.11.5.4. The representation of the taxa within the ecological groups

Cultivated cereals were the best-represented ecological group in all the analysed squares (Fig. 4.223). Wheats were dominant in all the samples (85-100%) and mainly hulled wheats (45-80%). Hulled and naked barley were identified in most samples, but not in some of the samples from contents of pots. The largest proportion of barley was found in square I8 (*c*. 15%). Among the glume wheats, emmer was usually the best-represented taxon, except in some of the samples from pots, like P4. Naked wheat was better represented than emmer or einkorn in square G8 and sample P2.

Chaff remains from barley, naked wheat, emmer and einkorn were identified. Only spare rachis finds from free-threshing cereals were documented. Glume wheat chaff was slightly better represented, although it was also rather sparsely recovered. The proportions of grain to chaff for emmer (Fig. 4.224) and einkorn (Fig. 4.225) show a clear predominance of grain in most cases and only a larger proportion of chaff is present in squares I7 and I8 (for both taxa).

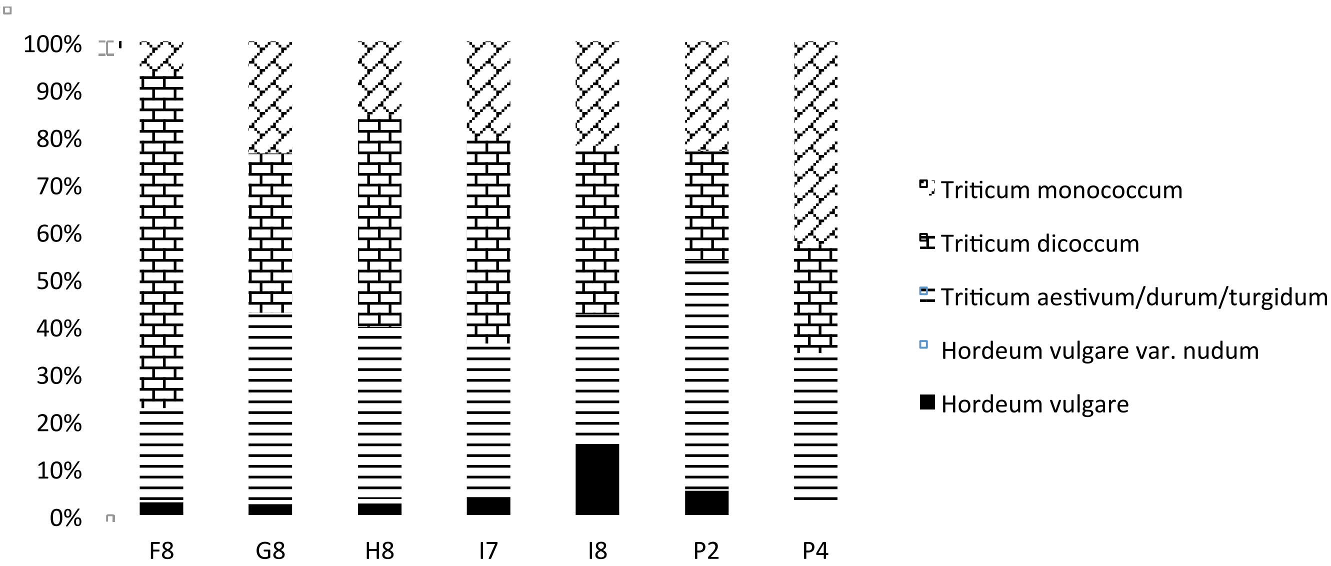

Fig. 4.223. Relative proportions between the MNI of the different identified cereal taxa from layer 18, Can Sadurní Cave.

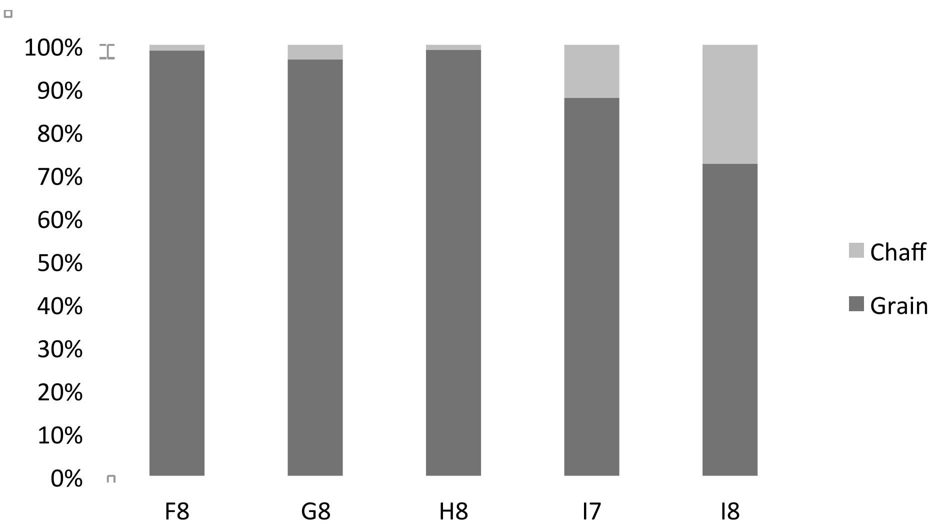

Fig. 4.224. Relative proportions between chaff and grain of emmer per square in layer 18, Can Sadurní Cave.

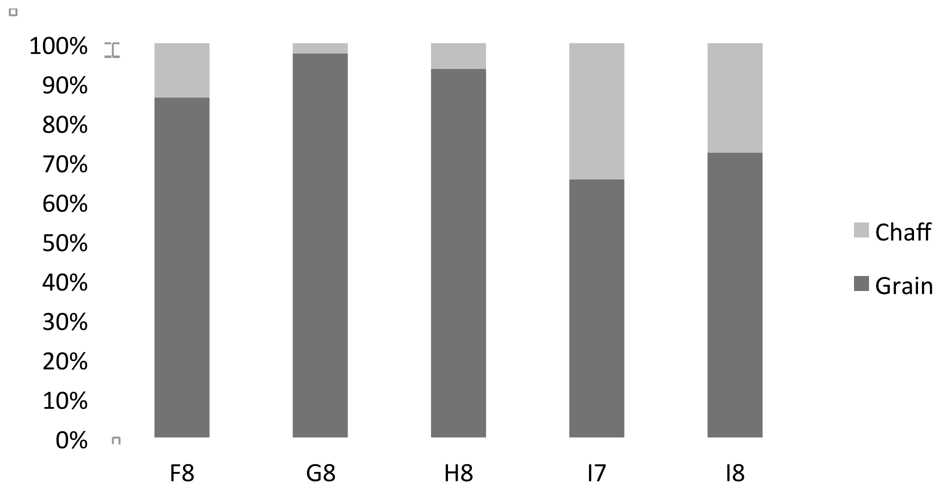

Fig. 4.225. Relative proportions between chaff and grain of einkorn per square in layer 18, Can Sadurní Cave.

Weeds and ruderals were very scarce (n=13). They were not found, hitherto, in any of the samples from contents of pots. The best-represented taxon is *Solanum nigrum* (n=9 and present in two samples). Most finds were in H8 and I8 (n=12).

The remaining wild fruits were very badly represented. One kernel of *Rubus idaeus*, five fragments of fruit of *Arbutus unedo*, three cone scale fragments of *Pinus* sp. and one fragment of acorn (*Quercus* sp.) were recovered in the assemblage. Their ecological characterization is complex, due to the imprecise degree of identification of the remains, but both *Rubus* and *Arbutus* would indicate open areas, being the former more typical of deciduous woodlands and the latter more frequently found in maquis formations. *Pinus* and *Quercus* could also be part of these open maquis formations. Their imprecise identification does not allow definite conclusions.

4.11.5.5. Taphonomic aspects

The taphonomic evaluation of the major part of the recovered materials was already published (Antolín, Buxó 2011c). Only the new data (the contents from vessels) will be presented here in order to proceed to an integrated discussion in chapter 4.11.5.

The main results of the taphonomic analysis of the previously analysed assemblage (Antolín & Buxó 2011c) were that there was a very large percentage of fragments (80%) and a very important degree of regular type of fragmentation. More than 50% of the remains from square I7 showed significant signs of degradation of the surface (semi-degraded to over-degraded surfaces). More than 50% of the grains lacked the embryo. The percentage of popped grains or grains with protrusions was below 10% for all taxa. Grains with concave flanks were not observed. Finally, one of the most significant features was that the fragmentation of the grains produced prior to charring presented different patterns according to each taxon. The glume wheats showed higher percentages and einkorn showed systematically higher proportions of fragments (*c.* 25%) with respect to emmer (*c.* 5-10%).

The degree of fragmentation of the materials recovered in direct association with the pots was as high as in the rest of the samples (over 80% when considering all the remains). Some taxa, like naked wheat and emmer, presented less fragmentation, as in previous works (Fig. 4.226). Part of this fragmentation was originated prior to charring. These fragments were only observed on glume wheat grains and they repeated the same pattern as already observed above, where einkorn got a larger percentage (close to 20%) and emmer a lower one (less than 5%) (Fig. 4.227). The fragmentation observed was mostly of irregular type, but an important proportion of regular fragments were also identified (34%) (Fig. 4.228). The state of preservation of the surface of the grains was slightly better than the one observed in previous works. Intact and semi-intact remains added up to 55% of the total assemblage (Fig. 4.229). More than half of the grains lacked the embryo (Fig. 4.230). Finally, rather low percentages of popped seeds and grains with protrusions were found (only in einkorn more than 10% of popped seeds were observed). Around 3-5% of the assemblage presented characteristic deformations produced by the charring in a confined environment (Fig. 4.231).

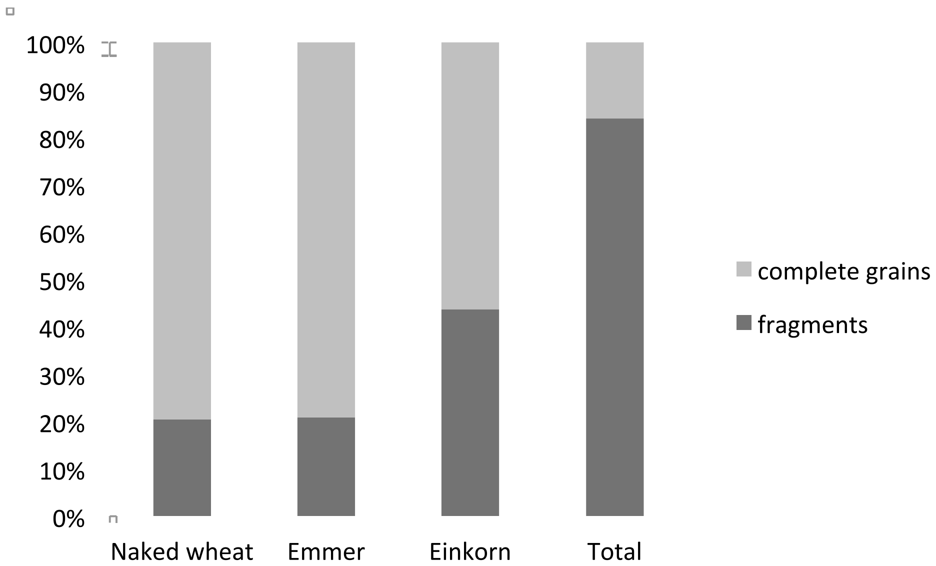

Fig. 4.226. Proportion of complete grains and fragments per taxon and in total for the contents of pots. Layer 18, Can Sadurní Cave (NR: 511).

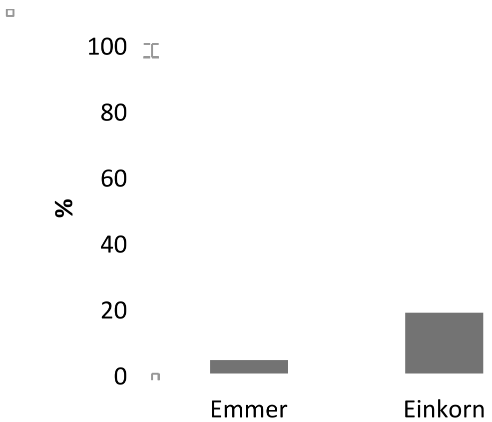

Fig. 4.227. Proportion of fragments produced prior to charring per taxon for the contents of pots. Layer 18, Can Sadurní Cave (NR: 57).

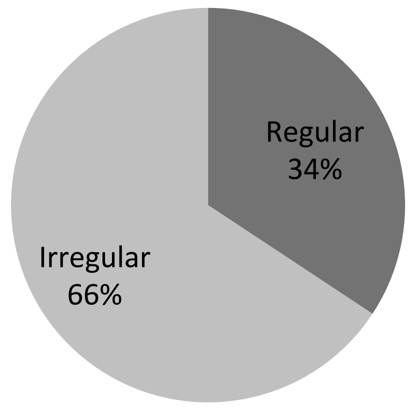

Fig. 4.228. Proportion of regular and irregular fragments of grain for the samples from contents of pots. Layer 18, Can Sadurní Cave (NR: 35).

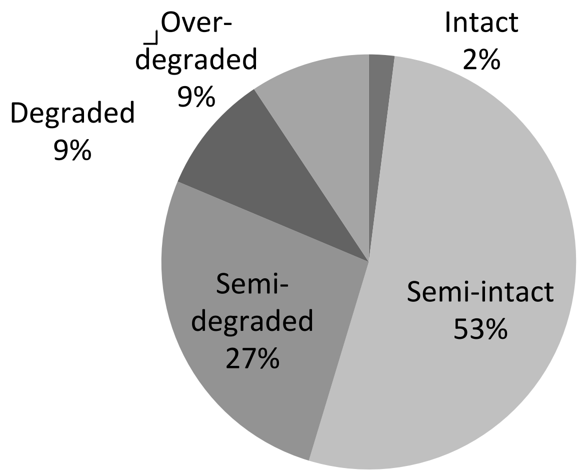

Fig. 4.229. State of preservation of the surface of the grains retrieved from the samples from contents of pots. Layer 18, Can Sadurní Cave (NR: 150).

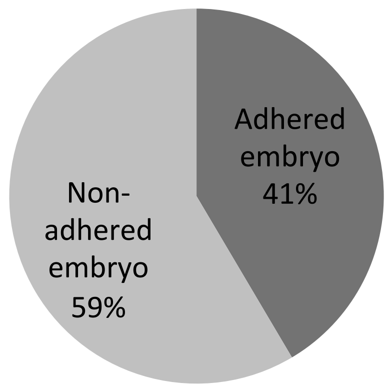

Fig. 4.230. Proportion of adhered and non-adhered embryos on the grains retrieved from the samples from contents of pots. Layer 18, Can Sadurní Cave (NR: 94).

	Popped grains		Grains with protrusions		Deformed grains produced by charring in a confined space	
	NR	%	NR	%	NR	%
Naked wheat	3	8.6	3	8.6	1	2.9
Emmer	1	4.2	2	8.3		
Einkorn	4	14.8			2	7.4

Fig. 4.231. Quantified effects of the charring process on the grains retrieved from the samples from contents of pots. Layer 18, Can Sadurní Cave.

4.11.6. Results: layer 11

A total number of 1814 seed and fruit remains were retrieved from this layer. The complete results per grid square are presented in Fig. III.28. The volume of the samples was never measured for this layer. No data concerning the density of plant remains can therefore be presented.

4.11.6.1. The number of remains and the number of taxa per grid square

The number of remains obtained per square was rather diverse. The average number of items per square was around 130 but only 9 of the 14 squares produced more than 35 items. The number of taxa per square was rather low (1-12) (Fig. 4.232). The largest amounts of remains were recovered at the centre of the cave, in G6, H7 and F8, G8 and H8 (Fig. 4.233).

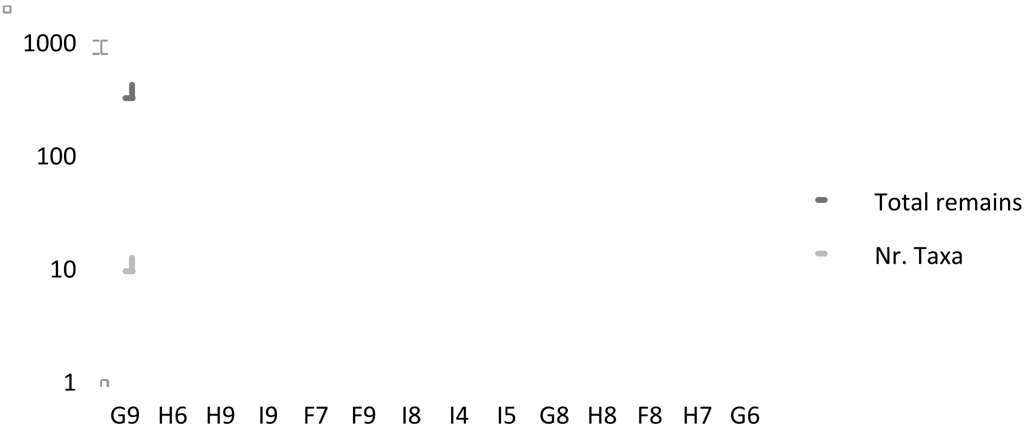

Fig. 4.232. Number of remains and number of taxa per grid square. Layer 11, Can Sadurní Cave.

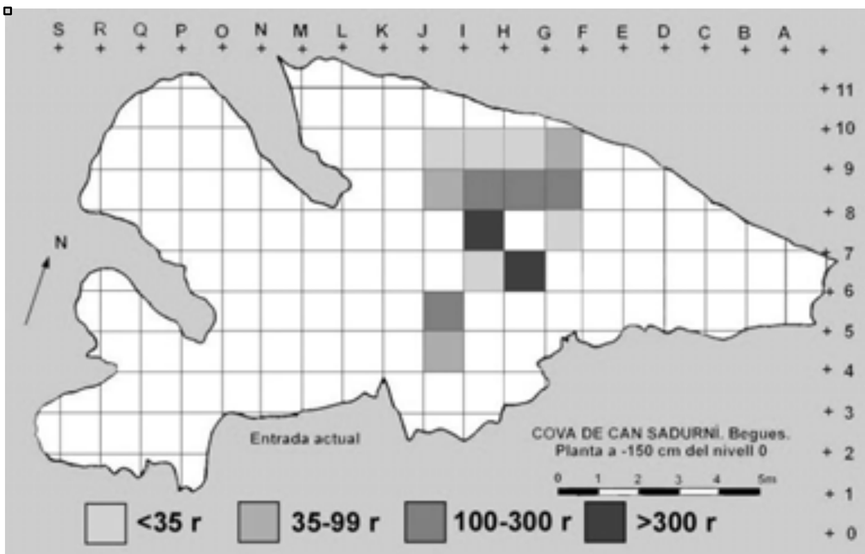

Fig. 4.233. Number of remains (r) per grid square. Layer 11, Can Sadurní Cave.

4.11.6.2. The botanical diversity and the classification of the taxa into ecological groups

Twenty-four taxa were recovered within this layer. Eight potential cultivars were identified: 5 cereals (*Hordeum distichum, Hordeum vulgare* var. *nudum, Triticum aestivum/durum/turgidum, Triticum dicoccum, Triticum monococcum*) and three pulses (*Lens culinaris, Pisum sativum, Vicia sativa*). Seven taxa were grouped as weeds and ruderals: *Atriplex* cf. *patula/prostrata, Chenopodium album, Galium aparine* subsp. *aparine*, *Malva* sp., *Reseda phyteuma, Setaria* sp. /*italica*, *Vicia tetrasperma* type. *Arbutus unedo* and *Pistacia lentiscus* were classified as vegetation from maquis formations, while *Vitis vinifera* subsp. *sylvestris* was put to the riverine vegetation group. *Pinus* sp. and *Quercus* sp. were put to the group of woodland/shrubland of diverse ecology, although, as mentioned above, they could have grown in maquis formations. Finally, four taxa were not possible to ascribe to any ecological group: Polygonaceae, *Silene* sp., *Solanum* sp., *Trifolium* sp. It should be pointed out at this stage that *Vicia sativa* was put to the group of potential cultivars because it has been documented as a cultivar in Claparouse, another site from similar chronology (4200 cal BC) in Southern France (Bouby & Léa 2006).

Taxa	Represented part	rNr	% Ubiquity (14 squares)
Cultivars: cereals			
Hordeum vulgare	**grain**	18	35.7
Hordeum* cf. *distichum	**rachis fr.**	1	7.1
Hordeum vulgare* var. *nudum	**grain**	17	57.1
***Hordeum* sp.**	**grain**	42	64.3
	rachis fr.	1	7.1
Triticum aestivum/durum/turgidum	**grain**	131	85.7
Triticum dicoccum	**grain**	27	42.9
Triticum monococcum	**grain**	17	57.1
Triticum dicoccum/monococcum	**grain**	4	21.4
***Triticum* sp./new type**	**grain**	6	14.3
***Triticum* sp.**	**grain**	92	78.6
Hordeum/Triticum	**grain**	88	50.0
Cerealia	**grain fr.**	19	28.6
Cultivars: legumes			
Lens culinaris	**seed/fruit**	1	7.1
Pisum sativum	**seed/fruit**	2	14.3
***Vicia sativa* type**	**seed/fruit**	1	7.1
Weeds and ruderals			
Atriplex* cf. *patula/prostrata	**seed/fruit**	1	7.1
Chenopodium album	**seed/fruit**	1	7.1
Galium aparine* subsp. *aparine	**seed/fruit**	1	7.1
***Malva* sp.**	**seed/fruit**	1	7.1
Reseda phyteuma	**seed/fruit**	1	7.1
Setaria* sp./*italica	**seed/fruit**	6	14.3
***Vicia tetrasperma* type**	**seed/fruit**	1	7.1
Maquis formations			
Arbutus unedo	**Total remains**	1401	71.4
Pistacia lentiscus	**fruit stone**	25	78.6
***Pistacia* sp.**	**fruit stone**	1	7.1
Riverine forest			
Vitis vinifera* subsp. *sylvestris	**seed/fruit**	2	14.3
Woodland/shrubland: diverse			
***Pinus* sp.**	**cone scale fr.**	3	21.4
***Quercus* sp.**	**Total remains**	11	50.0
Diverse/Unknown			
Chenopodiaceae	**seed/fruit**	1	7.1
Papilionaceae	**seed/fruit**	2	14.3
Papilionaceae (large)	**seed/fruit**	1	7.1
Papilionaceae (small)	**seed/fruit**	1	7.1
Poaceae	**seed/fruit**	1	7.1
Polygonaceae	**seed/fruit**	2	14.3
***Silene* sp.**	**seed/fruit**	1	7.1
Solanaceae	**seed/fruit**	2	14.3
***Solanum* sp.**	**seed/fruit**	1	7.1
***Trifolium* sp.**	**seed/fruit**	1	7.1
***Vicia* sp.**	**seed/fruit**	1	7.1
Vicieae	**seed/fruit**	4	21.4
	Total remains	**1814**	
	Nr. Taxa	**24**	

Fig. 4.234. List of identified taxa, ecological group in which they have been classified, total number of items and percentage of ubiquity of the seed and fruit remains recovered in Layer 11 of Can Sadurní Cave.

4.11.6.3. The representation of the taxa within the ecological groups

The cultivars are well represented in this layer. They were present in more than 90% of the analysed squares. On the other hand, on a quantitative basis, they only achieve around 24% of the total assemblage (Fig. 4.235). Among the cultivars, cereals are the best-represented group. Legumes were only documented in 21% of the squares and only a few items were identified. Among the cereals, naked wheat presented the highest index of relative abundance, followed by naked barley and einkorn, emmer and hulled barley (Fig. 4.236).

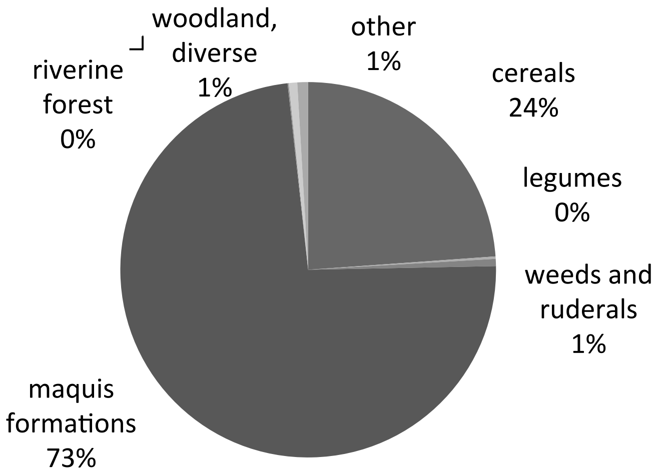

Fig. 4.235. Relative proportions among the number of items per ecological group in Layer 11 of Can Sadurní Cave (total NR: 1814).

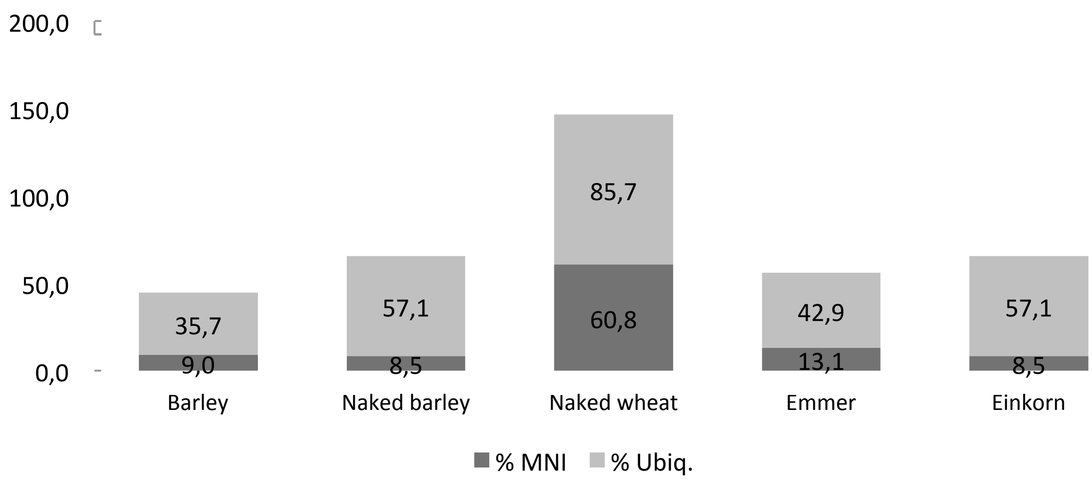

Fig. 4.236. Index of relative abundance of the cereal taxa identified in Layer 11 of Can Sadurní Cave.

Weeds were very scarce in the assemblage. All taxa were represented by one single find except for *Setaria* sp./*italica*, which appeared in two squares and yielded 6 remains. *Setaria* sp./*italica* was used to identify some remains which present the typical morphology of *Setaria italica*. Nevertheless, the earliest finds of this taxon in our region are dated to the Bronze Age (Alonso 1999). These remains could either be contaminations from a more recent settlement phase in the cave or the earliest evidences of *Setaria italica* in the Iberian Peninsula, potentially as a weed. These items were recently sent for being dated, which could help to solve this problem (P.Arias and I.López, pers.com.).

The best-represented group in the record were the plants from maquis formations, namely *Arbutus unedo* and *Pistacia lentiscus*. Both taxa were present in more than 70% of the squares and *Arbutus unedo* was the best-represented taxon in this settlement phase. The distribution of these remains was not even in the excavated surface. Most of the finds were concentrated in the southern sector, while cereals prevailed in samples F8 and G8 (Fig. 4.237).

The riverine vegetation was only represented by two pips of *Vitis vinifera* subsp. *sylvestris*, while other woodland vegetation was much better represented, especially for *Quercus* sp., which was recovered in half of the analysed squares. There are several species of *Quercus* which grow in maquis formations, for which this taxon could have been grouped with *Arbutus unedo* and *Pistacia lentiscus*.

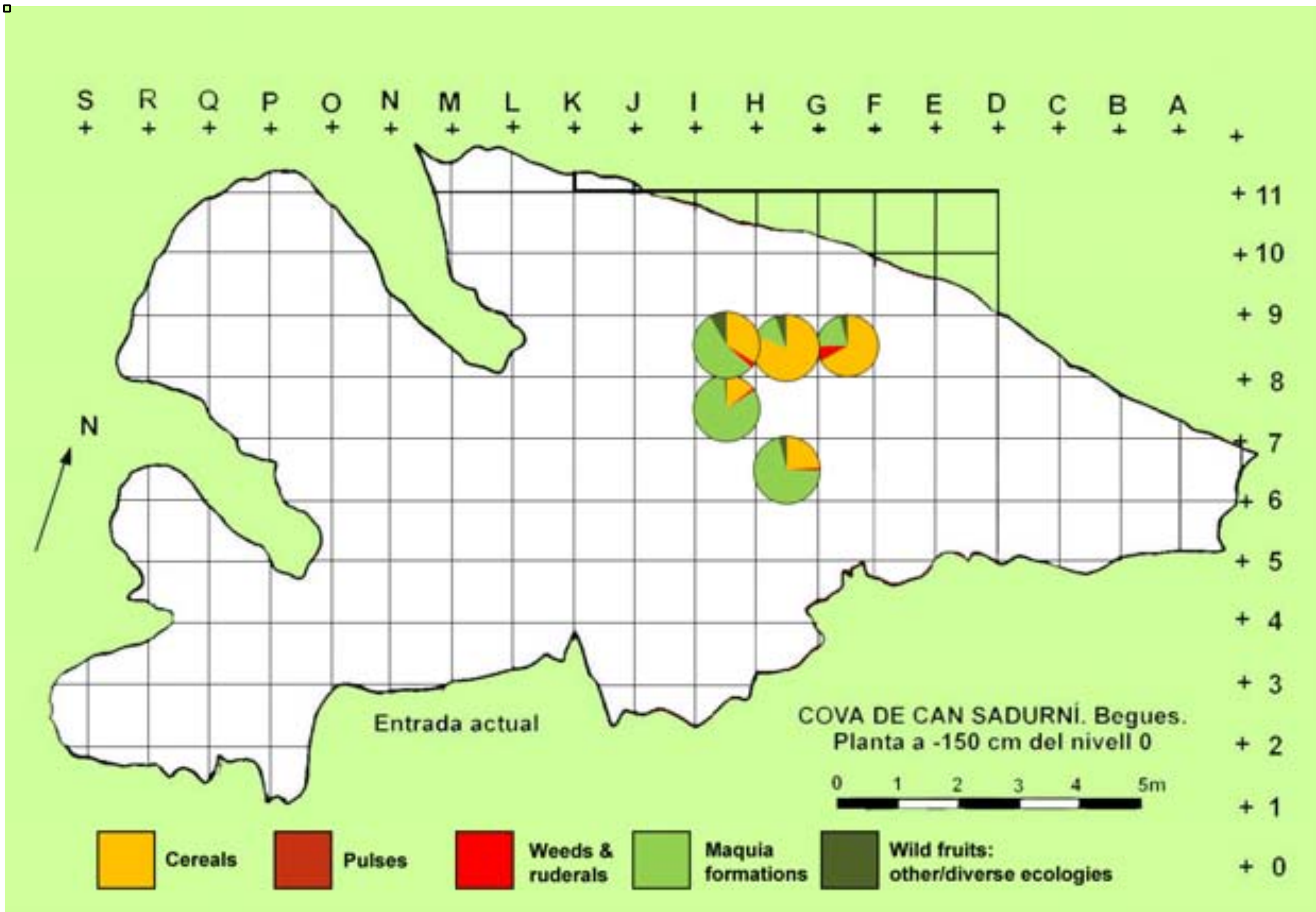

Fig. 4.237. Spatial representation of the relative proportions according to the number of remains ascribed to each ecological group per square in layer 11 at Can Sadurní Cave.

4.11.6.4. Taphonomic aspects

The taphonomic evaluation of the materials from this layer is of limited significance, since the number of cereal remains obtained was rather low. Nevertheless, it was observed that the percentage of fragmented grains was slightly over half of the total remains for cereals but more than 90% for fruits of *Arbutus unedo* (Fig. 4.238). Most of the fragmentation was of irregular type. The state of preservation of the surface of the cereal grains was rather bad; 84% of the assemblage were intensively degraded remains (Fig. 4.239). This variable was not quantified for *Arbutus* since most of the remains had suffered from erosion and fragmentation produced during the excavation and storage of the materials. Most of the cereal remains (75%) lacked the embryo (Fig. 4.240).

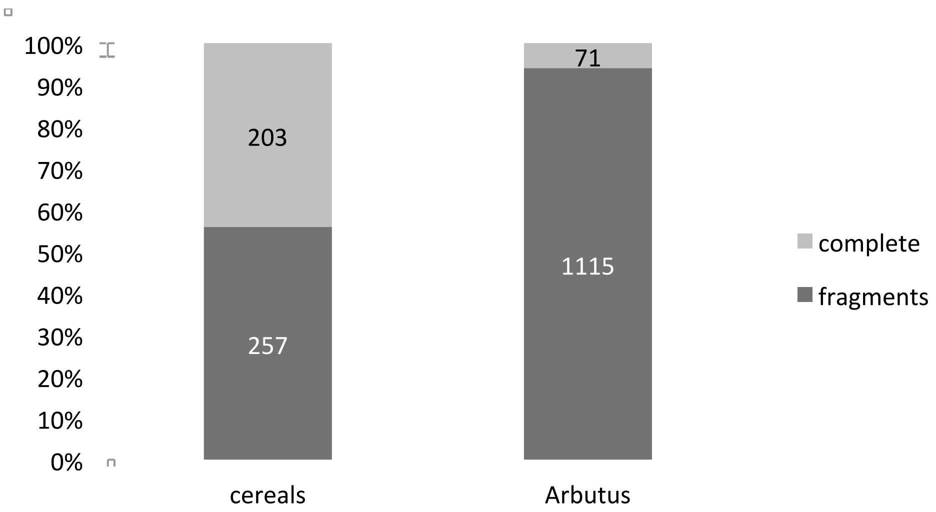

Fig. 4.238. Proportions of fragments and complete items in layer 11 of Can Sadurní Cave.

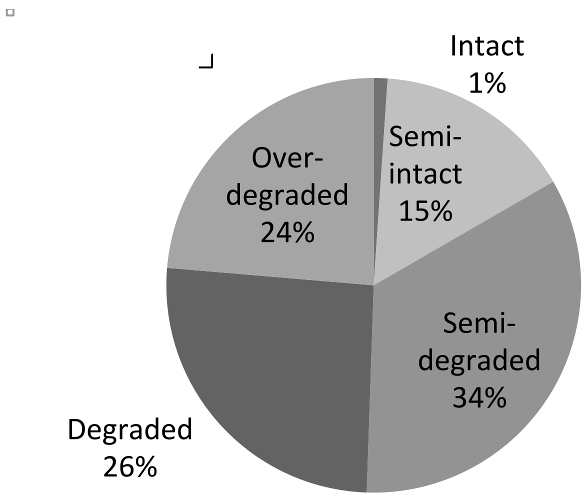

Fig. 4.239. State of preservation of the surface of the cereal grains in layer 11 of Can Sadurní Cave (NR: 186).

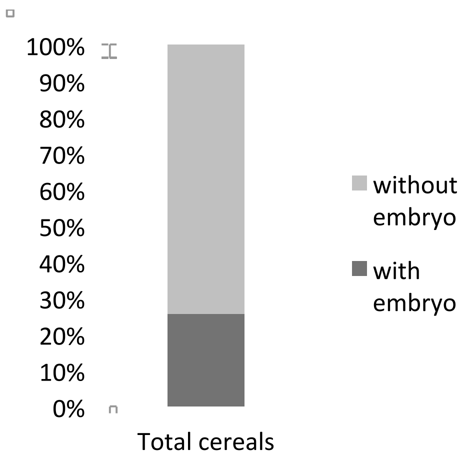

Fig. 4.240. Proportions of grains with and without embryo in layer 11 of Can Sadurní Cave (NR: 207).

	Popped seeds		Grains with protrusions		Grains with concave flanks	
	NR	%	NR	%	NR	%
Hordeum vulgare	2	11.1	2	11.1	1	5.6
Hordeum vulgare var. *nudum*			5			
Triticum aestivum/durum/turgidum	1	0.8	7	5.8	2	1.7
Triticum dicoccum	2	7.7	1	3.8	1	3.8

Fig. 4.241.Quantified effects of the charring process on grain morphology in layer 11 of Can Sadurní Cave site.

The effects of the charring process on the morphology of the grains were in general of low intensity (Fig. 4.241).

4.11.7. Results: layer 10

A total number of 429 seed and fruit remains were recovered from layer 10. The total results obtained per grid square are presented in Fig. III.29.

4.11.7.1. The number of remains and the number of taxa per grid square

The number of remains per grid square is rather low (17,7 in average). Only two samples yielded more than 35 remains, squares I7 and F9 (for which the processed volume was not measured). The number of taxa per square was small in all cases. The increase of volume did not produce significantly better results (Fig. 4.242).

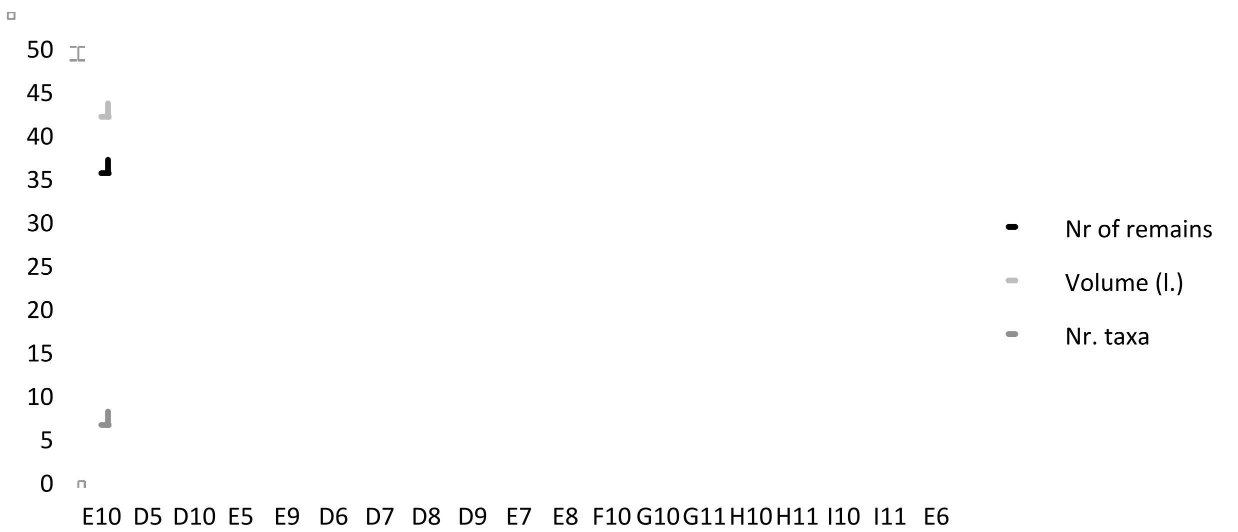

Fig. 4.242.Relation between the number of remains, the number of taxa and the volume per grid square in layer 10 in Can Sadurní Cave site.

4.11.7.2. The density of remains per grid square

The densities of remains per litre observed were very low in all cases. Only one sample presented a density of 3 r/l (E5). No significant concentrations of material were observed (Fig. 4.243). The distribution of the densities per grid square on a spatial view allowed the detection that these seemed to be somewhat higher towards the walls of the cave (Fig. 4.244).

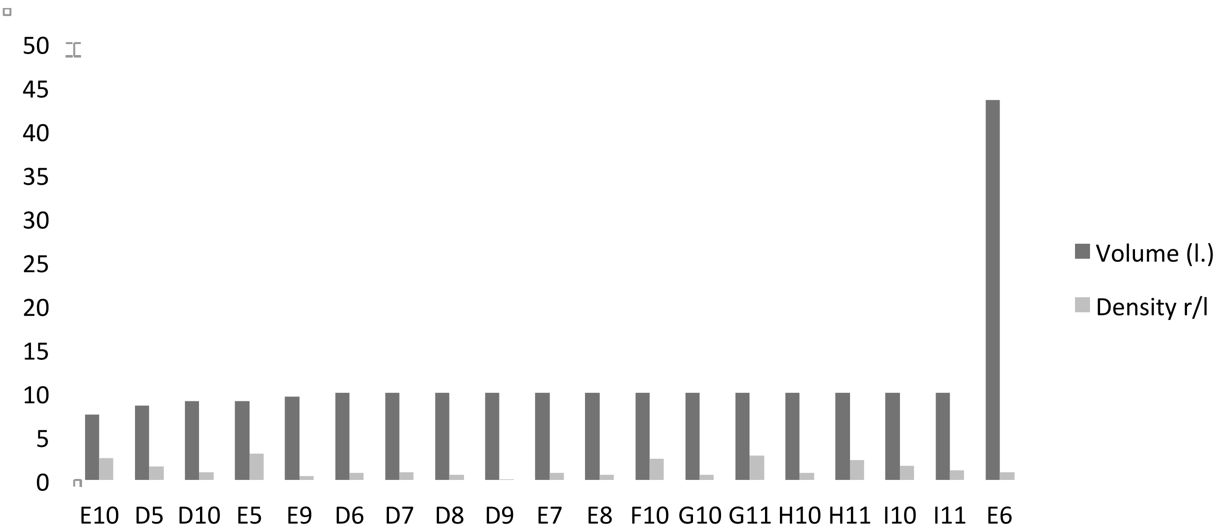

Fig. 4.243. Relation between the volume and the density of remains per grid square in layer 10 in Can Sadurní Cave.

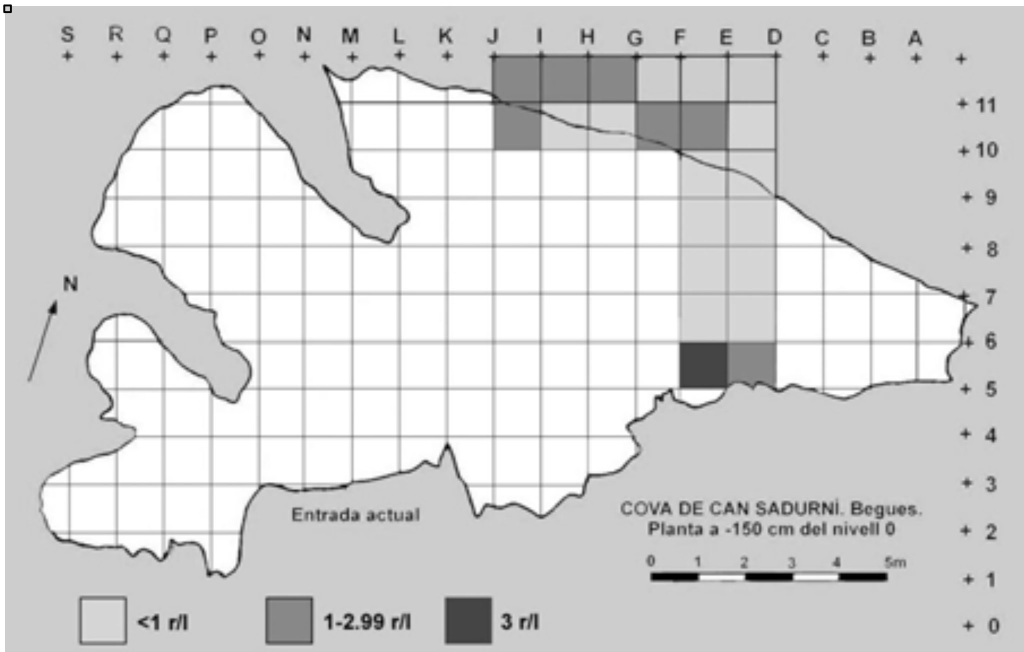

Fig. 4.244. Spatial representation of the density of remains per grid square in layer 11 of Can Sadurní Cave.

4.11.7.3. The botanical diversity and the classification of the taxa into ecological groups

Twenty-five taxa were identified in this layer (Fig. 4.245). Seven cultivars were recognized. Five cereals (*Hordeum vulgare, Hordeum vulgare* var. *nudum, Triticum aestivum/durum/turgidum, Triticum dicoccum, Triticum monococcum*) and two pulses (*Lens culinaris, Pisum sativum*). It should be mentioned that one seed of *Linum* sp. was identified for this layer by G. Kraus-Kashani. It was recovered in the sondage that was carried out outside the cave, in one of the storage pits which are considered as contemporary with layer 10 inside the cave. This remain could belong to cultivated flax but the measures given are by far too small (1,6x0,9 mm). Six taxa were put to the weeds and ruderal plants: *Avena* sp., *Lolium* cf. *perenne/rigidum, Chenopodium album, Setaria* sp./*italic*, *Solanum nigrum, Verbena officinalis*). A single taxon was classified as a plant from woodland edges and clearings: *Rubus fruticosus.* Three taxa are typical of maquis formations: *Arbutus unedo, Olea europaea* cf. var. *sylvestris*, *Pistacia lentiscus*). One taxon was put to the woodland/shrubland vegetation of diverse ecology (*Quercus* sp.). Seven taxa were not possible to ascribe to any ecological group (Caryophyllaceae, Lamiaceae*, Lathyrus* sp., *Medicago* sp., *Phalaris* sp., *Solanum* sp., *Vicia*, sp.).

Taxa	Represented part	TOTAL	% Ubiquity
Cultivars: cereals			
***Hordeum vulgare* (cf. incl.)**	**grain**	4	12
***Hordeum vulgare var. nudum* (cf. incl.)**	**grain**	5	12
***Hordeum* sp.**	**grain**	9	28
	rachis fr.	1	4
***Triticum aestivum/durum/turgidum* (cf. incl.)**	**grain**	30	64
***Triticum dicoccum* (cf. incl.)**	**grain**	5	20
***Triticum monococcum* (cf. incl.)**	**grain**	30	60
	glume base	6	16
***Triticum monococcum* (2-grained)**	**grain**	2	8
Triticum dicoccum/monococcum	**grain**	2	8
***Triticum* sp./new type**	**grain fr.**	1	4
***Triticum* sp.**	**grain**	41	64
Hordeum/Triticum	**grain fr.**	10	28
Cerealia	**grain fr.**	11	12
Cultivars: legumes			
Lens culinaris	**seed/fruit**	1	4
Pisum sativum	**seed/fruit**	1	4
Weeds and ruderals			
***Avena* sp.**	**seed/fruit**	2	4
Lolium* cf. *perenne/rigidum	**seed/fruit**	1	4
Chenopodium album	**seed/fruit**	3	12
***Chenopodium* sp.**	**seed/fruit**	1	4
Setaria* sp./*italica	**seed/fruit**	2	8
Solanum nigrum	**seed/fruit**	12	24
Verbena officinalis	**seed/fruit**	1	4
Woodland edges and clearings			
***Rubus fruticosus* agg.**	**seed/fruit**	3	8
Maquis formations			
Arbutus unedo	**Total remains**	70	44
Olea europaea* cf. var. *sylvestris	**fruit stone fr.**	1	4
Pistacia lentiscus	**fruit stone**	17	52
***Pistacia* sp.**	**fruit stone fr.**	2	8
Woodland/shrubland: diverse			
***Quercus* sp.**	**cotyledon fr.**	1	4
Diverse/Unknown			
Caryophyllaceae	**seed/fruit**	1	4
Lamiaceae	**seed/fruit**	1	4
***Lathyrus* sp.**	**seed/fruit**	1	4
***Medicago* sp.**	**seed/fruit**	1	4
Papilionaceae	**seed/fruit**	2	8
***Phalaris* sp.**	**seed/fruit**	2	4
Poaceae	**seed/fruit**	49	32
cf. Poaceae	**seed/fruit**	1	4
***Rubus* sp.**	**seed/fruit**	1	4
***Solanum* sp.**	**seed/fruit**	1	4
cf. Solanaceae	**seed/fruit**	1	4
***Vicia* sp.**	**seed/fruit**	3	12
Vicieae	**seed/fruit**	1	4
	Total results	**429**	
	Nr. taxa	**25**	

Fig. 4.245. List of identified taxa, ecological group in which they have been classified, total number of items and percentage of ubiquity of the seed and fruit remains recovered in Layer 10 of Can Sadurní Cave.

4.11.7.4. The representation of the taxa within the ecological groups

Cereals were present in 100% of the samples, legumes in 8%, weeds in 44%, plants from woodland edges and clearings in 8%, plants from maquis formations in 68% and taxa from other woodland formations in 4% of the samples. Therefore, cereals, plants from maquis fromations and weeds and ruderals were the best-represented ecological groups at the site. A similar picture was obtained by considering the relative proportion between the different groups based on the number of remains (Fig. 4.246). Cereals make up nearly 75% of the total remains, followed by plants from maquis vegetation (20%). A spatial evaluation was not possible to conduct given the low number of remains obtained per grid square.

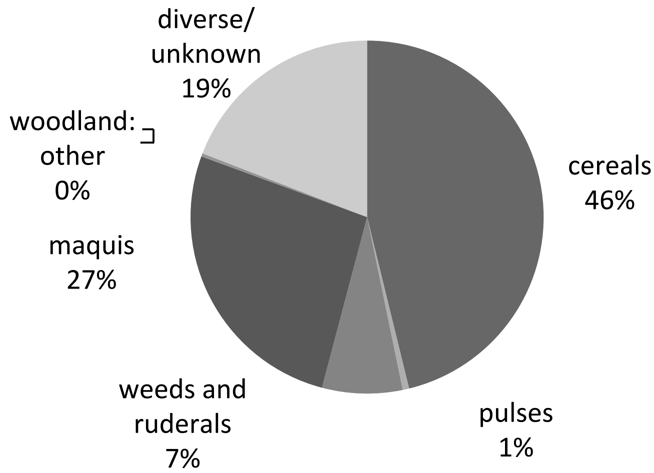

Fig. 4.246. Relative proportions among the number of items per ecological group in Layer 10 of Can Sadurní Cave (NR: 340).

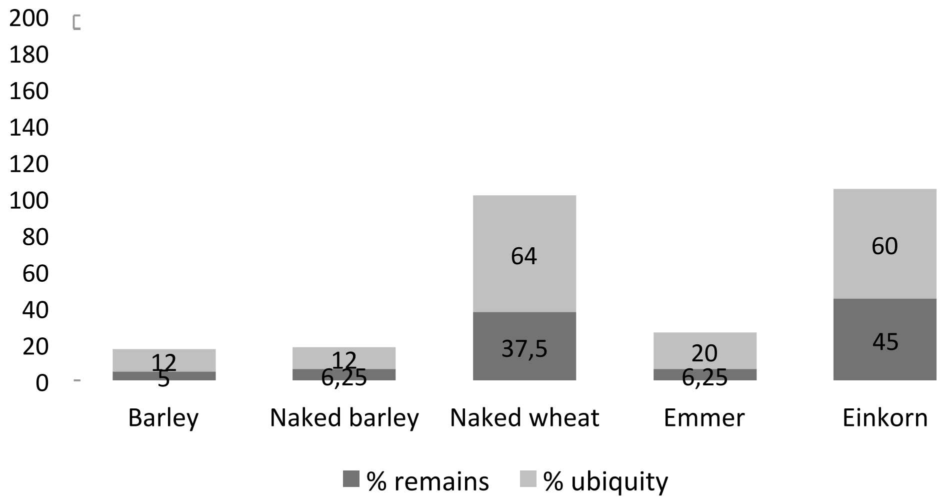

Fig. 4.247. Index of relative abundance of the cereal taxa identified in Layer 11 of Can Sadurní Cave.

Among the cereals, *Triticum monococcum* and *Triticum aestivum/durum/turgidum* were the best-represented taxa. Chaff remains were very scarce. Pulses were only represented by one single remain for each taxon.

Weeds and ruderals were rather sparse in the record but 12 remains of *Solanum nigrum* were retrieved (24% of ubiquity). Plants from woodland edges and clearings were only found in two squares where *Rubus fruticosus* was recovered.

Maquis formations were well represented, especially *Arbutus unedo* (78% of the remains and 44% of ubiquity) and *Pistacia lentiscus* (21% of the remains and 52% of ubiquity). Only a single remain of *Olea europaea* var. *sylvestris* was recovered. One further remain of *Quercus* sp. was identified. This could belong to *Quercus ilex* or *Q. coccifera* but it is not possible to distinguish among species from the shape or size of single finds of acorn. Therefore, this remain was put to the group of woodland/shrubland vegetation of diverse ecologies. It should be pointed out, though, that maquis vegetation was already well developed during this phase around the cave (Antolín et al. 2013, Ros 1996). Therefore, it is likely that these fruits belong to *Quercus coccifera.*

4.11.7.5. Taphonomic aspects

The assemblage recovered in layer 10 was rather intensively fragmented. Cereals presented around 60% of fragments while the fruits of *Arbutus unedo* were mostly represented by fragments (90%) (Fig. 4.248). The fragmentation was majorly of irregular type (over 90%). A different pattern was observed when considering the state of preservation of the surface of the remains. *Arbutus* presents almost 90% of remains with virtually intact surfaces, while the cereals have more than 70% of significantly degraded remains. The rest of the plant macroremains showed a lower intensity of degradation (*c*. 55% of significantly degraded remains) (Fig. 4.249). A larger part of cereal remains lacked the embryo (4.249).

The effects of the charring process on the grains were only detected on a small number of items and the MNI per taxon is too low to consider the results as representative. It is only worth to point out that some grains with mineral concretions were identified (Fig. 4.251; see Annex II for a comparable experimental example).

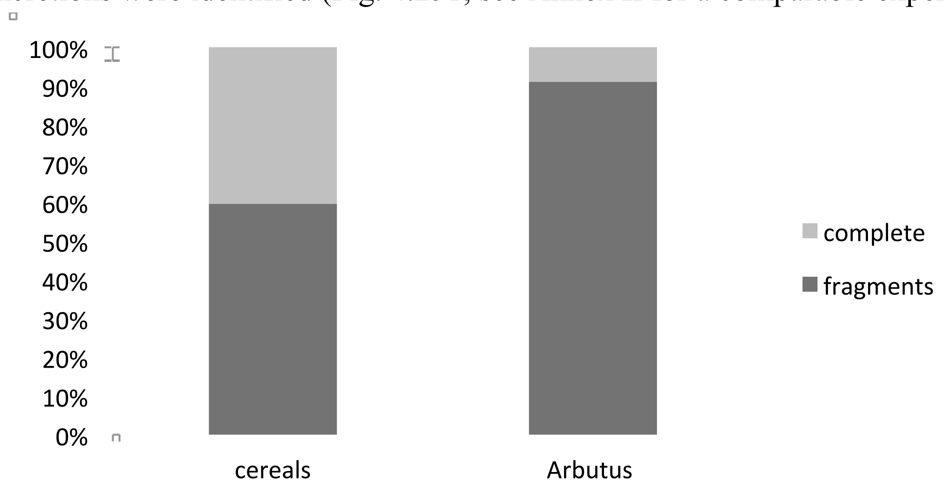

Fig. 4.248. Proportion of fragments and complete items of cereals and Arbutus *from layer 10 in Can Sadurní Cave (NR: 213).*

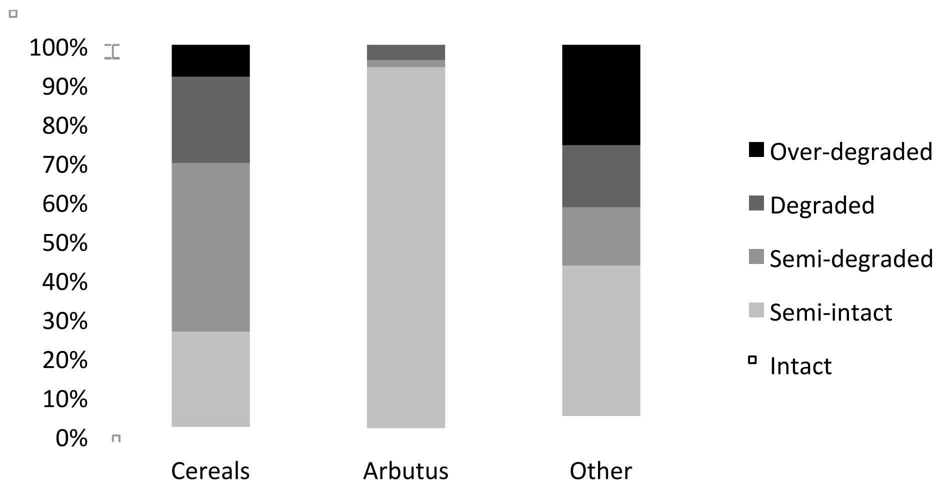

Fig. 4.249. State of preservation of the seed and fruit remains from layer 10 in Can Sadurní Cave (NR: 288).

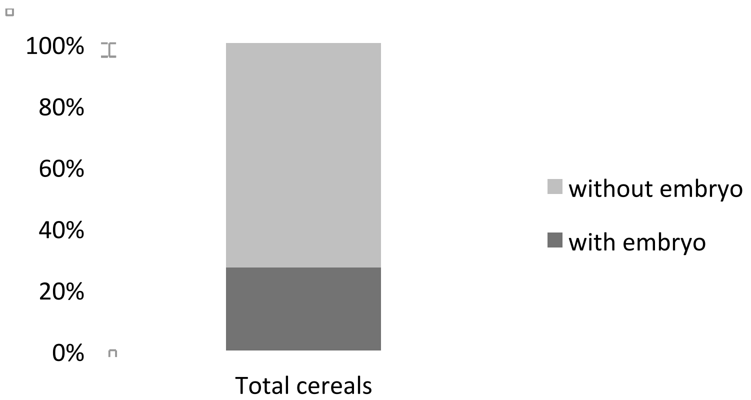

Fig. 4.250. Proportion of cereal grains with and without embryo in layer 10 in Can Sadurní Cave (NR: 74).

	Popped grains		Grains with protrusions		Grains with concave flanks		Grains with mineral concretions	
	Nr	%	Nr	%	Nr	%	Nr	%
Hordeum vulgare	1				1			
Hordeum vulgare var. *nudum*								
Triticum aest./dur./turg.			2	6.7	2	6.7	2	6.7
Triticum dicoccum	1						2	
Triticum monococcum	5	13.9						

Fig. 4.251. Effects of the charring process on the cereal grains from layer 10 in Can Sadurní Cave.

4.11.8. Discussion

4.11.8.1. The sampling strategy: is there an optimal strategy for all settlement phases in Can Sadurní Cave site?

The sampling strategies applied at the site to date were diverse but they had some elements in common: the preferential sampling of most of the excavated surface and the will to obtain a representative number of items.

Layer 18 was sampled in its entirety (even though it is only a sondage). The samples taken between 1998 and 2004 did not systematically differentiate the contents of pots from the sediment around them. Therefore, it was almost impossible to certify whether the contents of the vessels were originally a mixture of cereals or not. This problematic was already pointed out in previous work (Antolín 2008b) and it was suggested that some further efforts should be put into the individual sampling of the contents of each of the potsherds. The archaeologists applied this strategy in a small excavation that took place in 2008 and this allowed the results presented above. Unfortunately, this was a rescue excavation and only a minor work was carried out. Therefore, the obtained volumes of sediment and amount of samples were low. This strategy should be continued in future work.

Despite this fact, it is important to consider at this stage of research whether the analysis of (nearly) 100% of the recovered remains should continue or not. The record was, hitherto, very homogeneous, for which it is not worth to continue the identification and description of all the materials from this layer. The 2 mm fraction obtained from the flotation of surface samples should be subsampled with a riffle box in order to analyse quantities of around 400 crop items (as recommended by van der Veen & Fieller 1982)) per square and the remaining subsamples should be rapidly scanned for new taxa or other interesting finds. The 0,5 mm fraction should be completely sorted in all cases in order to recover as many potential weeds as possible. Pot contents, however, should be completely studied unless large amounts of remains are recovered (over 1000 per sample).

The sampling of layer 11 allowed the recovery of a large number of items and the observation of significant patterns of distribution of the materials. Unfortunately, the lack of data regarding the volume of sediment sieved was an important drawback in order to approach site formation processes. The continuation of the 100% sampling of the layer is convenient, since the results obtained could then be at least partly comparable with the previous ones. The singularity of the record of the layer supports such a particular effort in the recovery of plant macroremains.

The sampling of layer 10 was more problematic. Given that it was not possible in 2007 to sieve 100% of the sediment, a systematic interval sampling was applied, by taking 10 litres of sediment per grid square. This allowed the recovery of more than 400 items (in total), which is a relatively reliable number of items to characterize a settlement phase (van der Veen 1985). Nevertheless, if one calculates the potential number of items that could have been obtained if 100% of the sediment had been sampled (calculating and average volume of *c*. 40 litres of sediment per square, according to the results obtained in square E6), around 700 more remains would have been recovered. Ten samples would have yielded more than 35 remains and, three of them would have probably been of more than 100 items (Fig. 4.252). These figures might be completely overestimated, though, since square E6 was sieved in its entirety and only 37 items were recovered. It should also be considered that such strategy would have required a much larger amount of time for the processing and analysis of the samples.

	Volume (l.)	**NR**	**Potential NR if 40 l. had been sieved**
D5	**8.5**	**13**	**61.1**
D6	**10**	**8**	**32**
D7	**10**	**9**	**36**
D8	**10**	**6**	**24**
D9	**10**	**1**	**4**
D10	**9**	**8**	**35.52**
E5	**9**	**27**	**119.88**
E7	**10**	**8**	**32**
E8	**10**	**6**	**24**
E9	**9.5**	**4**	**16.84**
E10	**7.5**	**19**	**101.27**
F10	**10**	**24**	**96**
G10	**10**	**6**	**24**
G11	**10**	**28**	**112**
H10	**10**	**8**	**32**
H11	**10**	**23**	**92**
I10	**10**	**16**	**64**
I11	**10**	**11**	**44**

Fig. 4.252. Samples, volumes of sediment, number of remains per sample and potential number of items obtained if samples of 40 litres would have been taken in layer 10 of Can Sadurní Cave. Samples which yielded more than 35 items were shadowed in light grey and samples with more than 100 items in dark grey.

While the number of items recovered was observed to have a rather direct relation with the volume of the samples, this was not the case with the number of taxa per grid square. In all cases the botanical spectrum was limited to up to 12 taxa as a maximum per grid square. It is for this reason also important to continue sampling the entire excavated surface in order to find the maximum diversity of taxa possible, since it was through the analysis of multiple squares that the taxa spectrum was increased, rather than by looking at a large amount of remains per square.

To the question, "is there an optimal strategy for all settlement phases?", the conclusion is that a flexible strategy (in terms of volume of sediment and according to each type of context sampled and the questions that can be answered) of spatial sampling (on all the excavated surface) is the only possibility to get optimal results.

4.11.8.2. Taphonomic characterization of the layers

The taphonomic evaluation of the layers must take into consideration the preliminary results of the soil micromorphology analyses that were carried out at the site (Bergadà & Cervelló 2011). The formation of layer 18 was directly related with a colluvial episode which started with the collapse of the roof of the cave and continued with the entrance of detrital materials. The anthropogenic use of the cave took place and then the colluvial process was reactivated and it displaced the archaeological materials. Layer 11 presented a different pattern. Firstly, the sedimentation increased significantly (the layer is of 80 cm of depth) and, secondly, the origin of the vast majority of the sedimentation process was anthropogenic. During this period, this area of the cave would have been used as a byre and multiple episodes of burning of animal dung seem to have taken place. Increased sedimentation is usually linked to animal penning in caves (Angelucci et al. 2009). After this episode, the colluvial dynamics of the cave reactivate and layer 10 was formed. Anthropogenic agents (such as the burning of dung layers) were also identified in the micromorphological analyses but it was more difficult to characterize their role in the formation of the layer.

Layer 18

The taphonomic evaluation of layer 18 was already performed in previous work (Antolín 2008b, Antolín & Buxó 2011c) but it is worth to do a synthetic approach within this framework, after the analysis of the contents of the potsherds. First of all, it should be reminded that we are dealing with a funerary context (see chapter 3.1.11). One should also point out that the obtained results concerning the botanical composition of the samples were very homogeneous. Consequently, one can assume that layer 18 could represent one single context, a closed context. Secondly, it is certainly important to insist on the very high concentration of remains in this layer, which can only indicate to a massive assemblage, which was deposited in a short period of time. It might also be significant that a major concentration of materials was identified in square H8. This could be indicating that the distribution was not purely homogeneous. It is likely that the vessels broke as a result of the activation of the colluvial process and that at least some of them broke in the place where they were recovered during archaeological works. The large number of potsherds originated from the same vessel which were found in proximal location during the excavation could confirm this. Unfortunately, no quantitative evaluation (like a completeness index *sensu* (Schiffer 1983) or an analysis of the spatial distribution of the fragments from the same vessel) was carried out in this sense yet. It is also significant to notice that the concentration of remains observed in the contents of pots was higher than the results obtained for the surface sample. The results are still preliminary, since only a small number of samples from square I7 were evaluated on these terms. Nevertheless, it seems clear that the grains present in the sediment came from the pots.

The high fragmentation observed on the record might have several origins, partly due to the excavation techniques (over 30% of regular fragmentation was observed) and partly due to the colluvial process which was responsible for the formation of the layer. This episode might also be the cause for the relatively high percentages of degraded grains (*c.* 50%) on the assemblage.

The heating treatment of the assemblage seems to indicate temperatures of around 250-300° C and a low heating rate. The presence of fragments with deformations originated by charring inside a confined environment is relatively low (3-7% in the present analysis, 7-20% in previous works), but it is certainly higher than the percentages observed in other sites like Bòbila Madurell or Camp del Colomer (mostly below 1%). It is, for this reason, very likely that the charring conditions in Can Sadurní were different, probably because the grains were charred inside the vessels.

Layer 11

Layer 11 presented a wider botanical diversity compared with layer 18 and the distribution of the taxa (and the major concentrations of remains) seem to show, at least, two different contexts: one towards the north (squares F8 and G8) where cereals prevailed, and one towards the south (G6 and H7), where fruits of *Arbutus unedo* were dominant. This would indicate that the formation of the assemblages originated in more than one action, most probably.

The fragmentation of the remains was rather intense, but especially high for the fruits of *Arbutus unedo*. The state of preservation of the cereal remains, on the other hand, was significantly worse than in layer 18. Intensely degraded remains were more than 75% of the assemblage. These results indicate that the cereal assemblage could have suffered from intense erosion and that it could have originated elsewhere. The charring conditions were slightly stronger than in layer 18, since larger percentages of grains with concave flanks were documented (300-350° C at a low heating rate). This is just an orientative assumption which takes into consideration all cereal remains as one single assemblage. Nevertheless, it is very likely that these were originated after a large number of actions. Most of the grains lacked the embryo, which could be due to the intense degradation of most of the items.

Layer 10

The results from layer 10 could partly complement the ones obtained in layer 11. The densities observed in this layer indicate that the formation of the record was much slower than in layer 18. Therefore, it probably represents a large number of actions in a rather long period of time. The botanical diversity was similar to the one observed in layer 11 and some of the taphonomic observations as well. The fragmentation of the cereal remains was slightly lower in layer 10 but the fruits of *Arbutus* also presented a large percentage of fragments. On the other hand, the preservation of the surface of the fruits of *Arbutus* was very good. This variable was not possible to quantify for layer 11, given that the remains had been retrieved around 15 years earlier and they had not always been kept in optimal conditions. These results might be of major interest since they might indicate that cereals and fruits of *Arbutus* had very different taphonomic histories (probably in both layers, but for now this hypothesis is only based on the results obtained in layer 10). Thus, it seems that the fruits of *Arbutus* were charred *in situ* while the cereals were not. One possible explanation for this is that the fruits of *Arbutus* were incorporated into the dung layers that were continuously burnt inside the cave, reaching low temperatures during long periods of time, which would allow the preservation of such type of remains. These fruits would be incorporated along with the branches, which would be gathered as winter leaf fodder for the livestock. There are recent ethnobotanical references of the use of branches of

Arbutus as animal fodder (for sheep) during winter (Forbes 1976, Zapata & Peña-Chocarro 2003) or also of wild olives for pigs (Martín 1960). Further investigations on this topic are needed, especially of interdisciplinary type.

The charring history was difficult to establish, even for the cereal remains. But it probably consisted of temperatures around 300-350°C. No information was available to me concerning the charring process of fruits of *Arbutus*, for which it is at the moment not possible to know if they had a very different heating treatment than the one observed for the cereals. Experimental work on this issue is needed.

4.11.8.3. Agricultural practices along the Neolithic in Can Sadurní Cave

Given that the cereal remains from layers 10 and 11 could have originated after a large number of actions and that they were probably not recovered in a primary position (that is to say, where they were originally intentionally discarded), only the assemblage from layer 18 is optimal for the analysis of agricultural practices at the site. Nevertheless, an evaluation will be carried out for the three different layers.

Layer 18

The large assemblage recovered in layer 18 presents a mixture of different cereal remains which were nearly free from any other contaminants (chaff remains like spikelet forks, rachis fragments, etc., and also weeds). The ratios of grain:chaff observed seem to indicate that the grain was completely processed when it was put into the offering vases and burnt. The glume wheats presented some further evidences that they had been dehusked. The observed grain fragmentation patterns indicated that they were probably dehusked either by pounding with a wooden mortar or using a quern stone, as observed in experimental works (Meurers-Balke & Lüning 1992, Alonso et al. 2013). The different patterns of breakage in both taxa would indicate that these fragments had been produced using different techniques or intensities. Therefore, we concluded that this meant that each taxon was processed separately (Antolín 2008b , Antolín & Buxó 2011c). These results would also indicate that the glume wheats were most probably cultivated as monocrops. As a consequence, it was considered that naked wheat would have been grown separately as well. The status of both varieties of barley as crops is unknown. These could have been either contaminations in wheat fields, secondary crops or maybe they are hints to crop rotation.

The analysis of several contents of different pots confirmed that the different cereals were mixed inside them. They all contained naked wheat, emmer and einkorn, at least. It is then clear that this was an intentional deposition and that a large investment of labour was put so that the final product was as clean of impurities as possible. If these assemblages had been aimed for a long-term storage it is unlikely that the glume wheats had been dehusked, since they are more prone to infestations without the hulls (e.g. Alonso 1999, 203).

The limited weed assemblage recovered (Fig. 4.253) is characterized by mostly annual plants of long flowering time (more than 5 months). This is typical of intensely disturbed fields. Furthermore, only spring-summer germinating plants were found. This feature would be characteristic of spring sowing. Nevertheless, given the fact that an intensive perturbation of the plots might be taking place, it is possible that only the spring germinating plants survived an intensive weeding. Therefore, it is difficult to establish at the moment whether these were spring-sown crops or very intensively managed (and weeded) autumn crops. Even though this is a very limited weed spectrum, one should keep in mind that spring and summer-germinating plants are usually underrepresented in assemblages of grain which are in the final stages of processing, due to the biases introduced by crop processing, as demonstrated by other authors (Bogaard, Jones & Charles 2005). The main difficulty is to know if all cereals were grown under the same strategy or not. This is a question that should be targeted through other approaches such as isotope analyses on single grains.

	Life cicle	Flowering time	Height	Method of propagation	Germinating period
Cf. Avena sp.	annual		3-15 dm	seed	spring
Chenopodium album	annual	(V)VII-XII	2-20 dm	seed	spring/summer
Chenopodium hybridum	annual	VII-IX	2-10 dm	seed	summer
Solanum nigrum	annual	V-XI	1-6 dm	seed	spring/summer
Verbena officinalis	perennial (hemicryptophyte)	V-X	3-8 dm	seed	

Fig. 4.253. Ecological and botanical characterization of the weed spectrum of layer 18 of Can Sadurní Cave.

Layer 11

The crop assemblage of layer 11 not only included the same cereal taxa that were identified in layer 18, but also three potentially cultivated legumes. The representation of the cereal remains was rather limited but naked wheat was very well represented in the record. One could assume that it was probably the main cultivar at the site. The role of the rest of the taxa is more difficult to establish, since their index of relative abundance is mainly based on their ubiquity values (Fig.4.236) which could have no relation to the frequency of their use but to different postdepositional processes, as observed above. Given that the amount of chaff and weeds in the samples was very low, it is likely that these remains were originated as refuse from everyday cooking activities. The cultivation of pulses was only mildly documented but it is significant, given that they are largely underrepresented in the archaeobotanical record.

It is significant at this stage to highlight that the earliest evidences of the production of beer in the Iberian Peninsula were documented in this layer (Blasco, Edo & Villalba 2008). Calcium oxalates and silica skeletons of barley were identified in one of the pot fragments and malted starch grains were found in two grinding stones. These results show that the role of barley in the economy of the site might be underrepresented in the charred record.

The origin of the potential weeds documented is not known. It is difficult to tell if they arrived to the site as discarded weeds, in animal dung or through other channels. It is hoped that future studies of this layer can help into a better characterization of the crop husbandry practices.

Layer 10

The results obtained in layer 10 are largely comparable to those obtained in layer 11. A relatively small amount of cereal remains was recovered, mainly cereal grains. Naked wheat and einkorn were the best represented taxa, for which it could be said that it is likely that they were more frequently consumed at the site than the rest of the taxa. Pea and lentil were also identified, as in layer 11. The weed spectrum was equally impossible to relate to the crop remains, therefore no interpretation on the terms of crop husbandry was carried out.

4.11.8.4. Wild fruit management in the Neolithic episodes of Can Sadurní Cave

The representation of wild fruits in the record of Can Sadurní cave is quite irregular. The samples from layer 18 only yielded a small number of remains, while the ones fom layer 11 mostly contained wild fruits (Fig. 4.254). Eight taxa have high edible values (rank. ≥3). Among these, only three are present in the three settlement phases: *Chenopodium album, Arbutus unedo* and *Quercus* sp. These three taxa could have been gathered for alimentary purposes but the available record does not allow clear conclusions on this aspect. On the other hand, three taxa have medium medicinal value (rank. = 3) but the number of items recovered does not allow the supporting of any potential use in this sense.

		Layer 18	Layer 11	Layer 10
Weeds and ruderals				
Atriplex cf. *patula/prostrata*	seed/fruit		1	
Avena sp.	seed/fruit	**1**		2
Chenopodium album	seed/fruit	**1**	1	3
Chenopodium hybridum	seed/fruit	**1**		
Galium aparine subsp. *aparine*	seed/fruit		1	
Lolium cf. *perenne/rigidum*	seed/fruit			1
Malva sp.	seed/fruit		1	
Reseda phyteuma	seed/fruit		1	
Solanum nigrum	seed/fruit	**9**		12
Verbena officinalis	seed/fruit	**1**		1
Vicia tetrasperma type	seed/fruit		1	
Woodland edges and clearings				
Rubus fruticosus agg.	seed/fruit			3
Rubus idaeus	kernel	**1**		
Maquis formations				
Arbutus unedo	fragment of fruit	**5**	1401	70
Olea europaea cf. var. *sylvestris*	fruit stone fr.			1
Pistacia lentiscus	fruit stone		25	17
Riverine forest				
Vitis vinifera subsp. *sylvestris*	seed/fruit		2	
Woodland: diverse				
Pinus sp	fragment of cone scale	**3**	3	
Quercus sp	acorn fragment	**1**	11	1

Fig. 4.254. Total number of remains of wild fruits per layer in Can Sadurní Cave site.

Concerning Layer 18, it is not possible at the present state of research to give an economic value to the number of remains that were recovered along with a huge deposit of cereal grains. Part of the record could have arrived to the site as weeds and the rest could have reached the site either with the fuel (that could be the case for *Quercus* sp., *Pinus* sp., and *Arbutus unedo*) or transported by birds (*Rubus idaeus*), or they could have been gathered for human or animal consumption.

The wild fruits documented in layer 11 were diverse but the only quantitatively significant taxa were *Arbutus unedo, Pistacia lentiscus* and *Quercus* sp. All these taxa could have been gathered and consumed by humans but, as discussed in chapter 4.11.7.2., the taphonomy of the layer seems to suggest that these arrived to the site along with full branches in order to feed the livestock during the cold months of the year. As already mentioned, the use of leaves and young twigs of these taxa for animal foddering was ethnographically documented in the Iberian Peninsula (Martín 1960, Zapata & Peña-Chocarro 2003).

	Fruits	**Flowers**	**Young shoots**	**Aerial parts**	**Roots**	**Edibility rank.**	**Medic. Rank.**
Atriplex cf. *patula/prostrata*				Leaves, stewed		3	1
Chenopodium album	Edible when dried, parched and ground into flour.			Young leaves stewed		3	2
Chenopodium hybridum						2	1
Galium aparine subsp. *aparine*				Medicinal use		2	3
Lolium cf. *perenne/rigidum*						1	1
Malva sp.	Immature fruits eaten raw as snack	Medicinal uses (*M. sylvestris*)	Tender leaves and stems stewed	Leaves with medicinal uses (*M. sylvestris*)		3-5	0-2
Reseda phyteuma						1	0
Solanum nigrum	Eaten raw			eaten boiled; medicinal use		2	2
Verbena officinalis				infusion of aerial parts with medicinal value		1	2
Vicia tetrasperma type						1	0
Rubus fruticosus agg.	eaten raw, for jam, or drank as liqueur or other beverages		macerated with fruits for making liqueur, eaten steamed or in soup	Medicinal uses, young leaves used cooked	Medicinal uses	5	3
Rubus idaeus	Eaten raw or drank as liqueur or other beverages			Medicinal uses	Medicinal uses	5	3
Arbutus unedo	eaten raw, sometimes for making jam and liqueur			branches with leaves, as preservative for olives		4	2
Olea europaea cf. var. *sylvestris*	Fruits for oil or prepared in brine or as pickles					4	3
Pistacia lentiscus	Eaten as pickles, used as additive or used to make oil					2	2
Vitis vinifera subsp. *sylvestris*	Eaten raw or to make beverages and vinegar		Peeled and eaten raw as a snack			5	2
Quercus sp	fruits roasted, raw, boiled or grinded to flour to make bread		Twigs and leves of Q. ilex, to preserve olives	Barc and fruits of Q. petraea and robur used for medic. Purposes		2-5	2

Fig. 4.255. Ethnobotanically known uses of the wild plants that were identified in the seed and fruit record of Can Sadurní Cave, and edible and medicinal ranks for each taxon (www.pfaf.org).

Layer 10 was interpreted in rather similar terms. In this case, the best represented wild plants were *Solanum nigrum*, *Arbutus unedo* and *Pistacia lentiscus*. *Solanum nigrum* could have been consumed by humans, even though it can be toxic (at least when the fruits are green) and it has mind-altering properties (Guerra-Doce & López-Sáez 2006).

The obtention of leaf fodder is an intensive type of management of woodland resources and it is compatible with intensive farming. Leaf foddering would have been necessary for the survival of livestock during winter months. It would be during this time of the year when animals would be penned inside the rock shelter. The faunal evidence for the site seems to agree with these interpretations (Saña et al. in press). Unfortunately, the state of research at the site does not allow further discussion on this topic.

4.11.9. Summary and conclusions

The analysis of three different settlement phases of Can Sadurní Cave site allowed an approach to two different uses of a cave during the Neolithic period: firstly, a funerary use; and secondly, a productive use, through the evidences of agricultural practices and intensive wild fruit exploitation at the site.

The crop diversity was rather similar in all phases, but it is not possible to compare the results from layer 18 to those of layers 11 and 10. Layer 18 was formed in a very short period of time and the assemblage is interpreted as an offering. On the other hand, layers 11 and 10 represent longer periods of time and might be more relevant in order to describe the agriculture of the site. Naked wheat was well represented in all phases, while naked barley is only significant in layer 11, along with einkorn. Naked wheat and einkorn are the best represented crops in layer 10. Concerning crop husbandry practices, the weed spectrum of layer 18 seems to be characteristic of an intensive model, but the fact that several crops were mixed together does not allow a reliable conclusion for all the cultivars.

One of the most interesting observations in the latest phases (layers 11 and 10) was the fact that the relatively large amount of wild fruits recovered could respond to the use of leaf foddering to feed the livestock during winter months, when the cave would have been used as a byre. Further research is needed for a better understanding of the taphonomy of these layers.

4.12. Sant Llorenç Cave

4.12.1. Chronology and phases

Five different periods have been documented at the cave: Layer II (b), dated to *c.* 5200 cal BC; Layer III, dated to *c.* 4800 cal BC; Layer IV, dated to *c.* 3700 cal BC; Layer V, dated to *c.* 2550 cal BC; Layer VI, unknown (Chalcolithic or later periods) (O. Vicente, pers.com.). For more details see chapter 3.1.12.

4.12.2. Aims of the study

Sant Llorenç Cave offered the possibility of studying another multi-layered cave context, where several settlement phases could be analysed. A systematic sampling of the layers also presented the possibility of a low-scale spatial approach to the distribution of plant remains.

4.12.3. Materials and methods

The sampling strategy in Cova de Sant Llorenç was based on the arbitrary division of the surface of the cave into grid squares of 1 m of side, which were divided into four subsquares. The subsquares were named a, b, c and d, being subsquare a at the top left corner, b at the top right, c at the bottom right and d at the bottom left corner. Each subsquare was excavated according to archaeological layers and in spits of 5 cm of depth, which were given their name according to their depth in relation to a referenc point in the cave (T.114, T.116, etc.). This way, the materials were recovered within a very limited area, which would allow the reconstruction of activity areas at the site.

Settlement phase	Volume (l.)	Nr. samples
Layer II	35	7
Layer III	196	25
Layer IV	64	9
Layer V	19	3
	1177.15	226
	1491.15	270

Fig. 4.256.Volume of sediment and number of samples processed and ascribed to the different chronological phases in Sant Llorenç Cave.

A total number of 270 samples were taken (in the field campaigns of 2007, 2008 and 2009) and nearly 1500 litres of sediment were processed and sorted (the complete list of samples can be found in Fig. III.29). These were attributed to different layers or settlement phases during fieldwork. Nevertheless, the stratigraphy of the site is very complex, due to the illegal excavations that took place in the past, and the accurate ascription of the samples to each settlement phase can only be carried out on a sample by sample basis. For this reason, only those which yielded plant remains were correlated with the data available to the archaeologists (this work was performed by O. Vicente). Fortunately, several radiocarbon dates were carried out on cereal grains (Borrell et al. 2011), through which the ascription of the remains was confirmed.

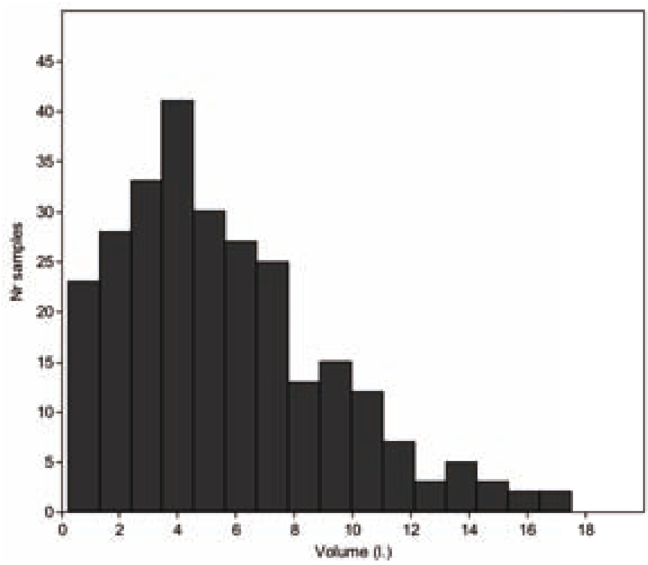

Fig. 4.257. Histogram of the volume of sediment per sample in Sant Llorenç Cave.

On the one hand, the average volume per sample was rather low (5.54 litres) and the vast majority of samples were of less than 10 litres of volume (Fig. 4.257). On the other hand, the possibility of amalgamating samples into meaningful contexts was always possible, since 100% of the sediment was recovered.

4.12.4. Results

A total number of 93 charred seed and fruit remains were ascribed to some of the settlement phases in Sant Llorenç Cave (see the total results amalgamated per subsquare in Fig. III.30). 23 plant remains were not possible to ascribe to any of the identified phases.

4.12.4.1. The number and density of remains, and the number of taxa per context

Each layer was considered as a single context, since the scarce number of items recovered did not allow the definition singular activities within each settlement phase. The number of items per context was very low: 6 in layer II, 44 in layer III, 9 in layer IV and 4 in layer V. The average density per layer was of 0.1-0.2 r/l in all cases. The maximum density at a sample level was 1 r/l, for which no particular concentration of items was identified in the excavated area. The number of taxa per context was equally low: three taxa in layer II; nine in layer III; three in layer IV; and two in layer V.

4.12.4.2. The botanical spectrum and the representation of the different ecological groups

A total number of nine taxa were identified. Three cultivars (*Hordeum vulgare, Triticum aestivum/durum/turgidum, Triticum dicoccum*), one taxon from maquis formations (*Pistacia lentiscus*), one from deciduous woodlands (*Prunus avium/mahaleb*) and two from woodland/shrubland formations of diverse ecologies (*Pinus* sp. and *Quercus* sp.) were identified. Two other taxa were not possible to classify within any ecological group (*Medicago* sp. and *Veronica* sp. type).

The complete diversity of ecological groups was only documented in layer III. Cultivars and woodland/shrubland vegetation of diverse ecology were present in all layers and they were rather equally represented in a quantitative sense. If not taking into account *Pinus* sp. and *Quercus* sp., plants from maquis formations and deciduous woodland were only recovered in layer III.

		5200 BC	4800 BC	3700 BC	2550 BC
Taxa	**Represented part**	**II**	**III**	**IV**	**V**
Cultivars: cereals					
Hordeum vulgare	grain		1		
cf. *Hordeum* sp.	grain fr.		1		
Triticum aestivum/durum/turgidum	grain	2	4	1	1
Triticum dicoccum	grain fr.		1		
***Triticum* sp.**	grain fr.		1		
Cerealia	Total remains		7	2	
Maquis formations					
Pistacia lentiscus	Total remains		1		
Deciduous woodland					
Prunus avium/mahaleb	fruit stone fragment		1		
Woodland/shrubland: diverse					
Pinus sp.	Total remains	2	13	1	
Quercus sp.	Total remains		1	1	3
Diverse/unknown					
***Medicago* sp.**	seed/fruit	1			
Papilionaceae	seed/fruit		1		
***Veronica* sp. Type**	seed/fruit		1		
	Total general	**6**	**44**	**9**	**4**
	Volume (l.)	**35**	**196**	**64**	**19**
	Density r/l	**0.2**	**0.2**	**0.1**	**0.2**
	Nr. of taxa	**3**	**9**	**3**	**2**

Fig. 4.258. Results of the seed and fruit analysis of Sant Llorenç Cave: identified taxa, number of items per settlement phase and ecological group in which they were grouped.

Only six remains were recovered in layer II and three taxa were identified: *Triticum aestivum/durum/turgidum, Pinus* sp., and *Medicago* sp.). In layer III, nine taxa were identified. Among the cereals, *Triticum aestivum/durum/turgidum* was slightly better represented. Among the wild plants, *Pinus* sp. yielded a larger number of remains. In layer IV, three taxa were recognized: *Triticum aestivum/durum/turgidum, Pinus* sp. and *Quercus* sp. In layer V, *T. aestivum/durum/turgidum* and *Quercus* sp. were recovered.

4.12.5. Discussion

4.12.5.1. The sampling strategy: is it worth to continue with the same strategy on the long term?

The scarcity of remains recovered to date in Sant Llorenç Cave makes the accurate strategy of sampling a worthless effort. The continuation of the strategy should take into account the interests of other materials such as charcoal or microfaunal remains. For the plant macroremains, given their scarcity, the sampling per subsquare of 50x50 cm would be unnecessary and the sorting of only a part of the 0,5 mm fraction would be sensible, since this fraction lacked of seed and fruit remains in most occasions. Layer III might deserve the greatest sampling efforts, given that it yielded the larger amount of remains to date.

4.12.5.2. Plant economy in Sant Llorenç Cave

The available data give few insights into plant economy at the site. The presence of cultivars in all phases leads to two possible interpretations: either some small groups of farmers established in the cave or in its surroundings and cultivated their own crops, or these were brought from elsewhere in order to be consumed in the site while carrying out other activities. The archaeological context is at the moment not clarifying enough and it is hoped that future work can help into a better understanding of the different settlement phases at the site. The repeated presence of naked wheat in all phases might be indicating the importance of this taxon along the Neolithic period.

Different wild fruits were identified. The uses of most of them have already been discussed in previous chapters. *Prunus avium* and *P.mahaleb* are two edible species that could have been gathered, just like *Quercus* sp., *Pinus* sp. and *Pistacia lentiscus*.

4.12.6. Summary and conclusions

A very accurate sampling strategy was applied in Sant Llorenç Cave. Around 1500 litres of sediment were processed. The archaeobotanical materials retrived were very scarce but they allowed (through their radiocarbon dating) a more accurate definition of the different settlement phases that took place at the site during the Neolithic period. Cultivars were present in all phases, being naked wheat constantly represented in each of them. Unfortunately, the data obtained did not make it possible to reach further interpretations.

4.13. Espina C

4.13.1. Chronology and phases

Most of the archaeological structures of this open-air site seem to belong to the Late Neolithic phase (2870-2570 cal BC). For more information, see chapter 3.1.13.

4.13.2. Aims of the study

The study of Espina C presented the possibility of approaching agricultural practices and wild fruit management in the Late Neolithic period. The identification of a dwelling context offered a great potential to investigate the access of individual households to plant food products and food refuse management strategies.

4.13.3. Materials and methods

Thirteen judgement samples were obtained from ten different archaeological features (the complete list of samples was presented in Fig. III.31): eight storage pits and two post holes (Fig. 4.259). A total volume of 104 litres was recovered, being the average volume per sample of 8 litres. All samples were processed by water-screening with a column of sieves of 4, 2 and 0,5 mm of mesh size. The residues of the 0,5 mm fraction were treated by manual flotation on a second stage, in order to reduce the sorting time, following previous experiences (Alonso 1999, 65).

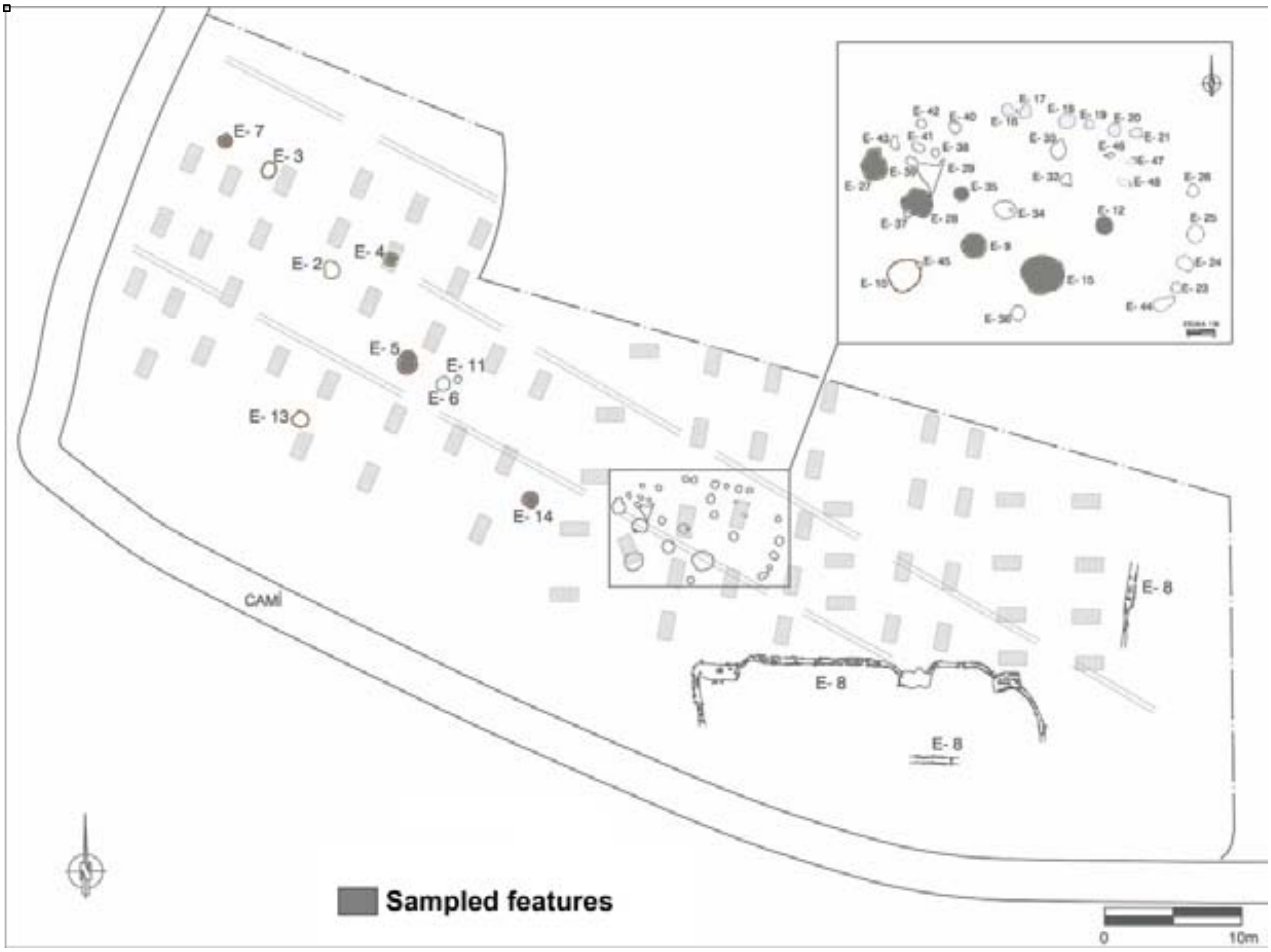

Fig. 4.259. Spatial distribution of the sampled features of Espina C site.

4.13.4. Results

Thirteen charred seed and fruit remains were recovered (Fig. 4.260). Only two features yielded positive results: E-15 (nr: 9) and E-5 (nr: 4), two storage pits. The densities of remains in both structures were very low, around 0,5 r/l.

Two taxa were identified: a cultivated cereal (*Hordeum vulgare*) and a taxon from maquis formations (*Pistacia lentiscus*). In E-5, no identifiable taxa remains were recovered. All the identified taxa were recovered in E-15, a storage pit located next to the dwelling structure.

Taxa	Represented part	E-15 UE 153	E-15 UE 154	E-5 UE 51	TOTAL SITE
Cultivars: cereals					
Hordeum vulgare	grain fr.	1			**1**
Cerealia	grain fr.	1			**1**
Maquis formations					
Pistacia lentiscus	seed/fruit	1			**1**
cf. *Pistacia* sp.	seed/fruit		2		**2**
Diverse/unknown					
Poaceae	grain fr.		1		**1**
Unidentified	fragment	3		4	**7**
	Total general	**6**	**3**	**4**	**13**
	Volume (l.)	**13**	**8**	**7**	**28**
	Density (r/l)	**0.5**	**0.4**	**0.4**	**0.5**
	Taxa	**2**	**2**	**0**	**2**

Fig.4.260.Results of the seed and fruit identification of Espina C site: taxa, represented part, ecological group and number of items.

4.13.5. Discussion

The sampling strategy at the site focused on those contexts which seemed to contain larger amounts of charred organic material. Nevertheless, the results were extremely poor. Even though the samples were, in average, of a small volume (an average of 20 litres of sediment per sample would have been more desirable), it is very likely that the site was meagre in archaeobotanical remains. This could be due to several reasons (that the crops were not processed close to the household, that refuse was not systematically burnt or that it was not discarded in pits or it might be due to other postdepositional processes like soil acidity). In any case, the sampling strategy was adequate for detecting this paucity of remains and a larger sampling would have only allowed a slight increase in the number of recovered items. The distribution of the remains indicates that a particular emphasis should be done in the sampling of those features which are directly related to dwelling structures.

Few can be said about plant economy at Espina C site. One single cultivar was identified, *Hordeum vulgare*. The presence of storage pits, quern stones and sickle blades (Piera et al. 2009) at the site would indicate that production, storage and consumption were being carried out by this community. The presence of *Pistacia lentiscus* in this context might be the result of its use for making oil or as ingredient on several recipes (Hadjichambis et al. 2008, Torres-Montes 2004). It could as well have been accidentally charred when using the wood of this taxon as fuel.

4.13.6. Summary and conclusions

The archaeobotanical analyses carried out at Espina C were of limited success in the obtention of new data. Nevertheless, it is of major significance for the region where the site is located to identify the presence of *Hordeum vulgare* and *Pistacia lentiscus* in the Late Neolithic period. Several elements of the archaeological context were used to defend a local agriculture.

4.14. Pla del Gardelo

4.14.1. Aims of the study

Pla del Gardelo offered the possibility of analysing plant economy in an open-air site from the Early Middle Neolithic (radiocarbon dates not available). It is one of the earliest Neolithic sites in the plain of Lleida, for which it could give interesting information on the first farming practices in this region. For more details see chapter 3.1.14.

4.14.2. Materials and methods

Thirteen samples were taken from all the eleven excavated archaeological features. An intense collection of judgement samples was carried out. A total of 620 litres of sediment were recovered, with an average volume per sample of 47.7 litres of sediment (the complete list of samples can be found in Fig. III.32). Most of the sampled features could were originally used as storage pits, but they were heavily damaged by recent agricultural works in the area, for which their original shape was not possible to reconstruct. Two more pits of unknown functionality, a burial (E.09) and a dwelling structure (E.06) were also identified. Most of the samples and contexts sampled were these potential storage pits (509 litres of volume of sediment), a relatively large sample of 69 litres was obtained from the dwelling structure, a sample of 28 litres was obtained from the funerary structure and two samples from the two different pits added up to 14 litres of volume (Fig. 4.261). In general, the largest samples (over 15 litres of volume) were processed with a flotation machine, the rest of the samples were water-screened as in Espina C (see chapter 4.13.2).

	Nr. of samples	**Nr. of contexts**	**Volume of sediment (l.)**
storage pit	9	7	509
pit	2	2	14
dwelling structure	1	1	69
burial	1	1	28

Fig. 4.261. Number of samples, number of contexts and volume of sediment processed per context type in Pla del Gardelo.

Fig. 4.262. Spatial distribution of the sampled features of Pla del Gardelo.

4.14.3. Results

A total amount of 44 seed and fruit remains in charred state were recovered (Fig. 4.263). Most samples yielded 2 items or less (n: 10), while only three samples produced 5 or more remains. The resulting densities of remains per litre were very low, 0,1 r/l in average. The botanical diversity per sample was equally low, with a maximum of two taxa in E.01 UE11 (probably, a storage pit).

Taxa	Represented part	E. 01 UE 11	E. 01 UE 12	E.02 UE 21	E.02 UE 22	E. 03 UE 31	E. 06 UE 61	E. 07 UE 71	E. 08 UE 81	E. 10 UE 101	TOTAL
Grasslands											
Teucrium* cf. *scordium	**seed/fruit**					1					**1**
Maquis formations											
***Pistacia lentiscus* (cf. incl.)**	**seed/fruit**			1	1				1	1	**4**
***Pistacia* sp.**	**fragment**	1		4	6						**11**
Woodland/shrubland: diverse											
***Quercus* sp.**	**fragment**	3									**3**
Diverse/unknown											
Unidentified	**fragment**	20	2				2	1			**25**
	Total general	**24**	**1**	**5**	**7**	**1**	**2**	**1**	**1**	**1**	**44**
	Volume (l.)	**257**	**87**	**7**	**15**	**12**	**69**	**44**	**11**	**28**	**530**
	Density (r/l)	**0.1**	**0.0**	**0.7**	**0.5**	**0.1**	**0.0**	**0.0**	**0.1**	**0.0**	**0.1**
	Nr. taxa	**2**	**0**	**1**	**1**	**1**	**0**	**0**	**1**	**1**	**3**

Fig. 4.263. Results of the seed and fruit analysis of Pla del Gardelo site: taxa, represented part, ecological group, number of items per sample.

Three taxa were identified at the site: one which is characteristic from wet meadows (*Teucrium* cf. *scordium*), one from maquis formations (*Pistacia lentiscus*) and one from woodland/shrubland formations of diverse ecology (*Quercus* sp.). *Pistacia lentiscus*, the taxon from the group of maquis formations, was the best represented taxon, both in a quantitative sense and on a ubiquity basis (present in 5 samples). One seed of *Teucrium scordium* and three fragments of acorn (*Quercus* sp.) were recovered from one single feature each.

4.14.4. Discussion

The sampling strategy applied at Pla del Gardelo was adequate. Large samples were taken from almost all of the archaeological features. Nevertheless, the results were not rewarding. Quite the opposite, the available data do not allow definite conclusions concerning plant economy at the site. The absence of cultivars is probably due to the lack of samples from nearby areas to the dwelling structure or because of postdepositional agents like soil acidity. However, some remains of wild fruits were present, like fruit stones of *Pistacia lentiscus* and kernels of *Quercus* sp. The repeated presence of *Pistacia lentiscus* in two different areas of the site seems to support a particular interest on this taxon which could have been used for several purposes, but especially for its oil content (Torres-Montes 2004). One should not rule out the possibility that the fruits just came with the wood that was gathered as fuel. *Pistacia* is one of the most commonly represented taxa in the charcoal record of the Western Plain during Prehistory (Vila & Piqué 2012, Piqué, Vila & Alonso 2012) *Teucrium scordium* has not many traditional uses, although some medicinal value (rank: 1) is acknowledged to it by the PFAF database and several species of *Teucrium* were traditionally used in the Iberian Peninsula to make herbal tea out of their flowers (Tardío, Pardo-de-Santayana & Morales 2006).

4.14.5. Summary and conclusions

The analysis of the archaeobotanical materials of Pla del Gardelo gave very poor results where only wild plants were represented. A rather intense sampling of most of the excavated features did not allow the reconstruction of economic practices at the site. The absence of cultivars on the record was not considered as representative of the economy of the settlement. The repeated finding of *Pistacia lentiscus,* on the other hand, was interpreted as evidence in favour of its interpretation as a consumed product, although other possibilities were proposed.

4.15. El Collet

4.15.1. Aims of the study

The analysis of El Collet site presented the opportunity of studying refuse management in an -ir site from the Vth millennium cal BC in the Western plain region. The state of preservation of the storage pits was excellent, for which this was a rather unique opportunity to approach taphonomic issues and plant economy in this region. For further data on the archaeological work at the site, see chapter 3.1.15.

4.15.2. Materials and methods

Four samples were taken from three different archaeological features (Fig. 4.264, see the complete list of samples was presented in Fig. III.33). 179 litres of sediment were processed, mainly from E-2 (154 litres in two samples); 20 litres were sieved from feature E-1 and 5 litres from E-3. They were all storage pits in their primary function but E-1 had been used as a grave and a burial was found inside (Piera et al. 2008). One sample was treated by flotation (E-2 UE12, of 104 litres of volume) but the rest were water-screened as in Espina C site (see chapter 4.13.2.).

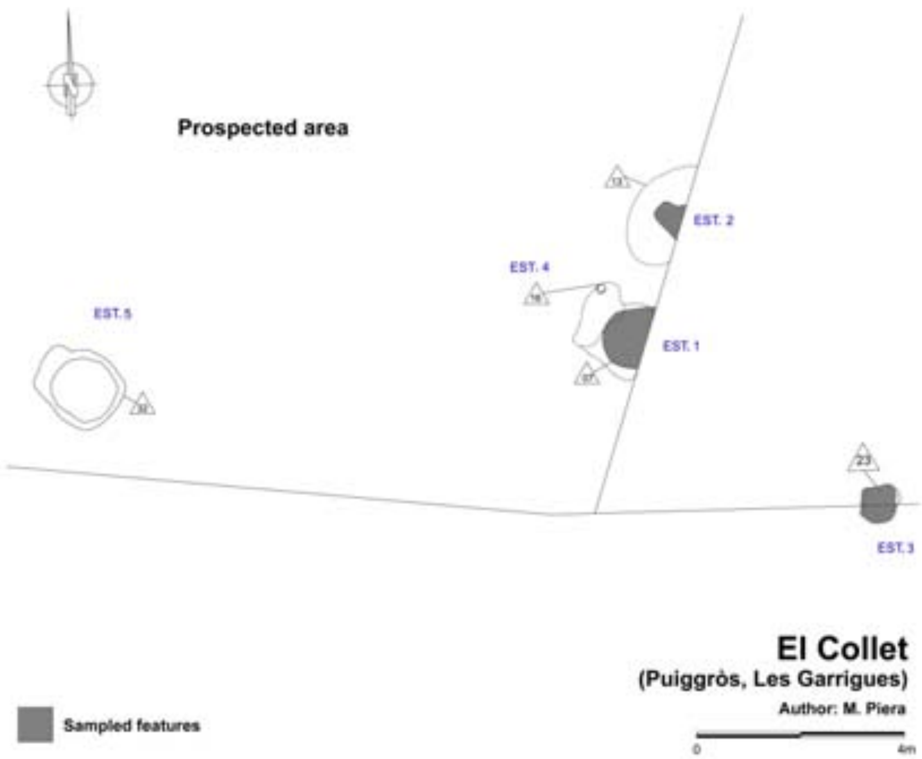

Fig. 4.264. Sampled features at El Collet site.

4.15.3. Results

A total number of 114 seed and fruit remains in charred state were recovered (Fig. 4.265). The number of remains per feature was uneven: 13 in E-1, 100 in E-2 and 1 in E-3. The densities of remains per litre of sediment were low (0,20-1,32 r/l). The number of taxa obtained per sample was also low, with a maximum of five taxa in sample E-2 UE15.

Taxa	Represented part	E-1 UE 28	E-2 UE 12	E-2 UE 15	E-3 UE 25	TOTAL
Cultivars: cereals						
Hordeum vulgare* var. *nudum	**grain fr.**			**1**		**1**
***Hordeum* sp.**	**grain**			**1**		**1**
***Triticum aestivum/durum/turgidum* (cf. incl.)**	**grain**			**2**		**2**
***Triticum* sp.**	**Total remains**		**1**	**3**		**4**
	grain fr.			3		3
	grain		1			1
Cerealia	**grain fr.**		**4**	**47**		**51**
Weeds and ruderals						
***Avena* sp.**	**awn fr.**	**1**		**2**		**3**
Maquis formations						
Pistacia lentiscus	**Total remains**		**2**	**1**		**3**
	fragment		1	1		2
	seed/fruit		1			1
Diverse/Unknown						
Poaceae	**grain fr.**	**9**	**25**	**6**		**40**
cf. *Potentilla* sp.	**seed/fruit**	**1**				**1**
Vicia/Pisum	**cotyledon**			**2**		**2**
Unidentified	**Total remains**	**2**	**2**	**1**	**1**	**6**
	fragment	1	2	1	1	5
	seed/fruit	1				1
	Total general	**13**	**34**	**66**	**1**	**114**
	Volume (l.)	**20**	**104**	**50**	**5**	**179**
	Density r/l	**0.65**	**0.33**	**1.32**	**0.20**	**0.64**
	Nr. taxa	**2**	**2**	**5**	**0**	**6**

Fig. 4.265. Results of the seed and fruit analysis of El Collet site: taxa, represented part, ecological group and number of remains per sample.

Six taxa were identified at the site. Two cultivars (*Hordeum vulgare* var. *nudum* and *Triticum aestivum/durum/turgidum*), one potential weed or ruderal plant (*Avena* sp.), one taxon characteristic of maquis formations (*Pistacia lentiscus*) and other taxa of diverse or unkown ecological groups (cf. *Potentilla* sp., *Vicia/Pisum*). Cultivars were the best represented ecological group, but they were only present in one feature (E-2). The number of items identified to species level (n:3) was very low. *Avena* was identified among the potential weeds and ruderals. Awn fragments were recovered in E-1 and E-2. A small number of *Pistacia lentiscus* were only found in E-1.

4.15.4. Discussion

The sampling strategy at El Collet was adequate, given that large samples were taken, when possible, from all archaeological features. Nevertheless, the results were very scarce. Among the cultivars, naked barley and naked wheat were identified. The retrieval of charred grains inside a storage pit with no chaff remains might respond to the fact that these were discarded refuse from everyday consumption. Given the poorness of the results, any interpretation remains very tentative. These remains concentrate in E-2. This structure might have been located near to a dwelling structure, given that it presented a slightly higher density of remains per litre of sediment. The archaeological context (sickle blades, quern stones and storage pits) supports the hypothesis of a local agriculture at the site (Piera et al. 2008)

Some wild plants were also recovered at the site. Among these, *Pistacia lentiscus* is relevant, since it seems to appear in all the Neolithic sites of this region (the Western Plain). As already mentioned in previous chapters, the fruits of this taxon do not have a high alimentary value but they are known to have been consumed as pickles or in other recipes, or also used to make oil (Hadjichambis et al. 2008, Torres-Montes 2004). It should be reminded, though, that *Pistacia* is always represented in the charcoal records of this region (Vila, Piqué 2012, Piqué, Vila & Alonso 2012) The presence of the taxon *Vicia/Pisum* is also relevant, since it could correspond to a cultivated legume. Nevertheless, the state of preservation of the remains and their scarcity in the record did not allow definite conclusions on this issue.

4.15.5. Summary and conclusions

The analyses performed at El Collet allowed the identification of the practice of agriculture in the second half of the Vth millennium cal BC in the Western plain. Naked wheat and naked barley were identified. *Pistacia lentiscus* was the best represented wild fruit, for which the use of its fruits with an economic value was proposed.

4.16. CIM “El Camp”

4.16.1. Aims of the study

The analysis of archaeobotanical materials from CIM “El Camp” presented a unique possibility of approaching plant economy in the southern coastal area of Catalonia. Archaeobotanical data for this region are largely lacking. For more details, see chapter 3.1.16.

4.16.2. Materials and methods

The sampling strategy at the site was carried out through the obtention of a large number of judgement samples from most of the archaeological features. Nonetheless, the majority of them lacked of culturally diagnostic archaeological material, for which no chronocultural ascription was possible. Forty-one samples (398 litres of sediment) were obtained and processed by D. López (the total number of samples was presented in Fig. III.34). The average volume per sample was of 9,7 litres. Six samples were taken from features which were culturally ascribed to the Neolithic: one to the Late Early Neolithic (10 litres of volume), four samples from two features dated to the late Early Neolithic (37 litres of volume); and another sample from the Late Neolithic (8 litres of volume) (Fig. 4.266). All the features were pits of unknown functionality.

	Nr. of samples	Nr. of structures	Volume (l.)
Late Early Neolithic	1	1	10
Early Middle Neolithic	4	2	37
Late Neolithic	1	1	8
Bronze Age	3	2	72
Unknown	30	22	71

Fig. 4.266. Number of samples, of sampled contexts and volume of sediment processed per chronological phase in CIM "El Camp" site.

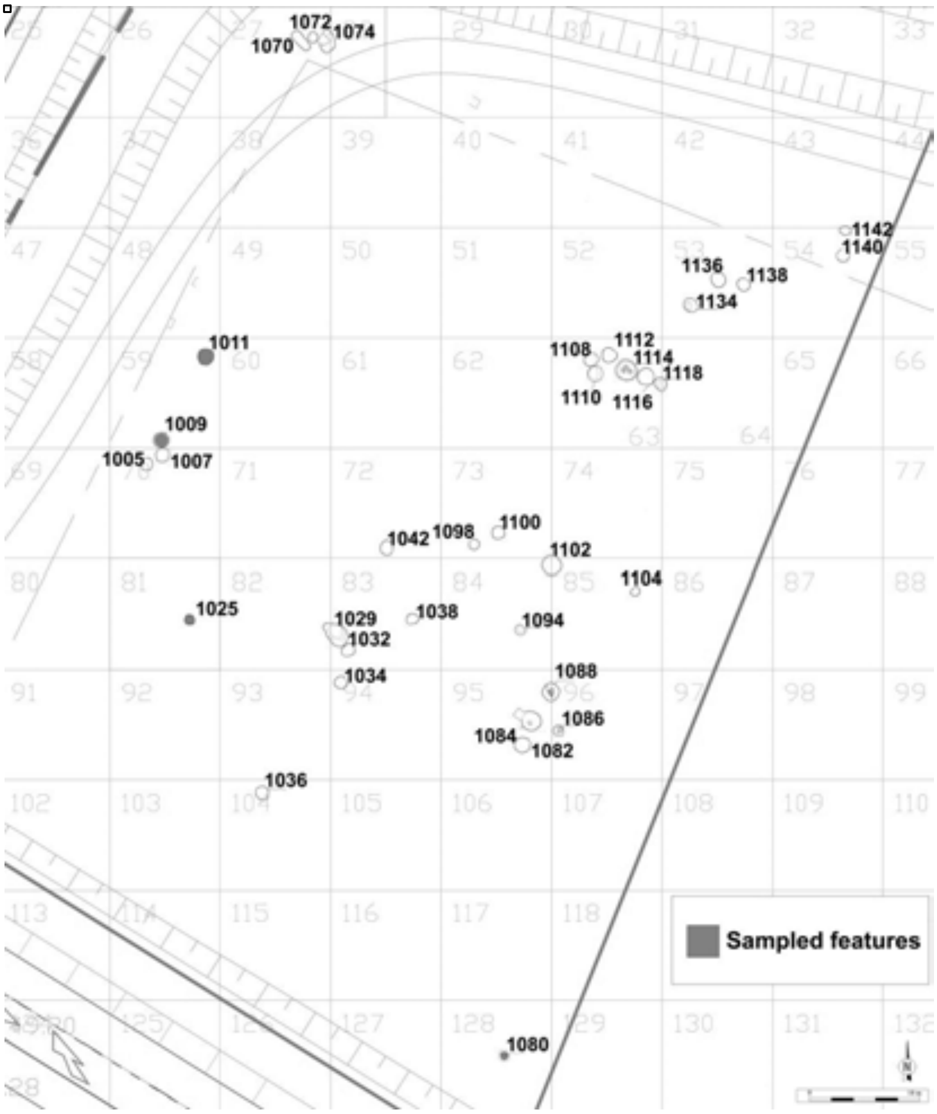

Fig. 4.267. Spatial representation of the sampled features in CIM "El Camp" site.

4.16.3. Results

Two seed and fruit remains were recovered, each one in a different pit from the Late Early Neolithic period: 1011 (feature 32) and 1009 (feature 37). The obtained densities were of 0,1 r/l. One single taxon was identified (Fig. 4.268): *Hordeum vulgare*. In consequence, only one ecological group was present in the record: the cultivated cereals.

		Feature 32	Feature 37	TOTAL
Taxa	**Represented part**	**1012**	**1215**	
Hordeum vulgare	**grain fr.**		**1**	**1**
Cerealia	**grain fr.**	**1**		**1**
	Total general	**1**	**1**	**2**
	Volume (l.)	**10**	**10**	**20**
	Density r/l	**0.1**	**0.1**	**0.1**
	Nr. of taxa	**1**	**1**	**1**

Fig. 4.268. Results of the seed and fruit analysis in CIM "El Camp": taxa, represented part and number of remains per sample.

4.16.4. Discussion and conclusions

The sampling strategy applied in CIM "El Camp" was the result of a considerable effort to recover archaeobotanical macroremains. Unfortunately, the record was extremely poor. Two cereal remains were identified in two features from the Late Early Neolithic period. A fragment of grain of hulled barley (*Hordeum vulgare*) was recovered, for which it is possible that agriculture was practiced at the site.

4.17. Fosca Cave

4.17.1. Aims of the study

The possibility of integrating the archaobotanical results of Fosca Cave into this study was considered of major interest, since the available data for the southern part of the region under study are very scarce and the stratigraphy of the site covered several periods from the Upper Palaeolithic to the Middle Neolithic (*c.* 13400-4000 cal BC). The excavation consisted on a sondage and it was not the aim of the archaeologists to carry out a thorough palaeoeconomic evaluation of each settlement phase, but only obtaining some complementary hints to the composition of each layer, which could guide future investigations on a larger surface of the site. For more information, see chapter 3.1.17.

4.17.2. Previous analyses

A previous publication on the materials of Cova Fosca, including the Palaeolithic and Mesolithic layers is already available (Antolín et al. 2010). The identification, quantification and chronological ascription of these materials were revised for this work.

4.17.3. Materials and methods

Seventeen judgement samples were taken from this site by the archaeologists. Seven further hand-collected samples were obtained (the complete list of samples was presented in Fig. III.35). Twelve of the soil samples belonged to the Early Neolithic phase (12,8 litres). For the Late Early Neolithic and Early Middle Neolithic phases only hand-collected material was analysed (Fig. 4.269). The average volume of the samples from the Early Neolithic period was of around one litre of volume. All sediment samples were water-screened as explained for Espina C site (see chapter 4.13.2).

	Nr. of samples	Volume (l.)	Manual collection
Upper Palaeolithic	3	17,3	
Mesolithic	2	0,26	
Early Neolithic	12	12,8	3
Late Early Neolithic			2
Early Middle Neolithic			1

Fig. 4.269. Number of samples, volume and manually collected samples per chronological phase in Fosca Cave.

4.17.4. Results

A total number of 126 seed and fruit remains were recovered for the three Neolithic settlement phases of Fosca Cave. The number of recovered items was much higher for the Early Neolithic period (n: 110) because this phase was more intensively sampled. The number of items recovered per sample was rather low, and only in one sample (-235/-242) of around 10 litres of volume, more than 35 remains were recovered. The number of taxa per sample was also very scarce except for the sample -235/-242, where 8 taxa were identified (Fig. 4.270). The densities of remains per litre of sediment observed for this phase were rather high, in some occasions, with 100 r/l in one sample and from 2,22 to 6,45 r/l in the rest. These were mainly small samples, for which one can conclude that judgement samples were prioritarily taken from clear concentrations of charred remains (Fig. 4.271).

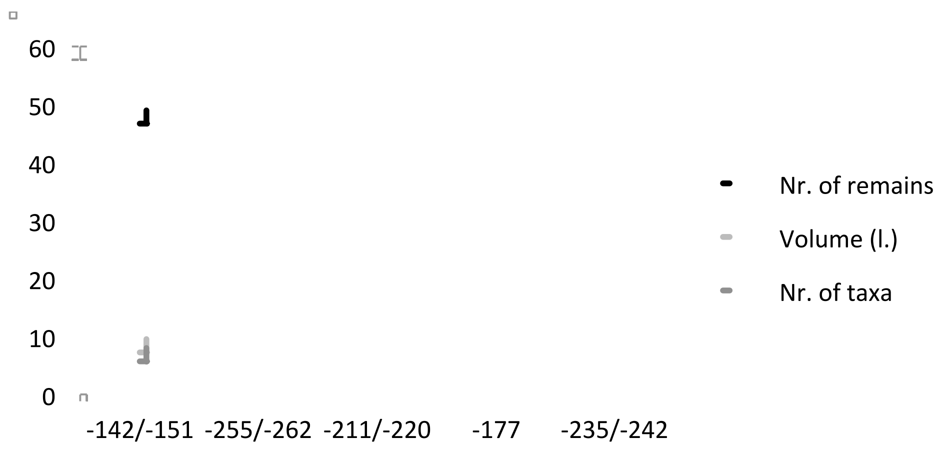

Fig. 4.270. Number of remains, volume of the samples and number of taxa obtained per sample in the Early Neolithic phase of Fosca Cave site.

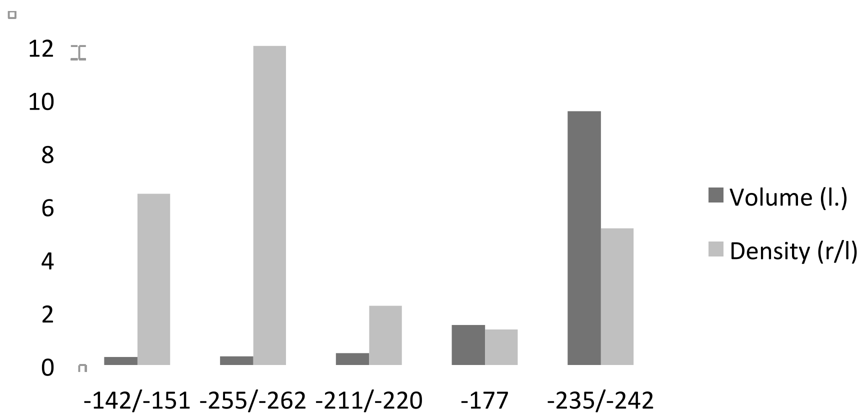

Fig. 4.271. Volume and density of remains per sample in the Early Neolithic phase of Fosca Cave site.

Eight taxa were recovered at the site (Fig. 4.272). One cultivated cereal (*Triticum aestivum/durum/turgidum*), one taxon from open deciduous woods or bushy formations (*Arctostaphylos uva-ursi*), three from deciduous woods (*Corylus avellana, Sorbus domestica, Taxus baccata*) and two from woodland formations of diverse ecology (*Pinus* sp. and *Quercus* sp.).All the taxa were identified in the Early Neolithic phase, while for the remaining two periods only *Quercus* sp. was identified.

Wild plants were the best represented group in all phases. Taxa from deciduous woodlands were well represented. Cultivars were only recovered in one sample (-235/-242).

Taxa	Represented part	EN	LEN	EMN
Cultivars: cereals				
Triticum* cf. *aestivum/durum/turgidum	**grain fr.**	1		
Cerealia	**grain fr.**	11		
Open deciduous woodland/Bush formations				
Arctostaphylos uva-ursi	**seed/fruit**	1		
Deciduous woodland				
Corylus avellana	**pericarp fr.**	11		
***Sorbus domestica* (cf. incl.)**	**Total remains**	2		
Pyrys malus/Sorbus domestica	**fruit flesh fr.**	1		
Taxus baccata	**fragment**	1		
Woodland: diverse ecologies				
***Pinus* sp.**	**cone scale fr.**	11		
***Quercus* sp.**	**Total remains**	46	14	2
Diverse/Unknown				
Unidentified	**Total remains**	5		
Unidentifiable	**fragment**	16		
Varia	**Total remains**	5		
	Total general	**110**	**14**	**2**
	Nr. taxa	**8**	**1**	**1**

Fig. 4.272. Results of the seed and fruit analysis of Fosca Cave: taxa, represented part, number of remains per chronological phase.

4.17.5. Discussion

The sampling strategy at the site was very inconsistent and focused on what was observable during fieldwork (concentrations of remains or large single items). It was detected that the largest sample (-235/-242) provided the largest amount of data and the widest botanical spectrum. Furthermore, it is not known whether similar samples from the rest of the levels could have produced comparable results. On the other hand, the materials obtained for the Late Early Neolithic and Early Middle Neolithic period were manually collected during fieldwork, which is not a guarantiee of a representative recovery strategy. In conclusion, the sampling plan applied in Fosca Cave biased the final results, for which they should be interpreted with care. An intensive surface sampling is strongly recommended in future works at the site, which could yield very promising results.

The obtained data for the Early Neolithic period were rather interesting, despite their scarcity and the methodological problems mentioned above. On the one hand, some evidences of the existence of cultivars at the site were documented. These were rather meagre but it is interesting to note that a sudden change was observed in the charred wood record of the level located just after the appearance of these cereal remains (-211/-220). This was interpreted as a potential evidence of the environmental impact of farming in the immediate surroundings of the cave (Antolín et al. 2010). The chronology of these grains is also remarkable, since the layer is dated to *c.*5700-5500 cal BC. If the direct radiocarbon dating of the grains could confirm this date, these would be among the oldest evidences of agriculture in this region. In the nearby site of Mas

Cremat (Portell de Morella, Castelló), *Triticum aestivum/durum/turgidum*, together with *Hordeum* sp., were also identified in Layer III, with very similar radiocarbon dates (*c.*5800-5500 cal BC) (Pérez-Jordà 2010), even though the cereal remains were not directly dated either.

The diversity of wild plants during the Early Neolithic phase at the site is, on the other hand, very significant. All of the identified taxa have known ethnobotanical uses, mainly as edible fruits, but also with medicinal value (*Arctostaphylos uva-ursi* and *Taxus baccata*) (Fig. 4.273). The identification of this rather wide diversity of wild plant resources probably indicates that the inhabitants of Fosca Cave made a frequent use of the wild resources available in the proximities of the cave. The season of collection of all these plants is between late summer and autumn.

	Fruits	Flowers	Young shoots	Aerial parts	Roots	Edibility rank.	Medic. Rank.
Arctostaphylos uva-ursi	eaten raw or in jam, with medicinal value			infusion of leaves with medicinal properties		3	4
Corylus avellana	Eaten, sometimes unripe, often raw, dried or in cakes, stews or as condiment					5	2
Sorbus domestica	eaten raw or in jam					5	0
Taxus baccata	arils of the seeds eaten raw; with medicinal value					3	4
Quercus sp.	fruits roasted, raw, boiled or grinded to flour to make bread		Twigs and leves of *Q. ilex*, to preserve olives	Barc and fruits of *Q. petraea* and *robur* used for medic. Purposes		2-5	2

Fig. 4.273. Ethnobotanically known uses among the wild plants that were identified in the seed and fruit record of Fosca Cave and edible and medicinal ranks for each taxon (www.pfaf.org).

The identification of acorns in the three settlement phases in Fosca Cave should be considered an indication of the frequent consumption of these fruits at the site. Acorns can be processed in a variety of ways before consumption, one of which could involve a roasting process. It is in this context where the fruits might get charred and discarded, which would allow their preservation in the sedimentary matrix.

The fruits of *Sorbus domestica* recovered could have been accidentally charred, also during roasting. These fruits are usually left to dry until they almost rotten. If a fruit was not consumed in time it could have also been discarded and in this process it could have become charred. A similar process could have taken place with *Arctostaphylos uva-ursi*. The remains of *Corylus avellana* and *Taxus baccata* could just be the by-products which cannot be consumed as food.

4.17.6. Summary and conclusions

The analyses performed at Fosca Cave were of limited potential, due to an inconsistent sampling strategy, but they provided very interesting data. First of all, the earliest cereal finds in the studied region were recovered in layer -235/-242. Naked wheat was identified. Besides, a rather diverse number of fruit remains with high edible value were identified. They were considered a potential evidence of the intensive use of wild resources that could be available in the vicinities of the site.

5. Discussion

This final discussion deals with several issues at a global perspective with the aim of addressing the questions that were raised in chapter 2. Here, I consider not only my own data, but also all the available data for the Neolithic period in the region under study (see Fig. III.36 for the complete table; see Figs. 2.8 to 2.12 for the location of the sites). Undated, preliminary studies or problematic sites with single finds were not included in any of the evaluations.

First of all, the applied methodology for this work is evaluated considering the results obtained for period, region and type of context in order to discuss the representativity of the available studies and of our own results and give guidelines for future research. More accurate methodological discussions at a sample or site level are to be found in the corresponding sub-chapters within chapter 4.

Secondly, two particular issues were approached on a larger scale: evolution of the crop spetrum and crop husbandry practices; and wild fruit gathering and consumption practices. These two approaches aim to provide an answer to our initial hypothesis, namely Neolithic farming economy was of intensive type. Finally, the socio-economic implications of these results for the Neolithic in the NE of the Iberian Peninsula will be discussed.

5.1. Methodological discussion

Before proceeding with the evaluation of the data, it is necessary to assess their representativity. Was the sampling strategy adequate for our goals? Did our studies bring out significantly relevant information on a quantitative and qualitative level? Are all regions and periods well represented in our database? For this, the methodological data presented in chapter 3 together with some of the results obtained in previous works are considered here.

5.1.1. Representativity of the analyses at a site level

In order to evaluate the representativity of the soil sampling strategies carried out on all the sampled sites to date in our region, the criteria developed by S. Jacomet and Ch. Brombacher (2005) for lakeshore sites in central Europe were adapted. Representativity is understood as the degree to which the results obtained (either good or bad) for a site (considering the quality of the sampling and archaeological work) can be considered as a reliable representation of the archaeobotanical record of the site. The maximum quality (1) is given to those sites where systematic sampling was carried out in more than 20 locations and several different dwelling units (houses), and for which the archaeological evaluation of the site was made. Sites with a good representativity (2) are those for which more than ten locations were sampled but it is not known how many dwelling units could have existed, or insufficient volumes were taken. Sites with few systematically taken samples and meagre archaeological information were considered as having a rather good representativity (3). Sites where only judgement samples were taken (but more than 20) and the archaeological information available was poor were considered as poorly representative (4). Very poorly representative sites (5) are those for which less than 5 locations, or much eroded layers, or with a very bad preservation of archaeobotanical remains, were sampled.

A synthetic description of the type of contexts, sampling strategy, the number of contexts with seeds and the chronological periods present at the site is presented in Fig. 5.1. The location of the sites can be found in Figs 2.11 to 2.15. The majority of sites have a good or very good representativity (n=10 out of a total of 24)

(Fig. 5.2), despite the fact that strictly systematic sampling was only carried out in 6 of the sites (this number can be increased to 15 when sites where judgement samples were rather systematically taken are considered too) (Fig. 5.3). A large diversity of types of contexts were analysed (Fig. 5.4). The fact that most of the sites (n= 17) had less than 10 contexts with seed and fruit remains (Fig. 5.5) should not be uncritically considered as a negative indicator without taking into account that most of these sites (n=12) did not have archaeological features, but just an archaeological layer resulting of a more or less large number of actions. Therefore, even when the number of sampled contexts is low, this does not need to affect the representativity of the data as these potentially result from a large number of activities carried out at the site. It should also be stressed that the sampling strategy of many sites is considered unrepresentative because the excavated surface of the site was small and, thus, it is impossible to know if the available data are representative for the whole site.

	Represen-tativity	Type of context								Sampling strategy	Nr of contexts with seeds	EN	LEN	EMN	MN	LN
		pit	stpit	hearth	dwelst	sph	ch-rich	post	burial							
Sardo Cave	2	X		X		X	X			probabilistic	4		X		X	X
Camp del Colomer	2	X	X		X					judg-syst	50			X		
Serra del Mas Bonet	2	X	X	X	X		X	X		judg-syst	17		X		X	X
Codella	5				X					interval	1		X			
La Dou	4	X		X		X	X	X		judgement	14		X	X		
120 Cave	4		X							judgement	7			X		
La Draga - sector D	2					X				systematic	4	X				
Bòbila Madurell	2	X	X	X	X				X	systematic	39				X	X
C/Reina Amàlia, 31-33	2		X	X	X		X	X	X	judg-syst	8		X	X		
Gavà Mines	3						X			judgement	7				X	
Can Sadurní Cave	2					X			X	interv-syst	3	X		X		
Sant Llorenç Cave	1					X				interv-syst	4	X	X		X	X
Espina C	3		X					X		judg-syst	2					X
Pla del Gardelo	4	X	X		X				X	judg-syst	6			X		
El Collet	4		X							judg-syst	3			X		
CIM "El Camp"	4	X								judg-syst	2		X			
Fosca Cave	5					X				grab	3	X	X	X		
La Draga - sector A	2			X						judgement	31	X				
Bauma del Serrat del Pont	3					X				judgement	3	X				X
Portes Cave	3					X				judgement	1					X
Plansallosa	4					X				judgement	unknown		X			
Toll Cave	5					X				judgement	1					X
Balma Margineda	3	X				X				judgement	4	X				
Caserna de Sant Pau	4		X	X		X				judg-syst	16	X		X		
Font del Ros	2	X								judg-syst	21	X				

Fig. 5.1. Sampling strategies in the Neolithic sites of NE of the Iberian Peninsula: representativity, type of contexts sampled (stpit: storage pit; dwelst: dwelling feature; sph: settlement phase, occupation layer; ch-rich: charcoal-rich layer), sampling methodology, number of samples with seed and fruit remains and chronological periods where these remains appeared (EN: 5400-5000 cal BC;LEN: 5000-4500 cal BC; EMN: 4500-4000 cal BC; MN: 4000-3200 cal BC; 3200-2300 cal BC). Bibliographical sources: (Hopf 1971, Alonso 1995, Bosch et al. 1998, Alcalde, Molist & Saña 2002, Buxó, Rovira & Sauch 2000, Marinval 2008, Buxó, Canal 2008, V.López, unpublished).

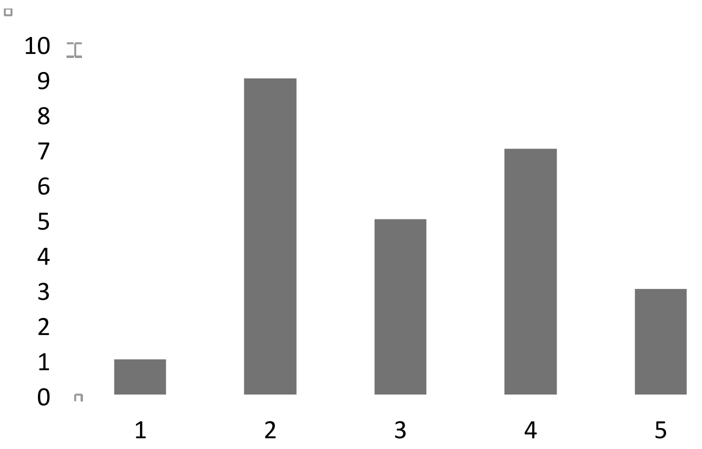

Fig. 5.2. Number of investigated Neolithic sites according to their representativity (1= very good; 5= very bad).

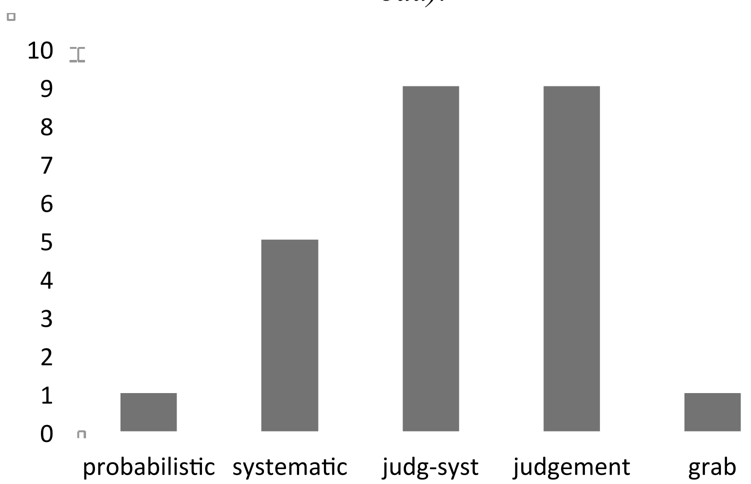

Fig. 5.3. Number of investigated Neolithic sites according to the sampling strategy.

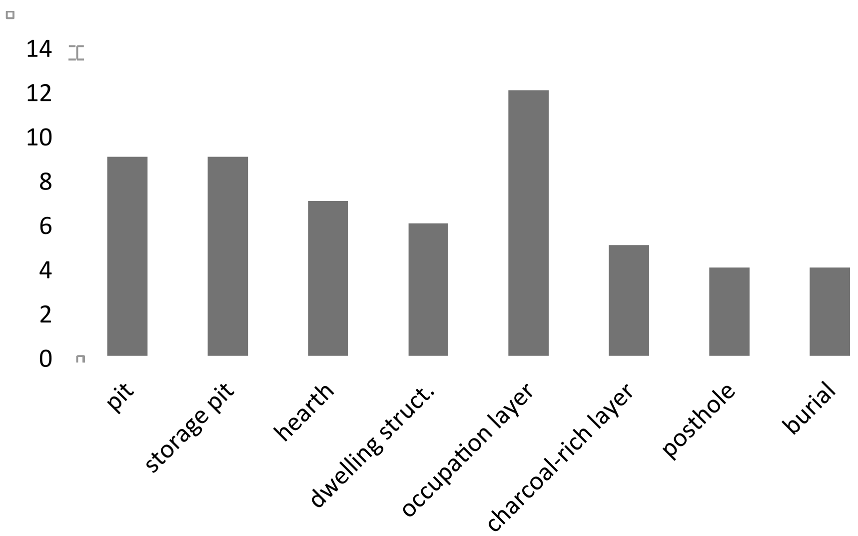

Fig. 5.4. Number of investigated Neolithic sites in which each type of context was sampled.

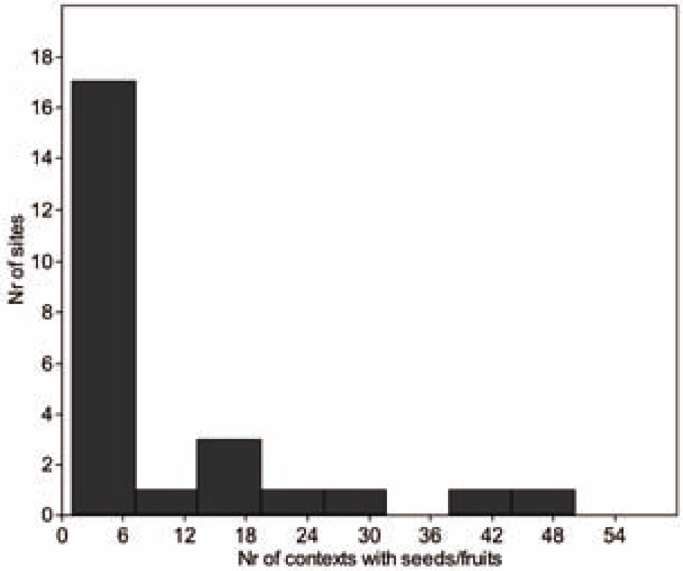

Fig. 5.5. Number of investigated Neolithic sites according to the number of samples with seed/fruit remains.

The data presented indicate that a significant corpus is available for the region under study, especially after this contribution (Fig. 5.6). Even though the number of remains analysed in the present study is around 27% of the total available at present, their significance is enhanced when one considers that around 300,000 of the previously available data were naked wheat grains from La Draga. In fact, not only a large number of new taxa were added to the available list (n= 107; 60 in charred state and 47 in waterlogged state), but also a large number of plant macroremains from a very important number of contexts (n= 164) from 17 different sites.

	TOTAL (incl. this work)	This work	% this work
Nr. of sites	24	17	70.8
Nr. of contexts	252	164	65.1
Nr. of taxa (charred state)	93	88	94.6
Nr. of items (charred state)	409135	113793	27.8
Nr. of samples with more than 35 items	84	41	48.8

Fig. 5.6. Comparison of the total data available for the Neolithic period in the region under study and the results obtained in this work. Only charred material was considered.

5.1.1.1. The representativity of the data per chronological period

It was not possible to attempt a full evaluation for a closer approach to the representativity of the data (like the one performed in chapter 3.2.1.2. for the sites analysed in this work), since we lack most of the information for some of the sites from previous analyses. A general approach already shows that the number of available investigated settlement phases is rather even for all periods except for the Middle Neolithic. For the latter only 5 settlement phases were analysed (Fig. 5.7). One should conclude, on the one hand, that the available data for the Middle Neolithic (4000-3200 cal BC) are, in general terms, less representative than those obtained for the Early (5400-4500 cal BC) and Late Neolithic (3200-2300 cal BC) periods. On the other hand, when considering the number of remains available per phase, one can observe that the absolute number of remains available for the Middle Neolithic is actually very high (Fig. 5.8). The Early Neolithic (especially between 5400 and 5000 cal BC) is the period for which the largest amount of data is available (mainly due to the huge number of charred cereal grains recovered at La Draga). Two periods are underrepresented: the Late Early Neolithic (5000-4500 cal BC) and the Late Neolithic (3200-2300 cal BC). Therefore the transition from the Early Neolithic (5400-5000 cal BC) to the Early Middle Neolithic (4500-4000 cal BC) will be difficult to understand from the available data. The Late Neolithic period will also be difficult to characterize in a reliable form and the data obtained for the Middle Neolithic might not be enough to characterize the total area under study. Future work within these chronological phases should emphasize systematic sampling strategies.

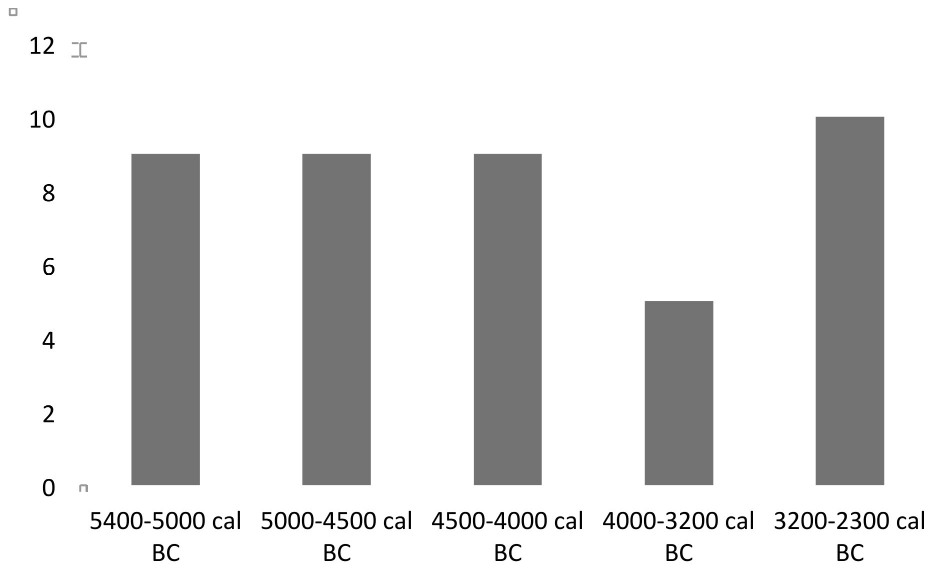

Fig. 5.7. Number of investigated Neolithic settlement phases per chronological phase.

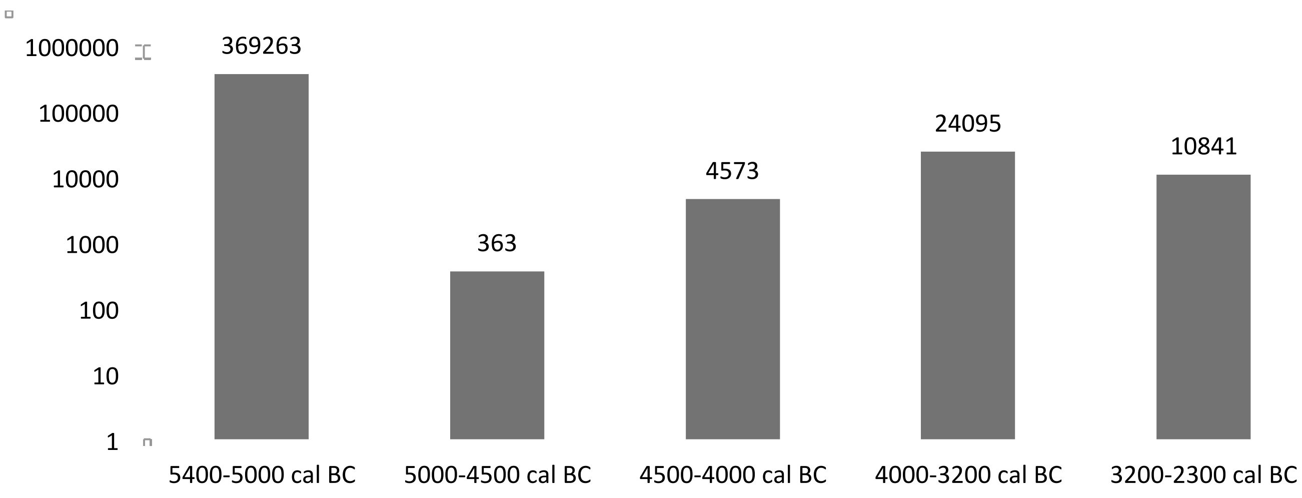

Fig. 5.8. Number of seed and fruit remains per chronological phase. Only charred material was considered.

5.1.1.2. The representativity of the data per region

The number of investigated sites per region is variable and, in fact, the differences that were already observed in our own data (Fig. 3.24) are increased when considering all the available data (Fig. 5.9). Most of the sites are located in the north-east and central coast areas (n= 25). Only three settlement phases were investigated in the western plain and three more in the southern region. Therefore, it is clear that these two areas are underrepresented in our database.

When comparing the number of investigated settlement phases with seed and fruit remains for each region and chronological period one can conclude that the north-eastern region is better represented during the first millennium of the Neolithic (5400-4500 cal BC), while the central coast is better represented during the Middle Neolithic. Data from the western plain are only available for the Middle and Late Neolithic, while no Late Neolithic material was studied for the southern region.

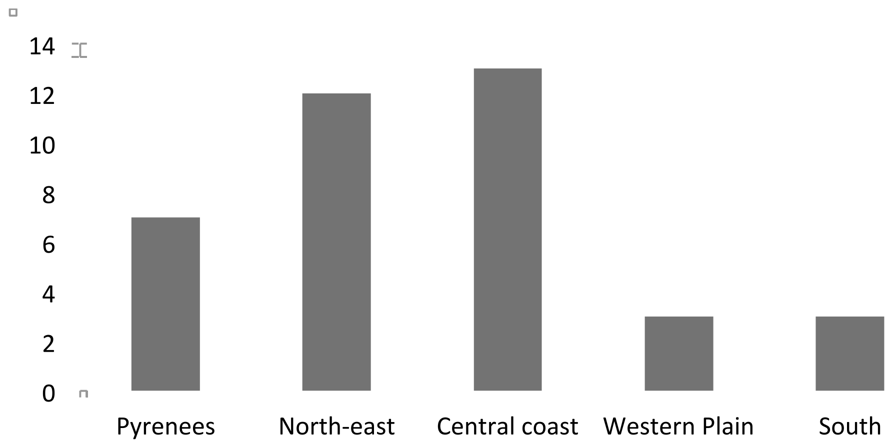

Fig. 5.9. Number of investigated Neolithic sites with seed and fruit remains presented per region.

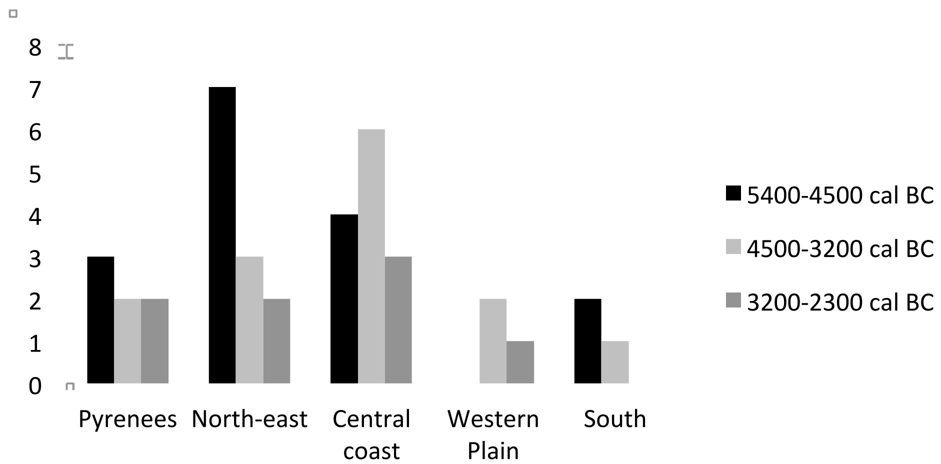

Fig. 5.10. Number of investigated sites with seed and fruit remains per region and chronological phase.

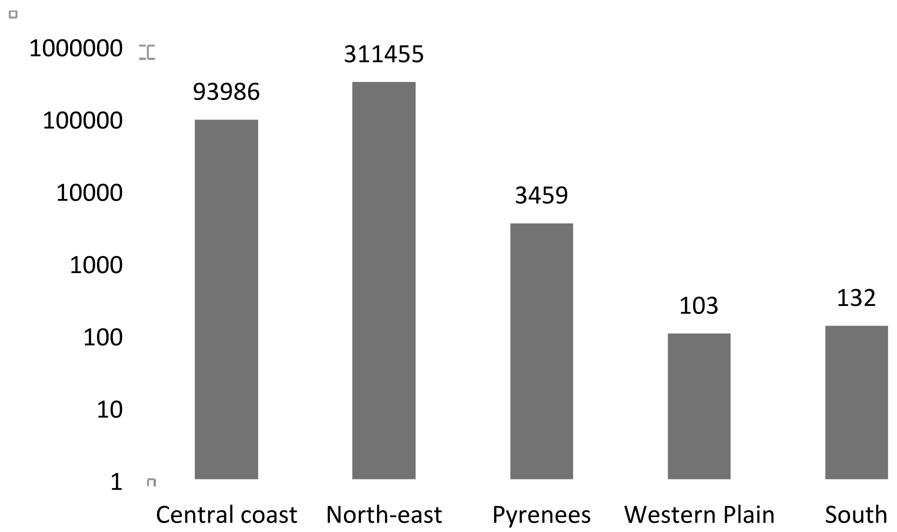

Fig. 5.11. Number of seed and fruit remains recovered per region. Only charred material was considered.

Finally, the number of seed and fruit remains recovered per region yields similar results. The majority of remains were retrieved from sites in the north-eastern and central coast areas. A high number of remains were recovered from the Pyrenean region (n= 3459), but a very low number of items was obtained from the Western Plain and the southern regions, just above 100. It seems clear that most of the conclusions will be driven by the data coming from the north-eastern and central coast regions as the Western Plain and the southern region are underrepresented in our database. Future work in these regions should stress the effort on sampling in order to improve this situation.

5.1.1.3. The representativity of the data per type of context

The total amount of remains per context type was calculated as well as the maximum number of remains obtained in a single context (Fig. 5.12). These data were calculated for a better understanding of the influence of each type of context in our results. Most of the remains were recovered in hearths, as well as funerary features and storage pits. Most of the remains recovered in hearths come from sector A of La Draga (not part of my own study; see, for instance, Buxó, Rovira & Sauch 2000). Without this site, only 908 seed and fruit remains would be recovered in this type of features. Concerning funerary structures, the vast majority of remains were obtained in the Early Neolithic funerary deposit of Can Sadurní cave. The material recovered from secondary fillins of storage pits is much better distributed in different sites and regions (they were sampled with positive results all over the area under study). These are interesting deposits, since they might represent discarded material from everyday consumption (secondary deposits). Other excavated features (pits) were also rather rich in remains, comparable to the storage pits (some of these pits might have originally been used for such purposes). Unfortunately, one of the worst results is that of the dwelling structures. These were rarely found in the studied region during the Neolithic and, even when sampled, they did not yield large amounts of remains. Most of these data come from the dwelling unit C-1 of Bòbila Madurell. Postholes were extremely poor in archaeobotanical remains. It is therefore not recommended to continue sampling this kind of features (at least with the purpose of recovering seed and fruit remains) in future works, unless the richness in archaeobotanical material is evident during fieldwork. Given the available results, it is advised to sample more primary contexts like dwelling areas in future research. If botanical macroremains are not available, studies of microremains (like phytoliths and starch) can be carried out to attempt a better insight into domestic activities during the Neolithic in the region.

	Total remains	Maximum in one context
Charcoal-rich layer	577	275
Dwelling structure	579	449
Funerary	57550	57482
Hearth	284796	139450
Pit	24766	14792
Post	1	
Storage pit	38126	15469
Settlement phase	2739	821

Fig. 5.12. Number of seed and fruit remains per context type and maximum number of remains in one single context.

5.1.1.4. Summary and conclusions

The results presented above show the potential and drawbacks of the available archaeobotanical data for the Neolithic in the NE of the Iberian Peninsula. The main problem does not reside in the sampling strategies but the difficulties arise when looking at the chronological and regional distribution of the sites. The available data for the first half of the Vth millennium cal BC and for the IIIrd millennium cal BC are still too scarce. It is difficult to characterize plant food economy for these important periods of transition. In addition, the amount of data available for some regions like the western plain and the southern area is still very meagre. Only a very tentative approach to these areas will be possible within the present study.

Concerning the type of contexts that were sampled and those which yielded the largest amounts of data, it is interesting to note that most of the data come from storage-type pits. These are usually filled with secondary deposits which result of one or several human activities. Therefore, this kind of context has a high potential for the characterization of plant food economy in the past. Nevertheless, their use for other approaches like spatial analyses and social access to resources is not always possible, only when very large areas are investigated (e.g. the case of Bòbila Madurell site in chapter 4.8.4.3).

5.2. Agricultural products and crop husbandry practices during the Neolithic (5400-2300 cal BC) in the NE of the Iberian Peninsula

Agricultural practices in the Iberian Peninsula, have received the attention of many researchers towards the end of the XXth century (see, for instance (Hopf 1966, Hopf 1971, Buxó 1991, Buxó 1992, Buxó 1997, Peña-Chocarro 1999, Zapata et al. 2004, Rovira 2007, Buxó 2007a, Buxó & Piqué 2008, Buxó, Rovira & Sauch 2000, Peña-Chocarro et al. 2005b, Peña-Chocarro 2007, Zapata 2007, Peña-Chocarro, Zapata 2011, Pérez-Jordà, Peña-Chocarro & Morales 2011). Unfortunately, most of these studies have focused in the first one thousand years of the Neolithic in the region and later phases received less attention. The lack of weed and chaff remains in the record was emphasized by several authors (Buxó 1997, Zapata et al. 2004). Therefore, discussions on agriculture and crop husbandry in the region were mainly based on the evaluation of the presence or absence of certain crops, usually emphasizing the larger diversity of legumes in southern Spain in comparison to the northern region.

My aim in this chapter is to define the main trends in the evolution of crop plants and crop husbandry techniques along the period under study and speculate on the potential causes for the observed results.

5.2.1. Standardization of the data

The available record for crop plants (in charred state) in the NE of the Iberian Peninsula before this study was carried out was considerably important (n= 294682). Nevertheless, the vast majority of data came from the concentrations of grain that were studied from sector A of La Draga (Buxó, Rovira & Sauch 2000). The contribution of this work to the available record on cultivars is quantitatively and qualitatively very significant (Fig. 5.13). Not only a very large amount of remains were recovered (n: 111708), but also from a large number of contexts (n= 119; 60% of the total number of contexts). The available record is about 25% of the total database for the region at present. Nevertheless, it should be stressed that, if the data from sector A of La Draga were not considered, our data would make around 91% of the available record. Besides this, nearly 99.5% of the chaff remains were recovered within this work, as well as 63% of the legumes and all of the oil plants. Finally, it is important to mention that around 7000 remains of cultivars were found in waterlogged state at La Draga (Fig. 5.14). These mainly belonged to seeds of poppy (n= 6506) but also to cereal chaff (n= 369).

Total seed and fruit remains in charred state	CULTIVARS (all included)		CEREAL CHAFF		LEGUMES		OIL PLANTS	
	TOTAL	This work	TOTAL	This work	TOTAL	This work	TOTAL	This work
Nr. of remains	406390	111708	3661	3640	35	22	18	18
Nr. of taxa	12	10	4	4	5	3	2	2
Nr. of contexts	198	119	14	9	25	15	8	8
Nr. of contexts >35 items	74	35	5	5	0	0	0	0

Fig. 5.13. General evaluation of the charred record of seeds and fruits belonging to cultivars. Total data available for the region under study (incl. this work) for the Neolithic period and total amount obtained in this work.

Waterlogged plant remains	TOTAL	CULTIVATED	CEREAL CHAFF	OIL PLANTS
Nr of items	25091	6990	369	6506
Nr of taxa	81	5	5	1

Fig. 5.14. General evaluation of the waterlogged record of seeds and fruits belonging to cultivars obtained in this work.

For a comprehensive evaluation of the data some amalgamation of taxa were carried out. For instance, naked wheat identifications were grouped as *Triticum aestivum/durum/turgidum* and grain remains of *Hordeum/Triticum* were left as Cerealia.

All the data from previous work were available in the literature in a fully quantified form. Only the data at a context level for Font del Ros were never published. These were obtained from the personal notes of the late Vicente López and included in this work, with the permission of the archaeologists who excavated the site.

5.2.2. The Early Neolithic (5400-5000 cal BC)

This is the period within the Neolithic (5400-2300 cal BC) for which the largest amount of data is available. The investigated sites for this phase are: La Draga (Phase 1 and 2), Can Sadurní Cave, Sant Llorenç Cave, Fosca Cave, Balma Margineda, Caserna de Sant Pau and Font del Ros. Over 350.000 charred remains of cultivars were recovered. These mostly belong to cereals and, more precisely, naked wheat (Fig. 5.15). This is mainly due to the high numbers of remains of this taxon recovered at La Draga, but one should note that it is the most ubiquitous taxon in the region (Fig. 5.16), appearing in 8 settlement phases and 43 contexts. Hulled barley presents a similar ubiquity, although a much lower amount of remains were retrieved. Two-rowed barley was identified at La Draga. Emmer and einkorn were also found in large quantities; most of these remains come from Can Sadurní cave. Nevertheless, emmer was identified in five sites and 15 contexts. Einkorn was much more sparsely documented. Chaff remains of barley, naked wheat and einkorn were only found at La Draga and Can Sadurní Cave, while chaff remains of emmer were also recovered in Caserna de Sant Pau.

Legumes were rather scarce in the record (n= 11). Pea was identified at La Draga, Balma Margineda and Caserna de Sant Pau, while broad bean was only documented at La Draga and Caserna de Sant Pau. Oil plants were only identified at La Draga, where a small number of charred remains of poppy were recovered. It is the first time that poppy is identified as a crop during this phase in the North-East of the Iberian Peninsula.

	NR in charred state	Max. per context	NR in waterlogged state
Hordeum vulgare, grain	9060	3001	
Hordeum distichum, chaff	365	338	8
Hordeum vulgare var. *nudum,* grain	90	90	
Hordeum sp., grain	1919	1760	
Hordeum sp., chaff	20	16	
Triticum aestivum/durum/turgidum, grain	295373	139450	
Triticum aestivum/durum/turgidum, chaff	2142	1251	103
Triticum dicoccum, grain	6277	5864	
Triticum dicoccum, chaff	470	220	82
Triticum sp./new type, grain	8	8	
Triticum dicoccum/monococcum, grain	8	4	
Triticum dicoccum/monococcum, chaff	91	91	
Triticum monococcum, grain	1928	1854	
Triticum monococcum, chaff	337	154	43
Triticum sp., grain	48224	44226	
Triticum sp., chaff	205	119	48
Cerealia, grain	2258	708	25
Cerealia, chaff	8	6	12
Cerealia, straw	94	86	
Pisum sativum, seed	5	3	
Vicia faba, seed	6	2	
Papaver somniferum	5	3	6506

Fig. 5.15. Evaluation of the cultivated taxa identified in the region under analysis during the Early Neolithic period: number of remains according to preservation type and maximum number of remains in charred state per context.

The waterlogged record of La Draga depicts a different image, since the vast majority of remains belong to poppy, followed by glume wheats, naked wheat and hulled barley. It could be possible that the type of processing of the glume wheats in the Neolithic did not favour the representation of chaff remains in the charred record (further discussion below). The cultivation of poppy cannot be assumed for other sites, at least at the present state of research. But one should keep in mind that poppy is rarely found in charred form (see, for instance, (Jacomet, Brombacher & Dick 1989) and that it is very fragile (susceptible of being destroyed during sample processing if inadequate techniques are applied), for which it is almost always underrepresented in the record.

When making a semi-quantitative comparison of the results obtained at a site level (Fig. 5.17) one can see that there is a considerable diversity. Hulled barley is well represented on several sites, but only very frequently encountered in La Draga (phase 1) and Caserna de Sant Pau. Chaff remains were only found in La Draga and Can Sadurní cave. Naked wheat is well represented in La Draga and Can Sadurní, where chaff remains were also identified, but only spare finds were recovered in the rest of the sites. Among the glume wheats, emmer is better represented than einkorn. The former is well represented at La Draga (phase 1) and Can Sadurní cave, while the latter is only significant in Can Sadurní. Legumes and oil plants were only scarcely represented.

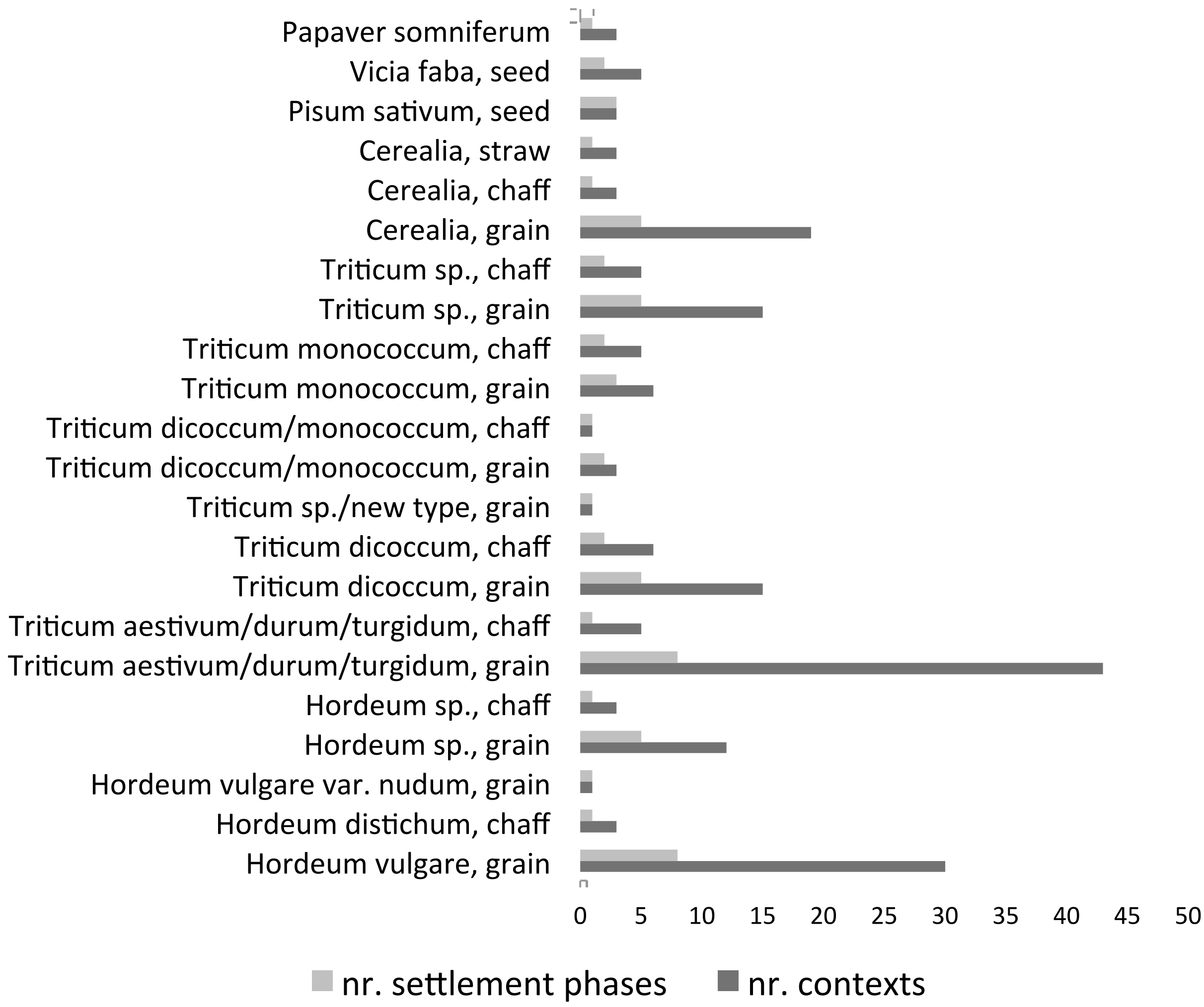

Fig. 5.16. Comparison between the number of settlement phases and the number of contexts in which each cultivated taxon was identified.

The geographical distribution of the taxa (Fig. 5.18) indicates that all the evidence of agriculture available for the region under analysis focuses on the eastern coast, the eastern Pyrenees and the Maestrat mountains in the south (see the geomorphologic units of the region in Fig. 2.2). This is probably related to the process of neolithisation, which seems to be of a maritime nature (Zilhao 2001). It might be worth mentioning here that there is evidence of the presence of naked wheat in Colomera Cave (Sant Esteve de la Sarga, Pallars Jussà), dated to the latest century of this period (Oms 2008). This site is located to the north of the Western plain, in the Pre-Pyrenean area. This opens new possibilities for the interpretation of the rapid spread of farming to certain areas.

Naked wheat is the most widespread taxon during this phase, with large concentrations in La Draga and Can Sadurní cave. Hulled wheats only appear in major concentrations in the latter. It is worth to remind, though, that their representation at La Draga seems to be more significant in waterlogged state than in charred state. Future studies of the subfossil record at the site could result in a more important role of these taxa. The available record, thus, seems to show that free-threshing cereals prevail in the northern areas while glume wheats could have been important in the central coast area.

Site	**Draga - Phase 1**		**Can Sadurní**	**Sant Llorenç**	**Draga - Phase 2**		**Balma Margineda**		**Caserna Sant Pau**		**Font del Ros**	
Nr. contexts	**4 contexts**		**1 context**	**1 context**	**31 contexts**		**4 contexts**		**8 contexts**		**21 contexts**	
Taxa	**ubiq**	**quantity**	**quantity**	**quantity**	**ubiquity**	**quantity**	**ubiquity**	**quantity**	**ubiquity**	**quantity**	**ubiquity**	**quantity**
Hordeum vulgare, grain	***	***	**		**	***			***	**	**	**
Hordeum distichum, chaff	*	**	*									
Hordeum vulgare var. *nudum*, grain			**									
Hordeum sp., grain	***	**	**		**	***	*	*	*	*		
Hordeum sp., chaff	***	*										
Triticum aestivum/durum/turgidum, grain	***	***	***	*	***	***	*	*	*	*	*	*
Triticum aestivum/durum/turgidum, chaff	***	***	*									
Triticum dicoccum, grain	***	***	***		**	*			*	*	**	**
Triticum dicoccum, chaff	**	**	**						*	*		
Triticum sp./new type, grain			*									
Triticum dicoccum/monococcum, grain	*	*									*	*
Triticum dicoccum/monococcum, chaff			**									
Triticum monococcum, grain	***	**	***								*	*
Triticum monococcum, chaff	***	**	**									
Triticum sp., grain	***	***	***		**	***	*	*			**	**
Triticum sp., chaff	***	**	*									
Cerealia, grain	***	***	**						**	**	**	***
Cerealia, chaff	**	*										
Cerealia, straw	**	*										
Pisum sativum, seed					*	*	*	*	*	*		
Vicia faba, seed					**	*			*	*		
Papaver somniferum	**	*										

*Fig. 5.17. Semi-quantitative evaluation of the ubiquity and quantity of cultivars per site in the Early Neolithic phase. Key: Ubiquity: *: 1 or 2 contexts; **: more than 2 but less than 50% of the contexts; ***: more than 50% of the contexts; Quantity: *:<30; **: 30-400; ***:>400.Only sites with a representativity value between 1 and 4 are shown.*

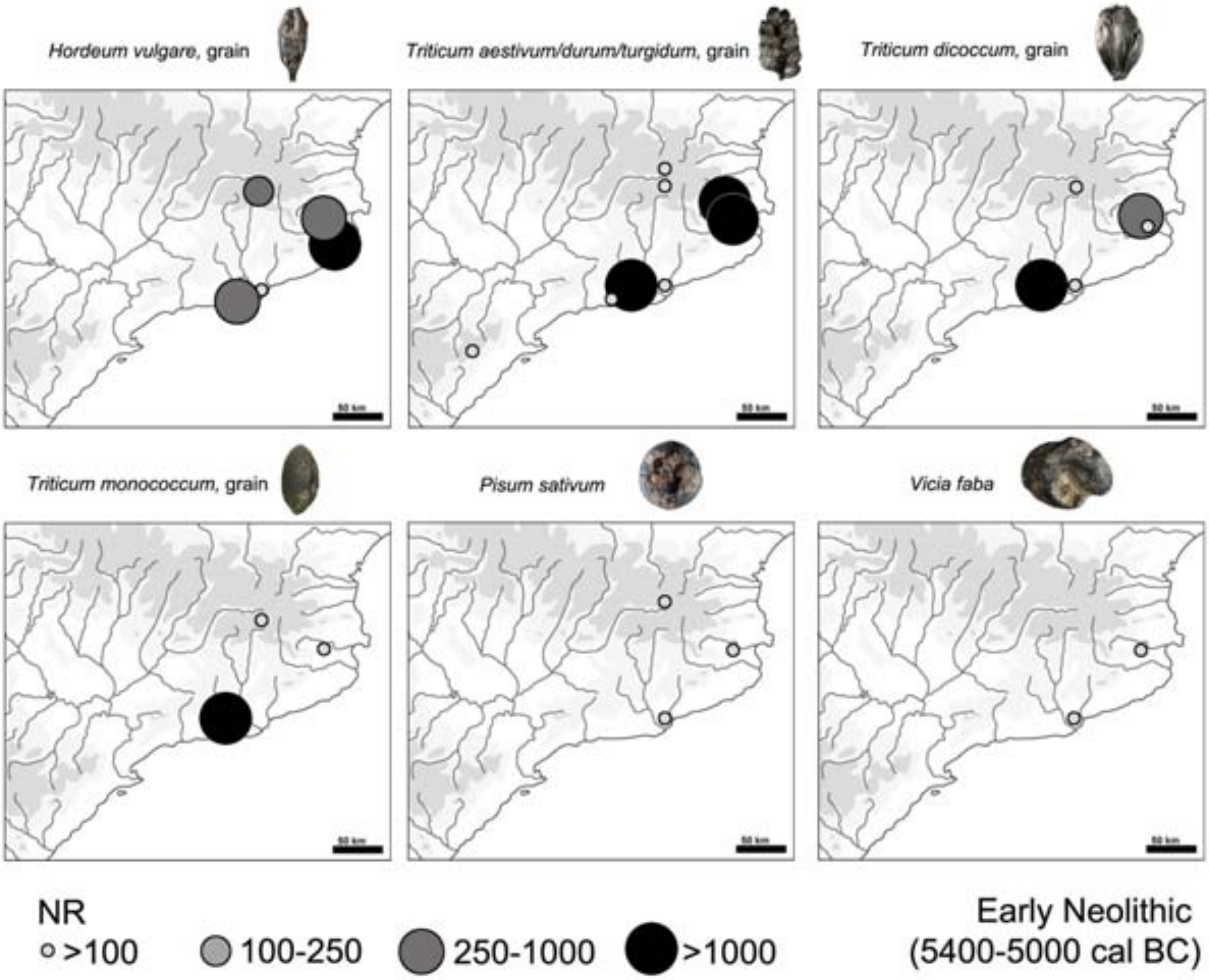

Fig. 5.18. Spatial representation of the total amount of remains recovered for the most significant cultivated taxa of the Early Neolithic period in the NE of the Iberian Peninsula.

5.2.3. The Late Early Neolithic (5000-4500 cal BC)

The record of charred remains of cultivars for this period is very scarce (n=175; Fig. 5.19) and it cannot be considered as representative. The sites which yielded archaeobotanical remains for this phase are: Sardo Cave, Codella, Serra del Mas Bonet, La Dou, C/Reina Amàlia, 31-33, Sant Llorenç Cave, CIM "El Camp", Fosca Cave and Plansallosa. Despite this paucity, it is worth to notice that there is some continuity with the previous phase for the cultivated crops and that free-threshing cereals are better represented in the record. Emmer is only represented at two sites with one single find per context. Legumes are only attested by one lentil recovered in Plansallosa. It is the earliest evidence of the cultivation of *Lens culinaris* in our region.

The results at a site level (Fig. 5.20) show that several sites only yielded unidentifiable remains of cereals, while others presented a relative diversity, especially C/Reina Amàlia, 31-33 and Sant Llorenç Cave, but with very few remains per taxon. This is probably due to taphonomic reasons. No charred storages were recovered for this phase.

	NR	max. per context	Nr contexts	Nr. settlement phases
Hordeum vulgare, grain	3	1	3	3
Hordeum vulgare var. nudum, grain	5	3	3	2
Hordeum sp., grain	37	35	3	3
Triticum aestivum/durum/turgidum, grain	19	11	4	3
Triticum dicoccum, grain	3	1	3	2
Triticum sp., grain	7	2	4	3
Cerealia, grain	100	42	5	3
Lens culinaris, seed	1	1	1	1

Fig. 5.19. Evaluation of the cultivated taxa identified in the region under analysis during the Late Early Neolithic period: number of remains, maximum number of remains per context, and number of contexts and settlement phases in which each taxon appears.

Site	**Codella**	**La Dou**	**C/Reina Amàlia, 31-33**		**Sant Llorenç**	**CIM „El Camp"**	**Plansallosa**
Nr. contexts	**1 context**	**3 contexts**	**4 contexts**		**1 context**	**2 contexts**	**unknown**
Taxa	**Quantity**	**Quantity**	**ubiquity**	**quantity**	**quantity**	**quantity**	**quantity**
Hordeum vulgare, grain					*	*	*
Hordeum vulgare var. *nudum*, grain			*	*			
Hordeum sp., grain			*	*	*		**
Triticum aestivum/durum/turgidum, grain			*	*	*		*
Triticum dicoccum, grain			*	*	*		
Triticum sp., grain	*		*	*	*		
Cerealia, grain		*	**	**	*	*	
Lens culinaris, seed							*

*Fig. 5.20. Semi-quantitative evaluation of the ubiquity and quantity of cultivars per site in the Late Early Neolithic phase. Key: Ubiquity: *: 1 or 2 contexts; **: more than 2 but less than 50% of the contexts; ***: more than 50% of the contexts; Quantity: *:<30; **: 30-400; ***:>400.Only sites with a representativity value between 1 and 4 are shown.*

From a geographical point of view, even though it was pointless to attempt to show the results on a map due to their low significance, one should note that data from several new sites were obtained for this period. Besides, it seems that the largest diversity of cultivars is found in the central coast region.

5.2.4. The Early Middle Neolithic (4500-4000 cal BC)

The available record of charred remains of cultivars is abundant for this chronological phase (n=2885), at least in comparison to the previous one. The investigated sites for this phase are: Camp del Colomer, La Dou, 120 Cave, C/Reina Amàlia, 31-33, Can Sadurní Cave (2 phases), Pla del Gardelo, El Collet, Fosca Cave and Caserna de Sant Pau. The results show, once more, that cereals are the best-represented group (Fig. 5.22), presenting a large continuity in the cultivated taxa. Among these, free-threshing cereals are the most common taxa, especially naked barley (n=989). Hulled barley, emmer and einkorn were much reduced from the record, most of them being recovered in Can Sadurní Cave. Legumes are slightly more abundant than in previous periods (n=20) and four different taxa were identified, two of which had not been identified before (*Vicia sativa* and *Vicia ervilia*). Oleaginous plants were recovered at a single site, Camp del Colomer; both flax and poppy were identified. Flax was also identified for the first time in the region.

	NR	max. per context
Hordeum vulgare, grain	41	18
Hordeum distichum, chaff	1	1
Hordeum vulgare var. *nudum,* grain	989	431
Hordeum sp., grain	431	237
Hordeum sp., chaff	2	1
Triticum aestivum/durum/turgidum, grain	253	121
Triticum dicoccum, grain	43	26
Triticum dicoccum, chaff	8	6
Triticum sp./new type, grain	7	6
Triticum dicoccum/monococcum, grain	6	4
Triticum monococcum, grain	50	32
Triticum monococcum, chaff	6	6
Triticum sp., grain	213	92
Triticum sp., chaff	3	3
Cerealia, grain	799	285
Lens culinaris, seed	2	1
Pisum sativum, seed	15	3
Vicia sativa seed	1	1
Vicia ervilia, seed	1	1
Cultivated legume, seed	1	1
Linum usitatissimum, seed	1	1
Papaver somniferum, seed	12	8

Fig. 5.21. Evaluation of the cultivated taxa identified in the region under analysis during the Early Middle Neolithic period: number of remains and maximum number of remains per context.

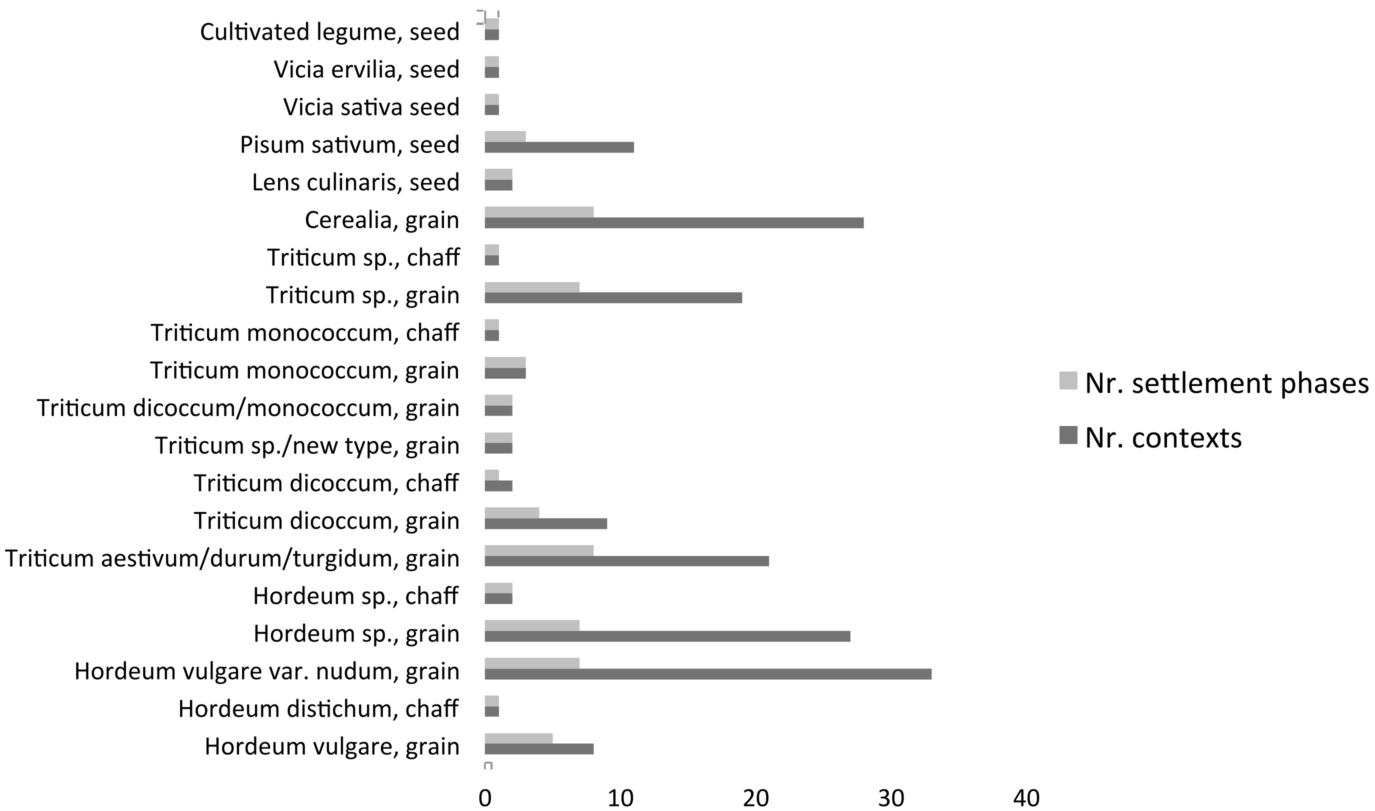

Fig. 5.22. Comparison between the number of settlement phases and the number of contexts in which each cultivated taxon was identified. Early Middle Neolithic phase.

Naked wheat is the taxon which was recovered on most sites (n=8), closely followed by naked barley (n=7). However, naked barley was identified in many more contexts (n=33) (Fig. 5.23). This might correspond with taphonomic issues, like the roasting of naked barley after long-term storage in pits and before short-term storage in vessels. This activity, which was put forward as a hypothesis for Camp del Colomer site (see chapters 4.2.4.9 and 4.8.4.3), might overrepresent this crop in the record. In any case, these results show that free-threshing naked cereals were mostly cultivated in the studied area. Among the pulses, pea was documented in a larger amount of sites and contexts; thus it is likely to have been the most common pulse crop in the region.

The semi-quantified results obtained at a site scale show that Camp del Colomer and Can Sadurní cave present the richest records for this phase. Naked barley has a significant role in the former, but a more diversified spectrum was found in the latter, where glume wheats are rather well represented. Naked wheat is present in all sites but Sardo Cave

Site	Sardo	Camp del Colomer		DOU		C/Reina Amàlia, 31-33		Can Sadurní	El Collet	Caserna Sant Pau		120 Cave	
Nr. contexts	1 context	50 contexts		11 contexts		4 contexts		2 contexts	3 contexts	8 contexts		7 contexts	
Taxa	Quantity	Ubiquity	Quantity	Ubiquity	Quantity	Ubiquity	Quantity	Quantity	Quantity	Ubiquity	Quantity	Ubiquity	Quantity
Hordeum vulgare, grain						*	*	*		*	*	**	*
Hordeum distichum, chaff								*				*	*
Hordeum vulgare var. *nudum*, grain	*	**	***	*	*			*	*			**	*
Hordeum sp., grain		**	***	*	*	*	*	**	*	*	*		
Hordeum sp., chaff								*				*	*
Triticum aestivum/durum/turgidum, grain		**	*	*	*	*	**	**	*	**	*	***	**
Triticum aestivum/durum/turgidum, chaff													
Triticum dicoccum, grain		**	*					**				*	*
Triticum dicoccum, chaff										*	*		
Triticum sp./new type, grain								*					
Triticum dicoccum/monococcum, grain								*					
Triticum monococcum, grain		*	*					**					
Triticum monococcum, chaff								*				*	*
Triticum sp., grain		**	*	*	*	*	**	**	*				
Triticum sp., chaff								*				*	*
Cerealia, grain		**	**	**	*	***	**	**	**	*	**		
Lens culinaris, seed								*					
Pisum sativum, seed		**	*					*					
Vicia sativa type								*					
Vicia cf. *ervilia*										*	*		
Papaver somniferum		**	*										
Linum ussitatissimum, seed		*	*										
Cultivated legume		*	*										

*Fig. 5.23. Semi-quantitative evaluation of the ubiquity and quantity of cultivars per site in the Early Middle Neolithic phase. Key: Ubiquity: *: 1 or 2 contexts; **: more than 2 but less than 50% of the contexts; ***: more than 50% of the contexts; Quantity: *:<30; **: 30-400; ***:>400.Only sites with a representativity value between 1 and 4 are shown.*

At a geographical scale, naked barley and naked wheat are also the most widespread taxa (Fig. 5.24). Large concentrations were only found for naked barley. Considering also the data from Fig. 5.23, one could present the hypothesis that naked barley was predominant in the north and North-East of the region, while naked wheat was more important in the south (central coast and western plain areas). This might indicate contacts with southern France during this phase, which could have contributed to the expansion of naked barley. Hulled barley seems to remain a crop in the central coast area (three different sites), and it was also identified in the northeastern area. Glume wheats were mainly documented in the central coast (Can Sadurní cave), emmer was also found in the north (Camp del Colomer and 120 Cave). Pea was only recovered in Can Sadurní cave and Camp del Colomer.

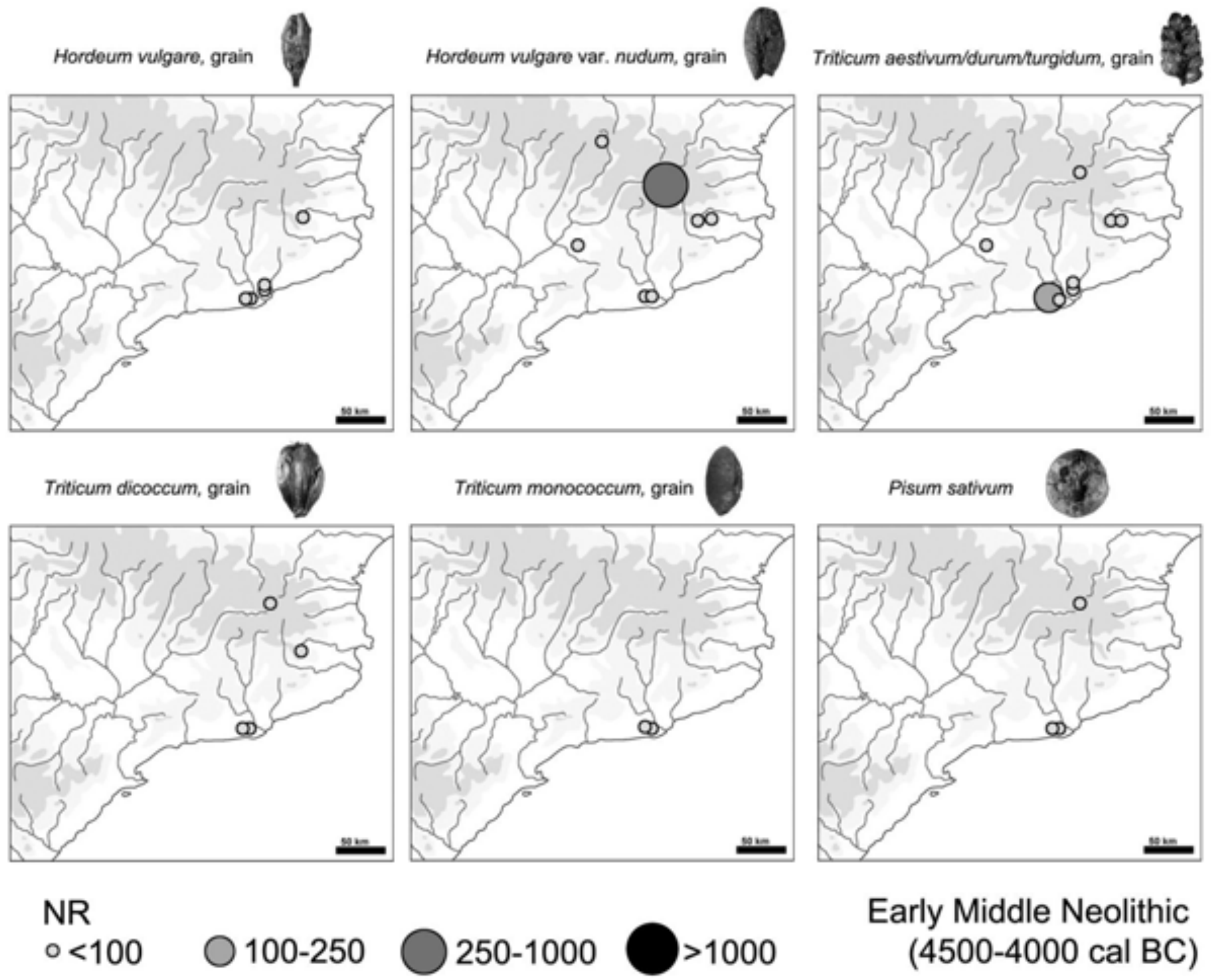

Fig. 5.24. Spatial representation of the total amount of remains recovered for the most significant cultivated taxa of the Early Middle Neolithic period in the NE of the Iberian Peninsula.

5.2.5. The Middle Neolithic (4000-3300 cal BC)

Even though the number of settlement phases with crop remains for this period is rather low (n=5), the number of seed and fruit remains of cultivars is considerably large (n=23717). These were mainly recovered on one site, Bòbila Madurell (n=23622). The general results show that free-threshing naked cereals are the best represented in the record, especially naked barley and naked wheat (Fig. 5.25). This is partly due to the fact that large concentrations of naked barley were found in Bòbila Madurell. Hulled wheats are poorly represented and, in general, chaff remains are barely absent in the record. In general, continuity with the previously cultivated taxa is observed, although the spectrum of legumes is reduced and the oil plants disappeared from the record.

Naked barley is the taxon which appears in the largest amount of contexts, but naked wheat was identified on more sites (Fig. 5.26). Hulled cereals and pulses were only sparsely represented.

	NR	max. per context
Hordeum vulgare, grain	18	12
Hordeum vulgare var. *nudum,* grain	13693	10063
Hordeum sp., grain	7730	4432
Triticum aestivum/durum/turgidum, grain	404	181
Triticum dicoccum, grain	126	83
Triticum sp./new type, grain	11	10
Triticum dicoccum/monococcum, grain	11	6
Triticum monococcum, grain	27	11
Triticum monococcum, chaff	1	1
Triticum sp., grain	299	137
Cerealia, grain	1395	275
Lens culinaris, seed	1	1
Pisum sativum, seed	1	1

Fig. 5.25. Evaluation of the cultivated taxa identified in the region under analysis during the Middle Neolithic period: number of remains and maximum number of remains per context.

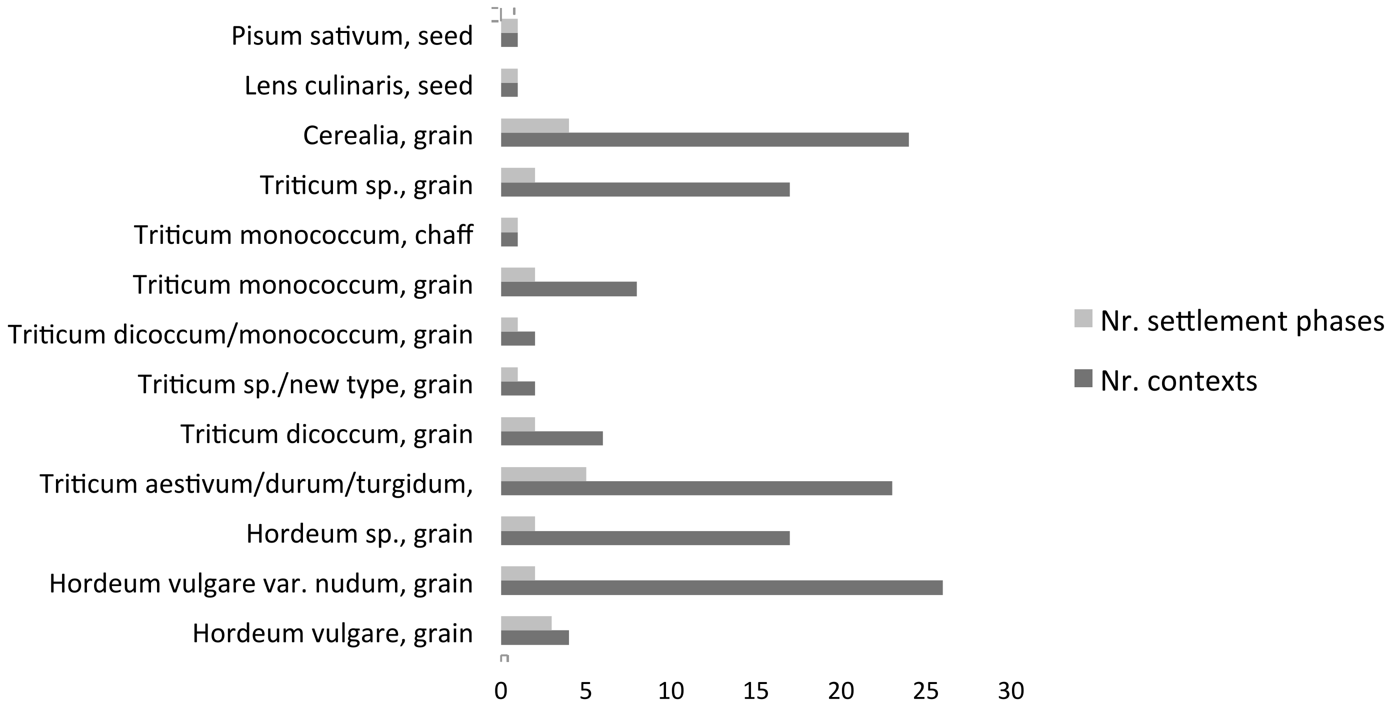

Fig. 5.26. Comparison between the number of settlement phases and the number of contexts in which each cultivated taxon was identified. Middle Neolithic phase.

The results obtained per site show that abundant data are only available for Bòbila Madurell and Gavà Mines (Fig. 5.27). Naked barley and naked wheat are the best-represented taxa. Naked wheat is found in all the investigated sites, while naked barley was only found in the two sites mentioned. Emmer is well represented in Bòbila Madurell only.

Site	**Sardo Cave**	**Serra del Mas Bonet**	**Bòbila Madurell**		**Sant Llorenç**	**Gavà Mines**	
Nr. contexts	**1 context**	**2 contexts**	**30 contexts**		**1 context**	**7 contexts**	
Taxa	**Quantity**	**Quantity**	**Ubiquity**	**Quantity**	**Quantity**	**Ubiquity**	**Quantity**
Hordeum vulgare, grain		*	*	*		*	*
Hordeum vulgare var. *nudum*, grain			***	***		***	*
Hordeum sp., grain			***	***		*	*
Triticum aestivum/durum/turgidum, grain	*	*	***	**	*	***	*
Triticum dicoccum, grain			**	**		*	*
Triticum sp./new type, grain			*	*			
Triticum dicoccum/monococcum, grain			*	*			
Triticum monococcum, grain			*	*		*	*
Triticum sp., grain			***	**		*	*
Cerealia, grain		*	***	***	*	*	*
Lens culinaris, seed						*	*
Pisum sativum, seed			*	*			

*Fig. 5.27. Semi-quantitative evaluation of the ubiquity and quantity of cultivars per site in the Middle Neolithic phase. Key: Ubiquity: *: 1 or 2 contexts; **: more than 2 but less than 50% of the contexts; ***: more than 50% of the contexts; Quantity: *:<30; **: 30-400; ***:>400.Only sites with a representativity value between 1 and 4 are shown.*

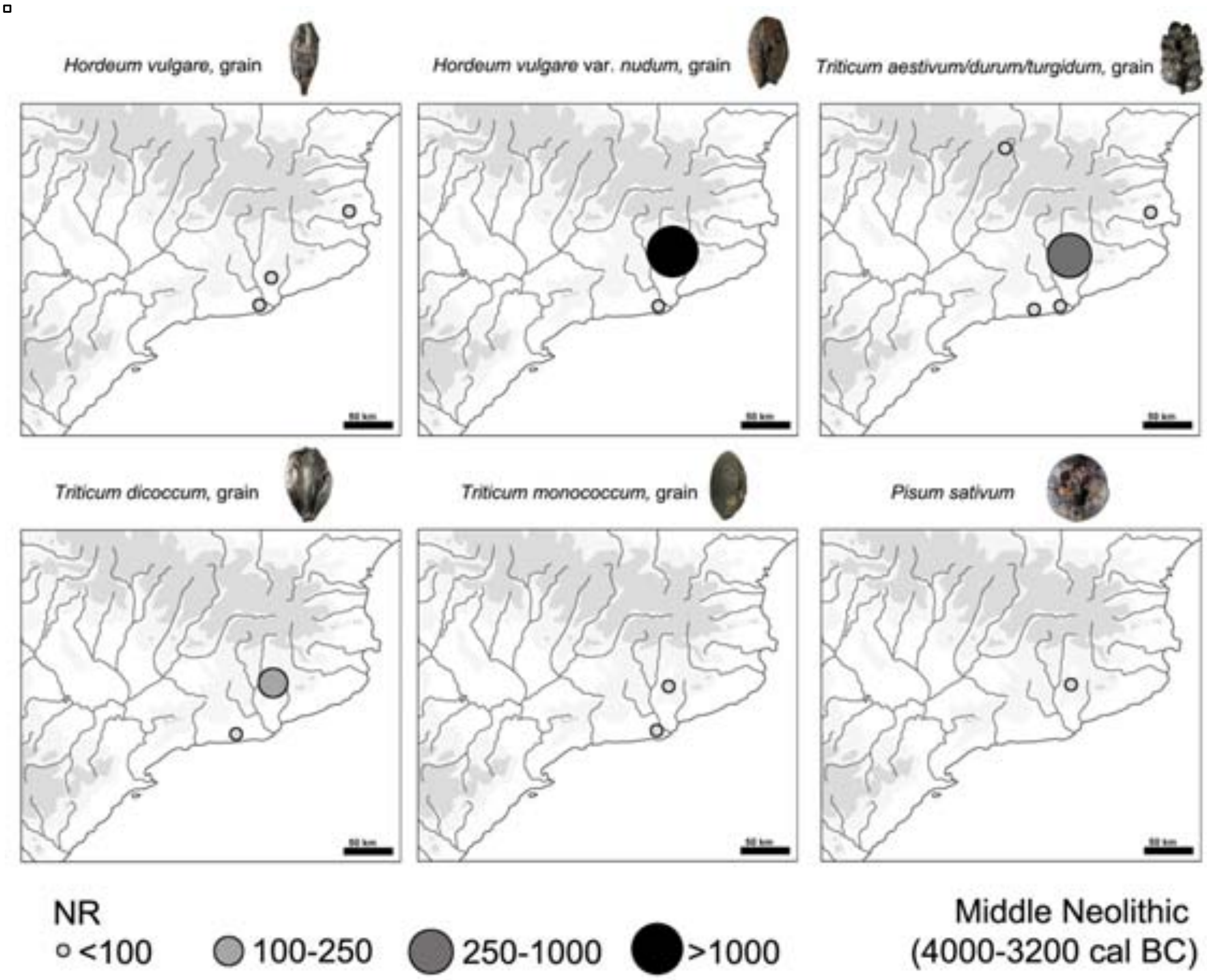

Fig. 5.28. Spatial representation of the total amount of remains recovered for the most significant cultivated taxa of the Middle Neolithic period in the NE of the Iberian Peninsula.

When looking at the data on a geographical scale (Fig. 5.28), one can observe that hulled barley continues to appear in the central coast region and also in the north-east. Finds of naked barley are concentrated in the central coast, especially in Bòbila Madurell, where it appears in huge quantities, and disappears from sites in the northern areas. Naked wheat is the most widespread taxon, only present in high numbers in Bòbila Madurell. Glume wheats and pea only appear in the central coast region. The continuity of hulled cereals in the central coast along the first 2000 years of the Neolithic is remarkable.

5.2.6. The Late Neolithic (3300-2300 cal BC)

The amount of data for this chronological phase is rather large (n=10718) and the number of investigated settlement phases is considerable (n=8). Nevertheless, the vast majority of data come from a single concentration of charred cereal grain in Toll Cave (n=9681). For this reason, the available data are should not be considered fully reliable. The crop diversity is similar to the one available for the Middle Neolithic, but the diversity of cultivated legumes is reduced to one single taxon, *Lens culinaris*.

	NR	max. per context
Hordeum vulgare, grain	9625	9600
Hordeum vulgare var. *nudum*, grain	85	60
Hordeum sp., grain	102	37
Hordeum sp., chaff	1	1
Triticum aestivum/durum/turgidum, grain	73	35
Triticum dicoccum, grain	49	46
Triticum dicoccum/monococcum, chaff	1	1
Triticum monococcum, grain	6	4
Triticum sp., grain	17	7
Cerealia, grain	758	341
Lens culinaris, seed	1	1

Fig. 5.29. Evaluation of the cultivated taxa identified in the region under analysis during the Late Neolithic period: number of remains and maximum number of remains per context.

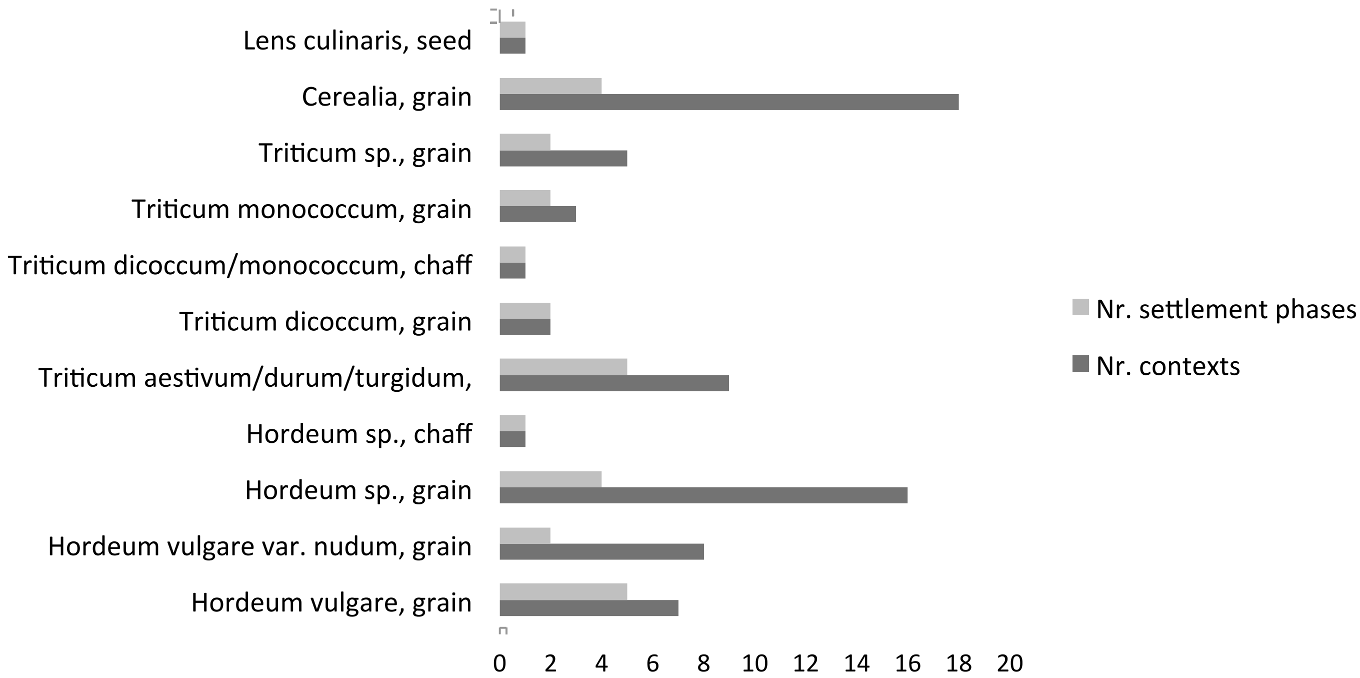

Fig. 5.30. Comparison between the number of settlement phases and the number of contexts in which each cultivated taxon was identified. Late Neolithic phase.

The best-represented taxon is hulled barley, mainly because this is the dominant crop in the sample from Toll Cave. Naked wheat, naked barley and emmer are rather well represented. Einkorn is very scarce and, concerning pulses, only one lentil was identified in Bòbila Madurell (Fig. 5.29).

When looking at the ubiquity of the different taxa (Fig. 5.30), one can observe that hulled barley is also the taxon which appears on most sites, together with naked wheat; while naked wheat and naked barley appear in more contexts. More significant is, though, that the most frequent type of remains are grain fragments of *Hordeum* sp. and Cerealia. This is due to the bad preservation of the seed and fruit record during this phase and can only be due to taphonomic reasons. It could also be related to the fact that many samples were obtained from dwelling areas, which were largely absent for previous periods (except for some examples like in C/Reina Amàlia, 31-33). Glume wheats and pulses are rare.

Site	**Sardo**	**Serra del Mas Bonet**		**Bòbila Madurell**		**Sant Llorenç**	**Espina C**	**Portes Cave**	**Bauma del Serrat del Pont**
Nr. contexts	**1 context**	**12 contexts**		**9 contexts**		**1 context**	**2 contexts**	**1 context**	**2 contexts**
Taxa	**Quantity**	**Ubiquity**	**Quantity**	**Ubiquity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**
Hordeum vulgare, grain		**	*				*	*	*
Hordeum vulgare var. *nudum*, grain		*	*	***	**				
Hordeum sp., grain		***	*	***	**				*
Hordeum sp., chaff				*	*				
Triticum aestivum/durum/turgidum, grain	*			***	*	*			*
Triticum dicoccum, grain									*
Triticum dicoccum/monococcum, chaff								*	
Triticum monococcum, grain				*	*				*
Triticum sp., grain				**	*			*	
Cerealia, grain		***	**	***	***		*	*	
Lens culinaris, seed				*	*				

*Fig. 5.31. Semi-quantitative evaluation of the ubiquity and quantity of cultivars per site in the Middle Neolithic phase. Key: Ubiquity: *: 1 or 2 contexts; **: more than 2 but less than 50% of the contexts; ***: more than 50% of the contexts; Quantity: *:<30; **: 30-400; ***:>400.Only sites with a representativity value between 1 and 4 are shown.*

Only on two sites crop remains were well represented (Fig. 5.31): Serra del Mas Bonet and Bòbila Madurell (Fig. 5.31). Naked wheat and naked barley are abundant in the latter, while hulled barley could be more important in Serra del Mas Bonet (wheats are absent in this site).

From a geographical perspective (Fig. 5.32), hulled barley seems to disappear from the central coast region (which could be due to the low number of investigated settlements in this area); however, it is well spread towards the interior and northern areas. Naked wheat is present all over the investigated region, except in the Western Plain (maybe due to the scarcity of data obtained for this area). Hulled wheats and lentil are sparsely represented: emmer only being present on northern sites, while einkorn and lentil are present in the central coast and north-eastern region.

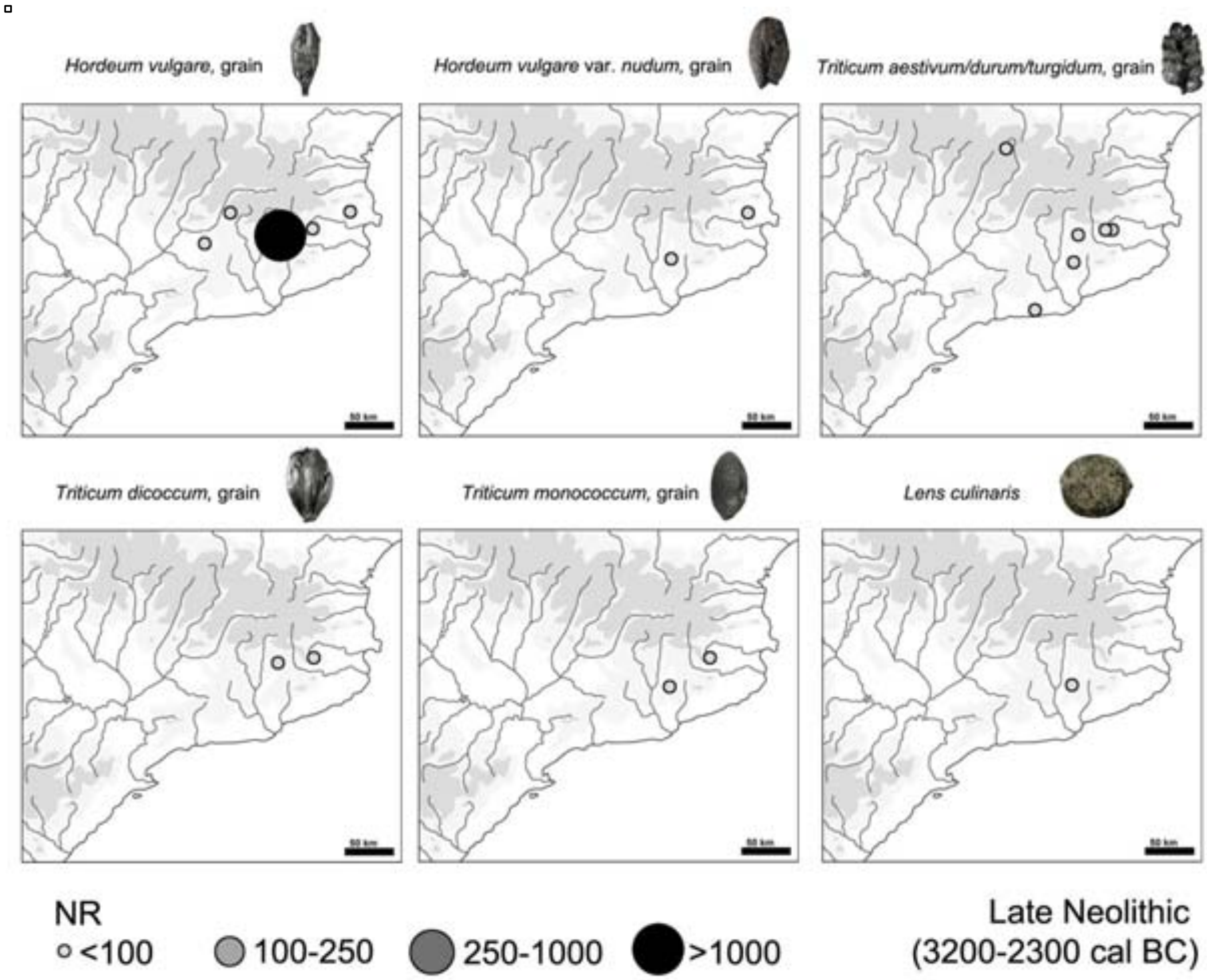

Fig. 5.32. Spatial representation of the total amount of remains recovered for the most significant cultivated taxa of the Late Neolithic period in the NE of the Iberian Peninsula.

5.2.7. Crop plants and crop husbandry practices during the Neolithic in the NE of the Iberian Peninsula

The presented data offer a new and challenging approach to crop plants and agricultural practices during the Neolithic in the NE of the Iberian Peninsula. Given the limitations of the state of research for some of the regions and periods under analysis, some of the following interpretations are derived from the best-represented regions and chronological phases. All of these hypotheses should be tested and discussed when more studies are available for areas like the Western Plain or the Southern sector.

The available data on this topic for **Western Europe** are rather uneven depending on regions and periods (for a relatively recent overview on the region, see (Colledge & Conolly 2007). On the one hand, the territory of France lacks of a comprehensive work on Neolithic archaeobotany. Only scanty references are available from general papers (Gassin et al. 2010). This situation is starting to change, at least for the north-eastern region (L.Berrio, PhD in progress). On the other hand, other territories are very well investigated for the considered time span, e.g. the Alpine Foreland (Jacomet 2006, Jacomet 2007) or parts of Germany (e.g. (Kreuz 2007, Kreuz 2012). In the Iberian peninsula, most of the available studies focus on the Eastern and Southern coastal areas, even though recent work has also targeted the northern and interior areas (see, for instance (Peña-Chocarro et al. 2005b, Stika 2005, Zapata 2007, Peña-Chocarro & Zapata 2011, Pérez-Jordà, Peña-Chocarro & Morales 2011). Large uninvestigated areas exist and the amount of data tends to decrease towards the Middle and Late Neolithic, in general terms (a similar situation is also observed in Italy Rottoli & Pessina 2007).

During the **second half of the VIth millennium cal BC**, hulled wheats seem to have dominated agricultural practices in Central Europe. Hulled barley had a variable significance depending on sites and regions. Pea and lentil were documented in most areas, and so were flax and poppy (Jacomet 2007, Kreuz 2007, Kohler-Schneider 2007).

In northern Italy, hulled cereals (including the so-called “new” glume wheat) also dominate the spectrum but six-rowed hulled barley seems to be the main crop on most sites. Flax was identified on some sites. It might be possible that naked wheat had a more prominent role in southern and central Italy, but glume wheats would still be the dominant crops in this area (Rottoli & Pessina 2007).

In Southern France it seems to be rather different. The earliest sites, connected to the first colonizers from the Ligurian coast, seem to base their agriculture on emmer and einkorn; slightly later sites, associated with the Cardial culture, mainly cultivated naked wheat, followed by naked barley, together with some emmer and einkorn (García-Atiénzar 2010, Gassin et al. 2010). No records of flax and poppy were reported.

The current state of research in the Iberian Peninsula shows some important divergences, even though large areas like Portugal remain to be systematically investigated (this will be part of the PhD work of I. López-Dóriga, University of Cantabria). Some sites at the eastern coast and in more interior areas presented large amounts of glume wheats, like Or Cave (Hopf 1966) or Can Sadurní Cave (Antolín & Buxó 2011c). But most of the sites seem to base their agriculture on free-threshing cereals, both naked wheat and barley. Barley seems to be of naked type mainly, at least in the South of the Iberian Peninsula, but not in the north-east. It is also in the South and the central eastern coast where the largest diversity of legumes were identified. Flax and poppy were also recovered on several sites of Southern Spain and the interior plateau (Peña-Chocarro 1999, Stika 2005, Rovira 2007, Pérez-Jordà, Peña-Chocarro & Morales 2011).

During the **first two thirds Vth millennium cal BC**, emmer and einkorn seem to continue to dominate the crop spectrum in some parts of central Europe like in Austria (Kohler-Schneider 2007). Pea, lentil and flax were also identified. In the Alpine foreland, naked wheat (of the hexaploid type) seems to increase its presence. Tetraploid wheat becomes more common towards the second half of the Vth millennium cal BC (Ebersbach et al. 2012). Naked barley also becomes better represented in comparison to previous phases (Jacomet 2007). Pulses were badly represented. A similar crop spectrum is observed in Italy (Rottoli & Pessina 2007).

In Southern France, agriculture seems to focus on naked wheat and naked barley; emmer and einkorn are less frequently represented. In the Iberian Peninsula, glume wheats also seem to be found more sparsely during this period, not only in the South (Pérez-Jordà, Peña-Chocarro & Morales 2011), but also on the Eastern coast (Pérez-Jordà 2005), not in the north (Peña-Chocarro et al. 2005a).

The crops observed in some parts of central Europe during the **IVth and IIIrd millennia cal BC** do not change significantly in general terms, since hulled cereals continue dominating the panorama in Austria (Kohler-Schneider 2007). Quite differently, many novelties are observed in the Alpine foreland during the

IVth millennium cal BC. Tetraploid naked wheat is the most important crop in several sites of the Neckar region, central Switzerland and Lake Constance region; naked barley is also very well represented. Peas, lentils, poppy and flax are very well represented, although pulses are rare. This will change again during the IIIrd millennium cal BC, with the Corded Ware Culture, when emmer (and barley) takes a prominent role in agriculture (Brombacher & Jacomet 1997, Jacomet 2006, Herbig 2009).

The data for the IVth and IIIrd millennia cal BC for southern Europe are rather scanty and unrepresentative. Free-threshing cereals (mainly naked barley and naked wheat) seem to prevail in several regions of the Iberian Peninsula (Buxó 1997, Pérez-Jordà 2005, López-Dóriga et al. 2011, Pérez-Jordà, Carrión 2011). Besides these two cereals, broad bean and other pulses, opium poppy and flax were identified in Portugal, in Buraco da Pala, dated to the Late Neolithic period (Ramil & Aira 1993). Aggregates of these seeds were interpreted as evidence of their use for the extraction of oil.

The data presented for the **north-east of the Iberian Peninsula** show that free-threshing cereals are the most important crops along the Neolithic period. The earliest evidence of agriculture was obtained in Fosca Cave (just one grain of naked wheat which was not directly dated) and Can Sadurní Cave. A predominance of hulled wheats at the latter, together with naked wheat, was observed. One could speculate that this assemblage does not represent agricultural practices at the site, since it was interpreted as a funerary offering. Nevertheless, the fact that hulled wheats maintain a significant role at the site until, at least, the late Vth millennium cal BC, might indicate that glume wheats were cultivated in this particular area of the region under study, maybe because of the good adaptability of glume wheats to the predominating calcareous soils. Other than this particular case, naked wheat and hulled barley are among the best represented crops during the **sixth millennium cal BC**. This is, in fact, different both from what is known at present from Southern France and the central eastern coast of the Iberian Peninsula, where naked barley and naked wheat are the most important crops. This, at least, would support a different origin for the groups which arrived to the mouth of the Llobregat River and its surroundings and those which arrived to the northeastern coast (Fig. 5.33). Finally, concerning cereals, the few mentions in this text to the presence of the "new" glume wheat in our region are the oldest (and the only) evidence of this taxon in the Iberian Peninsula. At the moment, its sparse documentation can only lead to the conclusion that it was probably not a crop. However, it should be kept in mind that the chaff remains are more characteristic for the identification of this taxon and, in general, chaff remains are absent from the record of the Iberian Peninsula.

Poppy was also identified at La Draga, but few pulses and no flax were recovered in the region. This evidence is of major significance for the history of agriculture of opium poppy, which had recently been proposed as originating in north-western Europe (Salavert 2010, Salavert 2011). Quite the opposite, our results would confirm, together with those from La Marmotta site (Lago di Bracciano, near Rome, Italy) (Rottoli 1993), Murciélagos cave (Peña-Chocarro 1999), Los Castillejos (Rovira 2007), and La Lámpara (Stika 2005) that opium poppy was already domesticated in the Early Neolithic of the Western Mediterranean region, as already supposed earlier (Bakels 1982, Kreuz 1990a: 172). The uses of the plant remain more cryptic, but it is likely that it was grown at least to obtain the oil from the seeds (Guerra-Doce & López-Sáez 2006) or just to eat them. This lack of knowledge will probably be overcome in the future. Until now, the analysis of the recovered artefacts never considered this possibility. Thus no evidence of the processing of capsules of poppy was ever detected.

There is a clear shift in the **Vth millennium cal BC.** It is difficult to locate it temporally because the data for the first half of the Vth millennium cal BC are scarce. Naked barley is the best represented taxon during the second half of this millennium, along with naked wheat. It is particularly widespread in the northern areas of the region. One could argue that the late introduction of naked barley as an important crop shows contacts with neighbouring regions during this phase (Fig. 5.33). Hulled barley seems to remain as an important crop in the central coast of Catalonia. This fact, along with the continued presence of hulled wheats in Can Sadurní cave, gives this region a singular character, at least during the first 1500 years of the Neolithic period.

Very significantly, flax and poppy were identified on one site (Camp del Colomer), along with some remains of pea. This reinforces the results obtained at La Draga concerning opium poppy and its identification as a cultivar. It is important to highlight the presence of flax in the region since the earliest evidences for cultivated flax were dated to the Bronze Age (Alonso & Buxó 1995, Alonso 1999). The frequent presence of pea in combination with naked barley was used to argument that crop rotation could have been practiced in Camp del Colomer (see chapter 4.2.5.5). Italian millet (*Setaria italica*) could have been identified in Can Sadurní Cave, but these could be intrusions. The grains are in the process of being C14 (AMS)-dated.

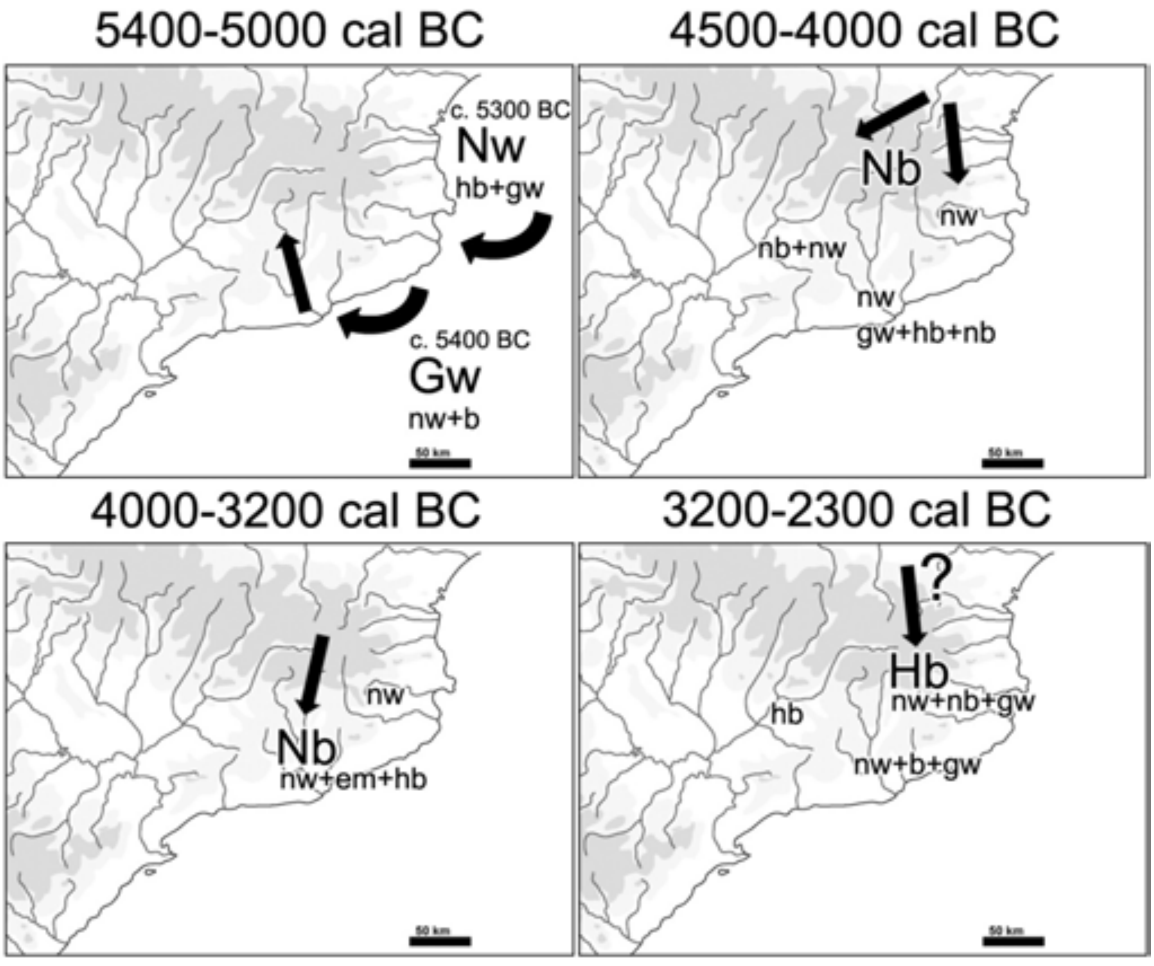

Fig.5.33. Cereal crop evolution in the NE of the Iberian Peninsula during the Neolithic period (nw: naked wheat; gw: glume wheat; b: barley; nb: naked barley; hb: hulled barley).

As observed in some regions of the Iberian Peninsula, free-threshing cereals (naked barley and naked wheat) are the main crops during the **Middle Neolithic**. But it is noteworthy that there might have been another shift in the crop assemblage in the **Late Neolithic** towards hulled barley instead of naked barley, at least in the northern areas of the region. This would settle the ground for the agriculture of the Bronze Age, which was based on naked wheat and hulled barley (Alonso 1999, Albizuri, Alonso & López-Cachero 2011). The increase of the representation of hulled barley during the Bronze Age was interpreted by N. Alonso (*op.cit.*) as potential evidence for the cultivation of poorer soils when cultivated land expanded. This might be applicable to our case. Drier climatic conditions and the expansion of agricultural land might have favoured the introduction and progressive expansion of hulled barley. Nevertheless, it could also correspond to external influences or exchanges. Their origin is unknown, although Southern France seems to be the most likely possibility (Fig. 5.33). Macroremains of opium poppy were not recovered for this phase but it was identified on the dental calculus of a buried individual and traces of opiates were detected on the bones of this one and another individual at the Gavà Mines. It is not clear whether poppy was used as a hallucinogen or as a medicinal plant (Juan-Tresserras & Villalba 1999).

As mentioned in chapter 3.2.12.2, crop husbandry practices can be approached from a variety of disciplines and techniques. It is not the aim of this work to carry out an interdisciplinary approach (which, on the other hand, would be the optimal approach), but it was considered of interest to integrate the most significant data within the discussion of our results. For this reason, in the next lines, several stages of the agricultural cycle will be dealt with, as far as possible, from an archaeobotanical point of view, and they will be complemented with the available archaeological data.

Soil disturbance

Data concerning field permanence and the intensity of soil disturbance were only available for a small number of sites and partly inconclusive interpretations were only possible. In those cases where weed assemblages were available, the permanent cultivation of plots was put forward as a hypothesis. This includes Can Sadurní cave and La Draga, for the Early Neolithic, C/Reina Amàlia, 31-33 and Camp del Colomer, for the Early Middle Neolithic, and Bòbila Madurell, for the Late Neolithic. Samples of the highest interpretative quality were almost only recovered in Camp del Colomer, for which any general conclusions derived from these data must remain on a preliminary status.

For the period between 5400 and 5000 cal BC, the weed assemblage of Can Sadurní cave was considered indicative of very intensive soil disturbance. Unfortunately, comparable data were obtained for La Draga. For the period between 4500 and 4000 cal BC, only the assemblage of Camp del Colomer allowed the proposal of some hypotheses. Fields were not too intensively managed; the weed spectrum might indicate that livestock could have had access to the fields (weeds which are typical of other ecological groups were encountered). The few weeds recovered in Bòbila Madurell within the period 3200-2300 cal BC indicate permanently cultivated fields with a low perturbation of the soil. Even though the data from the Early Neolithic are from a single site, one could interpret that the available data support that agricultural practices tend to more extensive crop husbandry techniques, with a decreasing intensity of soil perturbation towards the Middle and Late Neolithic.

The archaeological evidence of La Draga might reinforce the hypothesis of a very intensive agriculture during the earliest phases of the Neolithic. A large number of wooden tools that remind of small digging sticks were recovered in waterlogged state. A method for the identification of use-wear traces on wood is being developed at the moment (O. López-Bultó, PhD in progress, Universitat Autònoma de Barcelona), but preliminary results already show that digging sticks could have been used for agricultural work, mainly soil disturbance (López, Palomo & Piqué 2012). No spades have been recovered in La Draga. The available evidence for the early Neolithic does not support the use of the plough. Nevertheless, the available weed assemblages do not exclude this possibility, at least for the latest periods of the Neolithic. The use of the plough is not well attested in the early phases of the Neolithic. Different types of wooden ards are known from archaeological and ethnographic records, with different soil penetration capacity and function (from deep tillage to open new fields, to superficial drilling for sowing). The well-known Neolithic and Bronze Age ard marks in Europe seem to have been produced by the type of ard with a deeper penetration (rip ard), probably used to open new fields or prepare fallows for cultivation (Reynolds 1981). Available data in Europe show that the onset of the use of the plough was around the second half of the IV millennium cal BC (Jacomet & Schibler 2006, Sherratt 2006). Evidence of traction is not detected on animal bones until the late IVth millennium cal BC in Southeast France (Blaise 2005) and Switzerland (Jacomet & Schibler 2006). P.Halstead, among others, defended that ploughing with cows would be a late innovation, even though there is no clear evidence of the existence of long-term manually tilled fields (Isaakidou 2011).

In general, the type of soils that would have been chosen must have been of optimal quality, since free-threshing cereals, especially naked wheat, require soils of a higher quality. Nevertheless, no systematic geoarchaeological approach was yet performed for the region.

Permanent field cultivation was proposed for several phases of the Neolithic in other regions of Europe (Brombacher & Jacomet 1997, Maier 1999, Maier 2001, Bogaard 2004b, Hosch & Jacomet 2004). However, there exist different opinions about the intensity of the field management. Even though it is not the aim of this work review this topic (and several regions could not be included into the discussion due to the lack of data or investigations on this topic), it is worth to mention the two main interpretative trends at the moment. While A. Bogaard concludes that agricultural practices in the Neolithic of Central Europe were of intensive type taking into account the functional traits of the weeds that were present in assemblages of optimal quality (see criteria in chapter 3.2.12.1) (Bogaard 2004b, Bogaard 2005); A. Kreuz obtains different conclusions by including all the potential weeds in the analyses and considering other chorological and (aut-)ecological data. Kreuz considers that the presence of perennials in the fields would indicate low intensity of disturbance (Kreuz et al. 2005, Kreuz 2007, Kreuz & Schäfer 2011, Kreuz 2012). Our data would be more compatible with A. Bogaard's model, but crop husbandry practices could have been diverse in Neolithic Europe and there is no need to look for a single model for such a vast territory and time span. Whatever the case may be, it would be important to build robust models for interpreting weed data in order to avoid discrepancies resulting from the same data.

Sowing

The sowing time was only established at a hypothetical level for three sites: C/Reina Amàlia, 31-33 and Camp del Colomer, for the Early Middle Neolithic; and Bòbila Madurell for the Late Neolithic. The case of C/ Reina Amàlia, 31-33 is the only one for which spring sowing was identified. This would be compatible with floodplain agriculture. The presence of potential riverine vegetation, such as *Carex* sp. or *Phalaris* sp. could be interpreted as supporting this hypothesis. Nevertheless, these weeds were not obtained from optimal cereal assemblages (as defined in chapter 3.2.12.1), but from rather poor samples. The weed assemblages of Camp del Colomer and Bòbila Madurell are more typical of autumn-sown fields. Spring sowing was put forward as a generalized practice for the LBK agriculture in central Europe (Kreuz et al. 2005, Kreuz 2007, Kreuz & Schäfer 2011, Kreuz 2012), but other authors defend autumn sowing for the same or later periods (Brombacher & Jacomet 1997, Maier 1999, Bogaard 2004b).

The sowing method was only possible to approach from the archaeobotanical point of view at La Draga. The type of sickle hafts that were found at La Draga, were designed to gather several culms with the appendix and then cut them. According to the experimental works of Pétrequin and others (Pétrequin et al. 2006), this is only necessary when fields were not densely sown (that is to say, not sown by broadcasting). Sparsely sown crops would allow intensive weeding, which could explain the paucity of weeds at the site. Sowing in rows was also proposed by A. Kreuz for the LBK period in central Europe (*op.cit.*).

One final issue concerning the sowing of the cereals is to determine whether they were sown as maslins or monocrops and whether crop rotation could have taken place. Concerning the existence of maslins in the Neolithic, this was mainly assumed on the basis of the co-occurrence of different taxa in the same assemblage and their relative proportions. In particular occasions, other taphonomic aspects were used to discern whether different taxa from the same assemblage had been processed and grown separately. In those cases where these aspects were observable, mostly monocropping was identified. In the Early Neolithic, the different cereals that were used as offering in Can Sadurní cave were mixed *ex professo* after their processing. This assumption was made after observing the different patterns of fragmentation produced in each cereal taxon during threshing and dehusking (Antolín & Buxó 2011c). At the site of La Draga, the treatment of naked wheat as a monocrop seems rather clear. It is not so clear, though, whether the glume wheats were grown separately. The possibility that hulled barley was grown as a monocrop was reinforced when this was found stored in ear form mixed with a storage of threshed naked wheat grain. In this case, it is demonstrated that both taxa were treated separately when stored. It is not clear, though, whether they could have been grown as a maslin (with a major component of naked wheat) and only separated afterwards; one further possibility would be that crop rotation (naked wheat followed by barley) was practiced at the site. In the Early Middle Neolithic and Middle Neolithic periods, the cultivation of naked barley as a monocrop in Camp del Colomer and Bòbila Madurell is likely, although it appears mixed with naked wheat in some assemblages at both sites. In Bòbila Madurell, the separate treatment of the glume wheats with respect of the free-threshing cereals is very clear; therefore one should assume that they were grown separately. Finally, the assemblage of Cova del Toll dated to the Late Neolithic seems to belong to a monocrop of hulled barley. These results do not necessarily show the actual complexity of Neolithic plots. It is likely that a diverse panorama existed at the time. Further research is needed in order to increase the database for all periods.

Finally, concerning crop rotation, the evidence for this practice has always been very sparse and argumentation lacked of appropriate quantitative data. The results obtained in Camp del Colomer allowed a somewhat less tentative approach to crop rotation in the second half of the Vth millennium cal BC. Naked barley would deplete soil richness rather rapidly, for which it is interesting to take into consideration the fact that pea is the second best represented crop at the site. A crop rotation between naked barley and pea would allow the permanent cultivation of fields observed in the weed assemblages.

Harvesting

Harvesting practices were also attempted to define by considering the type of weeds and crop remains that were found in the analysed sites. These were only possible to evaluate for two sites: La Draga and Camp del Colomer. At La Draga, the scarce representation of weeds and the fact that, among those few potential weeds present, climbing weeds were dominant, was used to argument that the harvest would have taken place high on the straw. Besides, several fragments of straw were identified but only one straw node. This might be due to the fact that the straw was cut above the first culm node. This was also supported on complementary archaeological evidence, namely the sickle hafts and the experimentations that were carried out with them (Palomo et al. 2011). At Camp del Colomer, the presence of low weeds was used to propose a lower harvest. Nevertheless, no sickle blades were found at the site to date, for which the harvesting techniques are difficult to characterize.

The use of sickles is widely documented all along the Neolithic in the Eastern and Southern Iberian Peninsula (Ibáñez et al. 2008, Gibaja et al. 2011a), but not in the Cantabric basin, where research is still at an early stage (the use of wooden tools such as *mesorias* is proposed by some authors). Most sickle blades seem to be inserted parallel to the haft in this region (Gassin et al. 2010). Nevertheless, a very particular type of L-shaped sickle haft was identified at La Draga, where the blade is obliquely inserted into the haft. The haft has a hook at the end, which would have allowed first gathering the stems of the cereals and then cutting them with the blade at a certain distance from the floor (Palomo et al. 2011). In our region, blades inserted parallel to the haft prevail until the Bronze Age, although some slightly curved hafts start to appear and become generalized in the Iron Age (Alonso 1999, 194-198). Towards the middle of the IVth millennium cal BC and especially during the IIIrd millennium cal BC onwards, long blades were produced to harvest cereals. Use-wear analyses on lithic tools concluded that two types of uses were made: cutting at a medium height of the culm and cutting at a very low height or on the floor (Gibaja et al. 2004, Gibaja et al. 2010). A medium-height harvesting technique would already go in accordance with the observations carried out at Camp del Colomer. The cutting of cereal straw on the floor might correspond to other phases of the processing of the crop, like the separation of the straw from the ear (Clemente & Gibaja 1998). This practice is ethnographically documented. Particular gadgets were recorded in recent ethnographic work in Eastern Europe (Hajnalová & Dreslerová 2010).

Even though this discussion is largely based on cereals, which are the main crops during the Neolithic in the studied region, one mention should be made here to opium poppy. Capsules could have been gathered when dry and taken to the site in order to use the seeds as condiments or to obtain oil. Besides, the green capsules could have been used to obtain latex or opium. A specific interdisciplinary investigation should focus on the process of production of oil from poppy seeds and the associated instruments. There is a considerable potential for the identification of these objects at La Draga.

Threshing

The analysis of threshing methods by considering archaeobotanical macroremains is still at a very early stage (N. Alonso et al. forthcoming). Nevertheless, the presence of fragments of grain produced prior to charring in cereal assemblages was used to discuss the existence of some sort of threshing. This approach only produced significant results for La Draga. Two samples presented percentages of 3-5% of fragments of grain produced prior to charring. This was used to defend that the crop had been threshed. Unfortunately, experimental models are still not well defined and these results cannot be correlated with low-scale or large-scale practices. Our hypothesis is that this was generated by a low-scale processing carried out within the site on a household scale (Antolín et al. submitted).

Low-scale threshing techniques are almost impossible to document archaeologically. These could involve, stones, blades or threshing boards. It might be significant to note that flint blade with use-wear evidences of having cut non-woody plants (likely cereals) on the floor are found in most of the sites dated to the Neolithic period (Clemente & Gibaja 1998, Gibaja 2002b, Gibaja 2003, Ibáñez et al. 2008, Palomo et al. 2011, Gassin et al. 2010). These tools could have been used to thresh ears at a low scale (N. Alonso, pers.com.). Large-scale threshing techniques could be detected when a threshing sledge was used. The first evidence of the use of the threshing sledge in the Iberian Peninsula was recently documented in El Casetón de la Era (Valladolid), a Chalcolithic site dated to the III millennium cal BC (Gibaja et al. 2012). Much earlier dates were proposed for the onset of its use in southwest Asia (Anderson 2006). Use-wear analyses of lithic tools are still not systematically practiced for these periods and it is hard to evaluate how widespread this technique was. In any case, it would be logical to consider that the use of animals for threshing purposes should predate El Casetón and, as a consequence, one should assume that animal labour force (or trampling with animals) could be used for threshing during the Neolithic, too. Use of animal force is well documented in the Early Neolithic site of La Draga (Bosch et al. 2008), as already mentioned. Using animals for threshing would imply the existence of threshing floors, of which no archaeological evidence is yet available.

The tentative available data might point towards more extensive threshing methods towards the Late Neolithic in the Iberian Peninsula (if one considers the case of El Casetón as representative for this last region) while threshing techniques of lower-scale might have been used during the early Neolithic. Further research is needed on this topic.

Dehusking

The study of dehusking of glume wheats was only possible for one settlement phase: the Early Neolithic phase of Can Sadurní cave. In this case, it was interpreted that the cereals were dehulled before depositing them inside potsherds. This is confirmed by the percentages of grain fragments produced prior to charring and the major absence of the embryos, which was observed as a characteristic effect of dehusking in our experimental works (see chapter 3.2.10.1).

The archaeological evidence for dehusking practices in southwest Asia is usually linked to the appearance of stone mortars and pestles. Nevertheless, mortars are rarely identified in the archaeological record. If grain dehusking was practiced by pounding in our region, saddle querns or wooden mortars were probably used.

Dehusking practices could have been different in central Europe, where the occurrence of charred glume bases and spikelet forks of glume wheats is very common, at least during the LBK period (e.g. Kreuz 1990a, Kreuz et al. 2005, Kreuz 2007). Recent experimental work might indicate that such types of remains are more likely to be obtained when spikelets were roasted before dehusking (Alonso et al. 2013). This practice might not have taken place in the NE of the Iberian Peninsula, given the low representation of charred chaff remains in our record.

Storage

Storage practices were targeted at two scales: identifying potential *in situ* burnt storages; or the processing of the grain (by roasting) before storage. The identification of *in situ* burnt storages was based on the description of evidence of taphonomic agents on the state of preservation of the archaeobotanical record. The methodological basis for this evaluation was presented in chapter 3.2.10.3. The experimental work carried out in order to support this type of analysis is still at a very preliminary stage. More work should be dedicated to this issue in the future. Despite the need for improvement, this methodology allowed the identification of potential *in situ* burnt storages at La Draga, where no archaeological features would help reaching such a statement. It also allowed the discarding of other large concentrations of grain as potential storages, like the assemblages from Camp del Colomer and Bòbila Madurell. The case of Can Sadurní cave (layer 18) cannot be considered as a storage, since it was interpreted as an intentionally burned offering of grain. Such interpretations had major implications for the analysis of each site. Two different storages were identified at La Draga; one was already published in previous analyses (squares JH84-85 of sector B). It involved storage of clean grain of naked wheat, which was probably contained in baskets (Antolín & Buxó

2011b). The other one was presented in this work and interpreted as a threshed crop, which was stored with the chaff. It is difficult to interpret at this stage of research if the latter was a widespread practice at the site or just the result of some unexpected event, which forced people to store a small part of the crop before winnowing. Barley could have been stored in ear form, while glume wheats were probably kept in spikelet form. Currently there is one more potential charred storage under analysis (UE 7001) (A. Berrocal, in progress, Universitat Autònoma de Barcelona).

In the case of Camp del Colomer and Bòbila Madurell, no *in situ* burnt assemblages were found. Potential evidence of roasting of the grain in order to facilitate short-term storage in pottery vessels was put forward as an explicative hypothesis of the large amounts of charred assemblages of clean grains (without embryos) of naked barley. This process of roasting would take place after a period of long-term storage in underground silos, which are well documented On both sites. This practice was documented ethnographically in Northern Africa (Ferchiou 1985).

Storage practices can be very diverse and not all of them may be easily identifiable in the archaeological record. The most common storage devices that have been documented in our region are large ceramic vessels and storage pits. Besides, baskets were also recovered at La Draga in direct association with *in situ* burnt storages, as mentioned above. The use of underground pits for grain storage is well attested from the Early Neolithic period, in sites like El Cavet, in Cambrils (Fontanals et al. 2008) or Caserna de Sant Pau, in Barcelona (Molist, Vicente & Farré 2008); through the Late Early Neolithic, in sites like Cim “El Camp” (Bravo, Roig & Solà 2012); the Early Middle Neolithic, in sites like Camp del Colomer (Martínez, Vidal & Maese 2011), or in Can Sadurní cave (Edo & Blasco 1992); the Middle Neolithic, with rather large concentrations of these structures in Bòbila Madurell, in Sabadell (Bordas et al. 1994); and the Late Neolithic, in recently discovered settlements like La Cantorella, in Maldà (Moia, com. oral) or Espina C (Piera et al. 2009).

The calculation of capacities of underground pits and their interpretation is not always done in a reliable way. It is for this reason difficult to attempt further interpretations from storage capacities for the Neolithic period, as performed for the Bronze Age by N. Alonso (Alonso 1999, Albizuri, Alonso & López-Cachero 2011). This is a basic research in order to understand agricultural practices. This situation is being solved through a systematic extensive work on underground storage features in the north-western Mediterranean region (G.Prats, PhD in progress, Universitat de Lleida).

Storage is a complex phenomenon and not all surplus production must be stored in silos and not all the product for everyday consumption should be stored in ventilated conditions (for a detailed discussion see, Alonso 1999, 208). Storage in sacks or pottery containers is well attested ethnographically but it is not always easy to detect in archaeological contexts. As already mentioned, storage in baskets has been clearly documented in La Draga, while large pottery vessels for storage were identified in several sites like Camp del Colomer (Remolins, Antolín & Fortó 2011) and Bòbila Madurell (Masvidal, González & Mora 2005). Evidence for potentially above-ground structures for ventilated storage are not documented in the NE of the Iberian Peninsula until the Bronze Age, and more clearly, the Iron Age, with the finding of the so-called “grill-plan” structures (Carlús, González & Nadal 2010). However, their functionality is not clear due to the lack of specific interdisciplinary research and the bad state of preservation of the mentioned structures.

Culinary processing

The identification of the culinary processing of cereal and pulse crops in Europe has been approached in a number of interesting papers (see, for instance Samuel 1996, Samuel 2000, Valamoti et al. 2008, Valamoti 2009, Valamoti 2011, Valamoti, Moniaki & Karathanou 2011). The identification of cereal preparations such as bulgur requires the ability of identifying grain fragmentation produced prior to charring, which might be complicated, depending on the preservation of the materials. Besides, there is no expressed agreement on how to quantify it and how to interpret it. In this work, food preparations of the bulgur type (groats) were only proposed when aggregates of fragments of grain produced prior to charring were found. These never appeared in particularly grain-rich samples, for which it is unlikely that they were produced during threshing. Such evidences were only found at La Draga (sector D). Their identification is highly significant, since it shows the investment of labour in the preparation of food. This is considered by anthropologists as a sign of increased reliance in a food product as a staple food (Stahl 1989). Evidence of bulgur production has been documented in several Bronze Age sites in Greece (Valamoti 2002, Valamoti 2011).

Amorphous charred objects were identified in several sites like La Draga (sector D) or Bòbila Madurell. Their accurate study was not conducted for which their interpretation as fragments of some sort of bread or a similar product (remains of some dish or foodcrust in a pot) should remain on the hypothetical level.

Other cereal products were identified in the region. Evidences of malted barley and a fermented beverage made of barley were documented in Can Sadurní cave, within layer 11, dated to the second half of the Vth millennium cal BC (Blasco, Edo & Villalba 2008). Unfortunately, a complete publication of the evidences of this find is not yet available. Possible evidences of the production of flour have also been identified in this same context (Blasco et al. 1999). Skeletal pathologies potentially related to grinding have been identified in some Neolithic sites like El Collet, in Puiggròs (Piera et al. 2008). An emphasis on residue analyses, along with archaeobotanical microremains (phytoliths and starch) should be put in future investigations.

5.2.8. Were agricultural practices during the Neolithic (5400-2300 cal BC) in the NE of the Iberian Peninsula of intensive type?

The presented evidences support the existence of an intensive model of agriculture at least for the Early Neolithic period. The assemblages of Can Sadurní cave and La Draga give a rather clear perspective on this issue. Unfortunately, younger periods are not so well represented in our record and it is not possible to tell without a doubt whether agricultural practices were of intensive or extensive type. The maintenance of certain crop diversity in most sites until the Middle Neolithic would favour intensive practices. In any case, permanent cultivation of the plots seems possible for all the Neolithic period. With this one can discard the possibility of shifting agriculture. Less intensive agricultural practices during the Vth millennium cal BC might have made it possible to practice floodplain agriculture in some areas like in the plain of Barcelona. Nevertheless, more data are needed to support this interpretation. The apparent expansion of hulled barley and the almost disappearance of hulled wheats from the record during the Late Neolithic might respond to the cultivation of new and less suitable soils with more extensive techniques. The identification of the use of the threshing sledge, a large-scale threshing technique, in El Casetón de la Era, during this phase would reinforce this interpretation.

5.3. Wild fruit management during the Neolithic (5400-2300 cal BC) in the NE of the Iberian Peninsula

An important question, which could never be addressed using the archaeobotanical record of the Iberian Peninsula concerns the role of wild fruits in human diet during the Neolithic and to what extent their gathering, processing and consumption was integrated in the economy of early farmers. L. Zapata produced the most accurate investigation on this issue (Zapata 2000, Zapata, Baldellou & Utrilla 2008), even though the number of sites available at the time was rather low. Zapata considered that wild fruits played an important role in the Neolithic economy, based on their frequent appearance in several sites and the evidences of their intentional processing for human consumption. The situation in the Iberian Peninsula is, according to Zapata, comparable to the observations made on some central European lakeshore sites from younger periods, where it was interpreted that wild fruits could signify 1/3 or even 1/2 of the caloric input of vegetal origin to the diet at this site (e.g. Jacomet & Schibler 1985, Gross, Jacomet & Schibler 1990, Hosch & Jacomet 2004).

5.3.1. Standardization of the data and selection of the taxa for further analyses

The significance of the present study for the completion of the archaeobotanical database for the region under analysis is considerable (Fig. 5.34): 16 of the 22 sites which have yielded charred remains of wild fruits were analysed (119 of the 141 contexts with positive results); 78 of the 81 taxa in charred state were identified in this project (57 of these taxa were new) and 2085 of the 2746 charred wild fruit remains were recovered. Besides, 18101 waterlogged plant macroremains from wild taxa were retrieved (Fig. 5.35), only from La Draga. This was only possible after applying new sampling and recovery techniques at the site (see chapter 4.7). 47 new taxa were added to the carbonized record.

Plant remains in charred state	ALL TAXA		WILD FRUITS	
	TOTAL	This work	TOTAL	This work
Nr. of sites	24	17	22	16
Nr. of contexts	252	164	141	119
Nr. of taxa	93	88	81	78
Nr. of items	409135	113793	2746	2085

Fig. 5.34. General evaluation of the charred record including all taxa and only the wild taxa. Total data available for the region under study for the Neolithic period (including this work) and total amount obtained in this work.

Plant remains in waterlogged state	TOTAL	WILD
Nr. of items	25091	18101
Nr. of taxa	81	76

Fig. 5.35.Total number of waterlogged seeds and fruits recovered in this work and total amount of remains belonging to wild taxa.

Some difficulties arose when all the data from the available studies were put into the same database. These mainly concerned quantification issues. Tables of results from previous work were not always published and sometimes quantified data were only given for some of the taxa. When only the presence of a taxon was indicated, a value of 1 was introduced in the table. In Balma Margineda, only the volume of hazelnut shells was given, for which we used the available reference data to give an approximate number of hazelnuts (nr of hazelnuts= volume*109/207.5); for details, see (Berihuete & Antolín in press).

In order to carry out a selection of the most economically useful taxa, the PFAF database and the ethnobotanical reference work mentioned in chapter 3.2.12.3 were used. Only those taxa classified with a rank 3 or higher were considered (following S. Colledge, oral com.). The identification of seed and fruit remains as residues of the production process of artifacts made of other plant parts falls out of the scope of this work. Even when some of the identified taxa could have been used for other purposes, this is not enough evidence to discard the intentional gathering and consumption of the fruits. Thirty taxa were selected, together with nine more, which appeared as traditionally useful taxa in the Mediterranean region according to the ethnobotanical records. The total amount of taxa and known uses through ethnobotanical and ethnographic work can be observed in Annex 4. A total number of 87 contexts had some remains of at least one of these taxa.

The graphic representation of the data will group the two subphases of the Early Neolithic and the two subphases of the Middle Neolithic. This is mainly because of the lower number of seeds and fruits available in comparison to cultivars. Despite this, separate tables were produced for each of the subphases (see below), which allows a more accurate approach to the available numbers.

5.3.2. Some previous taphonomic observations: charring vs. waterlogging

Before going any further into the evaluation of the data, some comments on taphonomy should be put forward. The preservation of wild fruits in charred state is strongly biased in comparison to cultivated plants. They are very frequently consumed outside the settlement and, in many occasions, there is no need for their processing, therefore very few archaeological traces of them are left. This has been observed before by many archaeobotanists (e.g. Dennell 1976). For this reason, the charred record for the Neolithic period is dominated by cereal remains (Fig. 5.36). Only when waterlogged conditions prevail, it is possible to identify consumed kernels of some fruits (berries), like in the case of Hornstaad (Maier 2001) (see some further discussion, incl. archaeobotanical examples, in Jacomet 2013). In fact, the results obtained for the subfossil record of La Draga show a different spectra. Nearly 75% of the assemblage belongs to wild fruits (Fig. 5.37). When looking at the proportions of charred and waterlogged remains per taxon at La Draga (Fig. 5.38), it becomes clear that the majority of remains were waterlogged and, in some cases, such as *Corylus* or *Pyrus malus,* they would not have been preserved in dry mineral sites (they were not recovered in charred state in La Draga). If one considers these results as a model for the interpretation of charred assemblages, one should conclude that single finds of wild fruits with a clear economic use might reflect important resources in the economy of the village. For this reason, they should be taken into consideration, especially on the basis of their ubiquity values, rather than the absolute number of remains.

Even though the waterlogged record available at the moment only comes from a small surface of a single settlement phase of La Draga, 51 new taxa were identified; 30 taxa were identified both in charred and waterlogged state, and 47 only in charred state (Fig. 5.39). Both types of preservation are, therefore, complementary and they will both be considered in our analyses.

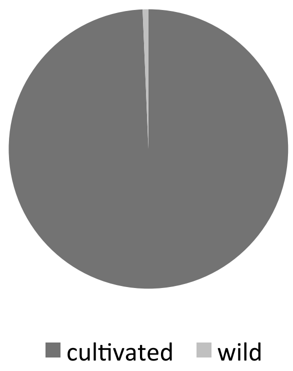

Fig. 5.36. Proportion of wild and cultivated seed/fruit remains in charred state in the Neolithic record of the region.

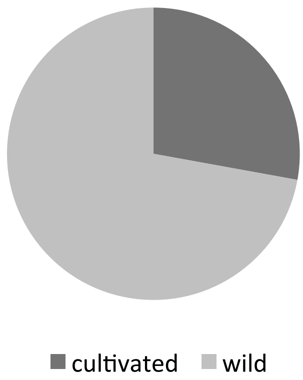

Fig. 5.37. Proportion of wild and cultivated seed/fruit remains in waterlogged state in La Draga.

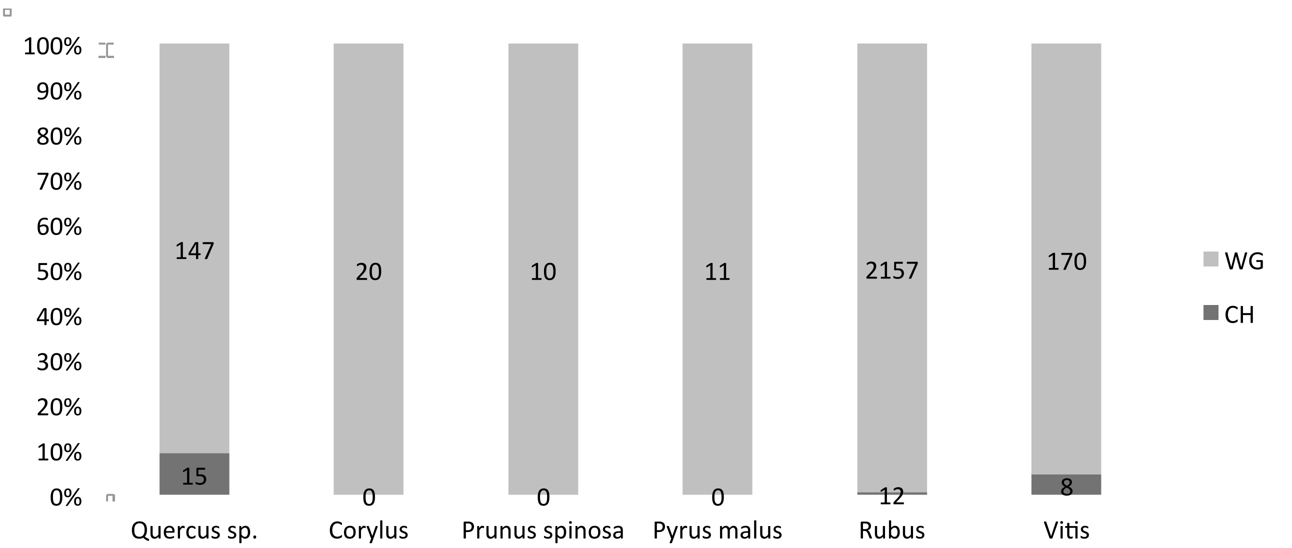

Fig. 5.38. Proportion of charred (ch) and waterlogged (wg) remains (MNI) of some of the most significant wild taxa of the Neolithic in the NE of the Iberian Peninsula at La Draga (Sector D).

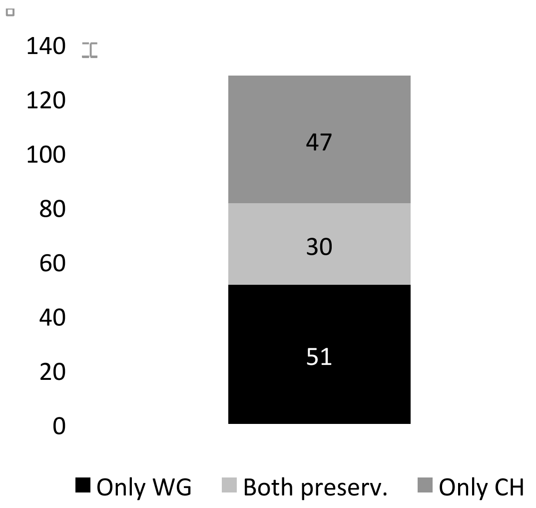

Fig. 5.39 Number of taxa per preservation type (wg: waterlogged; ch: charred) for the Neolithic period in the NE of the Iberian Peninsula.

5.3.3. The Early Neolithic and the Late Early Neolithic (5400-4500 cal BC)

A total number of 36 useful taxa were identified for the first phase of the Early Neolithic (5400-5000 cal BC), both charred and waterlogged (Fig. 5.40). Plants from several ecological groups were identified, and it is difficult to know, in some cases, the reasons for their presence at the site: for instance, potential weeds or, in the particular case of La Draga, the local vegetation (lakeshore and aquatic plants). The difficulties of interpreting these remains in waterlogged contexts have already been mentioned by other authors (for instance, (Bouby & Billaud 2005).

Within the group of weeds and ruderals/pastures and grasslands, the significant presence of *Chenopodium album* and *Apium graveolens* should be highlighted. The former could have been gathered for its seeds (they can be dried, parched and turned into flour). The identification of this taxon as a gathered plant can be found in many archaeobotanical investigations of the Neolithic period in Europe (e. g. Jacomet 2007, Kohler-Schneider 2007, Behre 2008, Bakels 2009). Nevertheless, the available record in our region is still meagre, especially in charred state. The seed of *C. album* from Can Sadurní Cave is more likely to have arrived to the site as a weed, since the assemblage was mainly consisting on cereal grain. The finding from Caserna de Sant Pau (Buxó & Canal 2008) is of less clear origin, thus it could originate from a variety of actions.

Apium was only identified in La Draga, possibly due to taphonomic phactors, since it was only preserved in waterlogged state. A relatively large number of remains were recovered. This plant has both alimentary and medicinal value.

The presence of *Silybum marianum* at La Draga is equally significant, especially because its fruits appear in fragmented form, in a very similar state to those recovered in La Marmotta site (Lake Bracciano, Italy) (Rottoli 2000-2001). This taxon could have been gathered for the oil content of its seeds. The possibility that it could have been tended or cultivated, as proposed by other authors (Guinard & Guinard 2001), should not be discarded. The available record is not conclusive in this sense.

5400-5000 cal BC	Nr. of settlement phases	Nr. of contexts	Nr. of remains in charred state	Nr. of remains in waterlogged state
Weeds and ruderals				
Atriplex patula/latifolia	1	1	1	
Chenopodium album	3	4	2	139
Galium aparine s.l.	2	2	2	1
Polygonum aviculare	2	2	1	34
Silybum marianum	1	1		2
Solanum nigrum	1	1	9	
Stellaria media s.l.	1	2		2
Urtica dioica	1	3		3
Vicia villosa	1	1	1	
Pastures and grasslands				
Apium graveolens	1	3		365
Hypericum perforatum	1	3		3
Woodland edgles and clearings				
Agrimonia eupatoria	1	1		1
Arctostaphylos uva-ursi	1	1	1	
Crataegus monogyna	1	1		7
Origanum vulgare	1	2		10
Prunus spinosa	1	4		10
Rubus fruticosus	1	2	12	2157
Rubus idaeus	1	1	1	
Vicia sepium	1	1	3	
Maquis formations				
Arbutus unedo	1	1	5	
Woodland				
Corylus avellana	5	11	72	20
Prunus avium	1	3		7
Pyrus malus subsp. *sylvestris*	1	3		11
Quercus sp.	6	13	65	147
Sorbus domestica	1	1	2	
Taxus baccata	2	2	1	1
Lakeshore				
Alisma plantago-aquatica	1	3		1077
Alnus glutinosa	1	3	11	7
Eupatorium cannabinum	1	2		156
Mentha sp.	1	3		73
Phragmites australis	1	1		1
Plantago major	1	2		482
Scirpus lacustris	1	3		386
Vitis vinifera subsp. *sylvestris*	1	4	8	170
Aquatic				
Nymphaea alba	1	1		1

Fig. 5.40. Evaluation of the wild taxa identified in the NE of the Iberian Peninsula for the Early Neolithic period: number of settlement phases and contexts in which they were found and number of remains according to preservation type.

Among the plants from woodland edges and clearings, several important taxa were recovered, some of which in relatively high numbers. However, each of them was identified on a single site only. It is worth highlighting the high numbers of *Rubus fruticosus* that were retrieved at La Draga, presenting some particular concentrations within the analysed surface of the site. As already mentioned, such concentrations could correspond to the accumulation of excrements (see, for instance, Maier 2001). The consumption of *Rubus fruticosus* was probably frequent at the site. Other fruits like *Prunus spinosa* and *Crataegus monogyna* were also identified, though in lower numbers. These were commonly gathered in other areas of

Europe during the Neolithic (Jacomet 2007, Rottoli & Pessina 2007, Kohler-Schneider 2007). This is probably due to methodological biases derived from the small size of the samples in La Draga. Both fruits are edible.

Among the taxa from woodland areas, *Corylus avellana* and *Quercus* sp. were the best represented, both considering the charred and the waterlogged record. The charred remains of *Corylus* came in their majority from Balma Margineda, in the Pyrenees, while most of the charred remains of *Quercus* came from Fosca Cave, in the Maestrat mountains. At La Draga, most of the remains were in waterlogged state, as mentioned above. Other taxa like *Pyrus malus* and *Prunus avium* were only identified in waterlogged state, but in somewhat lower numbers. Both taxa could have had an important alimentary role. The importance of hazelnuts, acorns and wild apples as gathered food resources in the Neolithic of the Iberian Peninsula was already stressed by L. Zapata (Zapata 2000). Besides this, the stones of *Prunus avium* were also used to make beads at La Draga. No other records of these ornaments are known in the region, since the preservation of these beads would depend on their carbonization. It is not known whether these beads were given any added social value, but they certainly indicate the investment of time and labour in their production. *Sorbus domestica* was only identified in Fosca Cave, while *Taxus baccata* was both recovered in Fosca Cave and La Draga. These two taxa have a clear alimentary value, although *Taxus* also has medicinal value. The finding of *Taxus* in Mas Cremat, close to Fosca Cave, was interpreted as incidental, probably due to the use of whole branches as fuel (Pérez-Jordà 2010). Charcoal remains of *Taxus* were not identified in this period at Fosca Cave (Antolín et al. 2010), for which the possibility of their consumption remains open. The recovery of this taxon in other areas of Europe is documented, but mostly linked to livestock foddering practices (Favre & Jacomet 1998, Delhon et al. 2008, Martin, Thiébault 2010).

Lakeshore and aquatic plants were the most difficult to interpret as consumed products. Their presence was restricted to La Draga. They were mostly preserved by waterlogging, except for *Alnus glutinosa* and *Vitis vinifera* subsp. *sylvestris*. Fruits of wild *Vitis* are edible, even though their taste is not as sweet as those of the present-day cultivated varieties. This taxon was identified in other areas of Europe as a gathered pland, especially in southern Europe (Rovira 2007, Rottoli & Pessina 2007) but also in the north (Jones & Legge 1987). The economic use of *Alnus* is more difficult to establish, even though crashed cones are known to have been used in infusions with anti-inflammatory purposes.

The spectrum for the second phase of the Early Neolithic (5000-4500 cal BC) is significantly smaller, both in the number of taxa and the number of recovered items (Fig. 5.41). The best represented taxa were *Corylus avellana* and *Quercus* sp. They were found in three different settlement phases and in somewhat larger numbers. This would indicate that these taxa were probably frequently gathered. It is also significant to note, for the first time, the presence of *Pistacia lentiscus* in the sites from the central coast area. According to the pollen records, the presence of this taxon increases in the region during the Vth and IVth millennia cal BC (Riera, Esteve & Nadal 2007). This is probably due to the climatic change towards drier conditions which takes place during the middle Holocene (Pérez-Obiol et al. 2011). This change is also observed in the charcoal record of Can Sadurní cave, where a major increase of Mediterranean vegetation during the Vth millennium cal BC is noticed (Antolín et al. 2013). The identification of *Pistacia lentiscus* as a gathered edible fruit (and its leaves as fodder for livestock) can be found in many other sites of the western Mediterranean region (for instance, in Ifri Oudadane, in Morocco (Morales et al. 2013) but some authors mainly consider its use as fuel (Rovira 2007). The lower representation of wild fruits during this phase runs parallel to the lower representation of cultivars. It is unlikely that this reflects real economic changes (e.g. a larger tendency towards herding practices). This is likely to be related to the lack of data for this particular chronological phase.

5000-4500 cal BC	Nr. of settlement phases	Nr. of contexts	Nr. of remains in charred state
Weeds and ruderals			
Euphorbia helioscopia	1	1	1
Galium aparine s.l.	2	2	7
Polygonum aviculare	1	1	1
Woodland edges and clearings			
Rubus fruticosus	1	1	1
Maquis formations			
Pistacia lentiscus	2	2	2
Woodland: diverse			
Abies alba	1	1	1
Corylus avellana	3	4	14
Prunus avium/mahaleb	1	1	1
Prunus padus	1	1	1
Quercus sp.	3	3	16
Riverside			
Vitis vinifera subsp. *sylvestris*	1	1	5

Fig. 5.41. Evaluation of the wild taxa identified in the NE of the Iberian Peninsula for the Late Early Neolithic period: number of settlement phases and contexts in which they were found and number of remains according to preservation type.

From a geographical perspective (Fig. 5.42), it can be observed that the woodland taxa appear in larger numbers in the north and in high areas from the southern region, while only a few remains of maquis vegetation and (Mediterranean) woodland were found in the central coast area. These results indicate an ecological difference between these regions but also potential economic and cultural differences. The appearance of larger assemblages of charred hazelnuts and acorns only in the mountain areas and the dominance of subfossil pericarp fragments of their fruits at La Draga might indicate that the processing of these fruits could have been different in mountain areas. Roasting processes would have taken place more often, which would have resulted in higher amounts of charred remains. Such processing activities would facilitate storage (Cunningham 2011a, Cunningham 2011b).

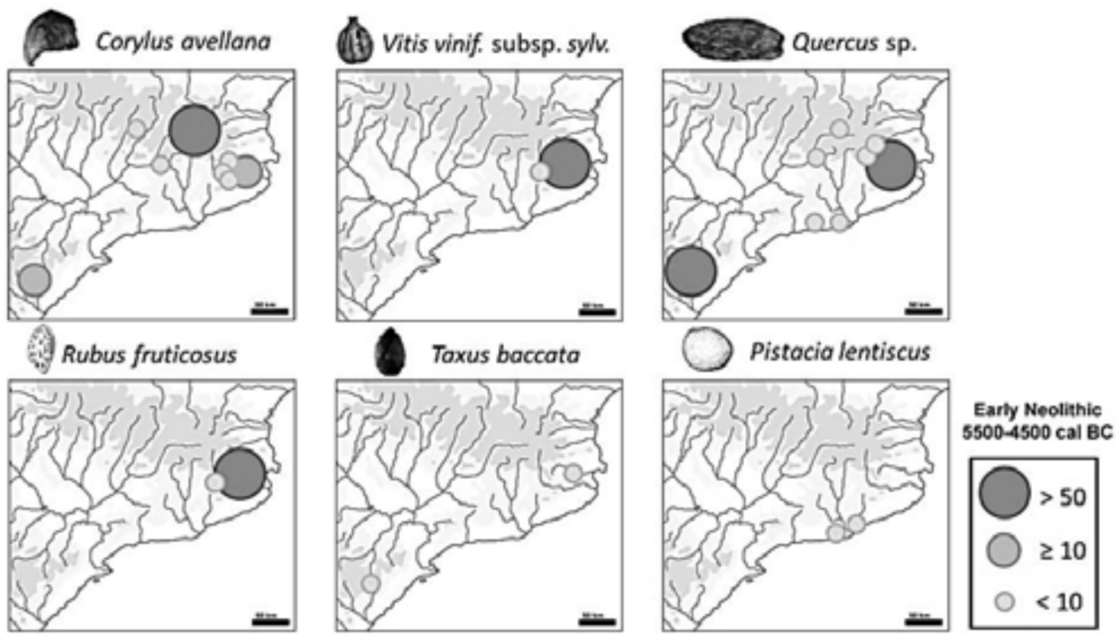

Fig. 5.42. Spatial representation of the total amount of remains recovered per site for the most significant wild taxa of the Early and Late Early Neolithic period in the NE of the Iberian Peninsula.

5.3.4. The Early Middle Neolithic and the Middle Neolithic (4500-3200 cal BC)

Twenty-three useful taxa were identified for the first part of the Middle Neolithic (4500-4000 cal BC). The data for this phase (Fig. 5.43) is quantitatively much more significant than the ones for the previous 500 years. In fact, it is the richest period for charred wild plant remains during the Neolithic in the studied region.

Among the weeds and ruderals, the repeated presence of *Chenopodium album* must be highlighted. These results allow the proposal of the possibility that this taxon was gathered as a food plant. Looking back at Fig. 4.34, it is significant to note that *Chenopodium album* appears in the correspondence analysis of the samples from Camp del Colomer, in the same area as *Corylus* and *Pyrus malus*, which were clearly gathered fruits. In fact, *Chenopodium* appears in several samples with none or very few crop items. Thus this taxon does not behave as a typical weed which could have been discarded during crop processing. It seems feasible that *Chenopodium* was being gathered as a food plant at the site. The other site where *Chenopodium* was recovered was Can Sadurní cave. Nevertheless, no comparable statements can be put forward for this site. Two more taxa are worth to mention: *Solanum nigrum* and *Urtica dioica*. Both are edible taxa, but *Solanum* can be toxic and it can produce hallucinations. *Solanum* was identified in three different sites in rather different contexts. On the one hand, the sample from Camp del Colomer comes from a context interpreted as the potential burning of dung. Can Sadurní was equally interpreted as a byre context during this period, for which the seeds could have undergone a similar taphonomic process. In C/Reina Amàlia, 31-33, on the other hand, the seeds seem to be related to the only crop-rich assemblage; it was interpreted as a potential weed. It seems, for the moment, that the available evidences of *Solanum nigrum* during the Neolithic were not clearly related to human consumption. Finally, *Urtica dioica* was identified in several samples from Camp del Colomer. The seeds of *Urtica* do not have as much use as the plant itself, which is edible. It was found both in samples which were rich in crop remains and others rich in inedible wild plants. Hence, its economic nature is difficult to establish.

Plants from woodland edges and clearings were probably intensively exploited on the sites where they were found; in general each taxon was documented on one site only. One large concentration of stones of *Crataegus monogyna* was identified at La Dou by R. Buxó (Buxó 2007b). As already mentioned (chapter 4.4.5.2), it is likely that these had been consumed by humans. *Fragaria vesca* was identified in several samples from Camp del Colomer and it is very probable that these fruits were gathered and consumed at the site. Its consumption is well attested in the Neolithic of other areas of Europe (e.g. Jacomet 2007, Bakels 2009).

The case of the taxa from maquis formations is rather different. As already discussed within chapter 4.11., these remains were recovered in Can Sadurní cave; they were interpreted as resulting from the use of branches of *Arbutus unedo, Pistacia lentiscus* and *Olea europaea* as leaf fodder. These fruits could also have been consumed by humans, but we lack clear evidence for it. *Pistacia* was identified on other sites of the Western Plain. The remains, recovered in a variety of features, could be the result of the consumption of the fruits or the use of the seeds for making oil. On the other hand, they could respond to the frequent gathering of wood for fuel. Nevertheless, this would not explain the state in which the fruits appear (clean fruit stones).

4500-4000 cal BC	Nr. of settlement phases	Nr. of contexts	Nr. of remains in charred state
Weeds and ruderals			
Atriplex patula	1	1	1
Chenopodium album	2	10	24
Galium aparine	3	4	4
Hyoscyamus niger	1	1	4
Malva sp.	1	1	1
Polygonum aviculare	1	1	1
Solanum nigrum	3	3	26
Urtica dioica	1	6	53
Pastures and grasslands			
Artemisia vulgaris	1	4	12
Capsella bursa-pastoris	1	1	10
Thymus serpyllinum	1	2	14
Woodland edges and clearings			
Crataegus monogyna	1	1	216
Fragaria vesca	1	7	181
Physalis alkekengi	1	1	2
Rubus fruticosus	2	3	5
Maquis formations			
Arbutus unedo	2	2	233
Olea europaea var. *sylvestris*	1	1	1
Pistacia lentiscus	4	8	49
Woodland: diverse			
Corylus avellana	2	24	60
Pyrus malus subsp. *sylvestris*	1	5	18
Quercus sp.	4	10	43
Riverside/wetland			
Plantago major	1	2	3
Vitis vinifera subsp. *sylvestris*	2	2	3

Fig. 5.43. Evaluation of the wild taxa identified in the NE of the Iberian Peninsula for the Early Middle Neolithic period: number of settlement phases and contexts in which they were found and number of remains according to preservation type.

Evidences of keeping livestock inside the settlement area are documented in several Neolithic sites across Europe. Accumulations of twigs and goat/sheep faeces were recovered in Egolzwil 3, in Switzerland (Rasmussen 1993), dated to c. 4300 cal BC. Mixtures of beech leaves and twigs together with various herbs were used to feed goats and sheep in the early spring (Haas, Karg & Rasmussen 1998, Kühn & Hadorn 2004). Leaves and twigs of silver fir were fed to cattle in Arbon Bleiche 3, Switzerland (Akeret & Rentzel 2001), but O. Akeret states that goat and sheep were mainly fed by pasturing near the site and foddering would only take place during short periods of time. Similar observations were proposed for Can Sadurní, since the ripening season of the identified fruits is autumn. Leafs and flowering branches were fed to livestock (mainly goats) in the Neolithic occupations of La Grande Rivoire, in the French Alps (Delhon et al. 2008). No systematic analyses of dung have been carried out in the region under study, and only scanty references are known, like the appearance of leaves of *Buxus sempervirens* in a burnt layer of dung of Cova Colomera (Sant Esteve de la Sarga, Lleida) (Oms et al. 2008).

Typical woodland taxa were mainly identified in the north of the region under study, except for *Quercus* sp., which was recovered in several regions, including the southern area. It is of major interest to note that the three taxa from woodland areas (*Corylus, Quercus* and *Pyrus*) were identified in Camp del Colomer in charred state. Considering both archaeological and archaeobotanical data, it was concluded that acorns and hazelnuts were roasted on a rather regular basis at the site and that both taxa would have been gathered and processed separately (see chapter 4.2). Apples could have undergone a similar process. Single finds of these taxa were recovered from other sites, probably because this process of roasting did not take place.

Finally, two riverine taxa were identified. *Vitis vinifera* was collected in La Dou and Can Sadurní. It is difficult to establish its economic value given the low number of recovered items, but it could have been gathered for its edible fruits. This taxon was gathered in other areas of Europe like in Northern Italy (Rottoli & Castiglioni 2009) and Slovenia (Tolar et al. 2010).

The second phase of the Middle Neolithic (4000-3300 cal BC) yielded a lower amount of charred remains of wild fruits, as well as a lower number of taxa (n: 10) (Fig. 5.45). Edible weeds and ruderals were badly represented, as well as plants of woodland edges and clearings. Woodland taxa were better represented, especially fruits from maquis vegetation, such as *Olea europaea* at Gavà Mines or *Pistacia lentiscus*, at Bòbila Madurell. Wild olives were found within a funerary context at Gavà Mines (Buxó, Català & Villalba 1991), but the taphonomy of the assemblage is yet to be properly understood (how could charred olive stones end up within a burial context? Why were they mixed with some scanty cereal remains? Were they accidentally present because of the use of the wood of olive tree as fuel?). A cache of charred olive stones deposited inside a pottery vessel was recovered in Les Moreres, in the Valencian Coast, dated to the IIIrd millennium cal BC. This was interpreted as a clear evidence of the gathering and consumption of this fruit at the site (Pérez-Jordà & Carrión 2011). Wild olives, in fact, are among the most frequent wild taxa in the South of the Iberian Peninsula during the Neolithic (Pérez-Jordà, Peña-Chocarro & Morales 2011). The remaining taxa were only identified (mostly) as single finds in one site.

4000-3200 cal BC	Nr. of settlement phases	Nr. of contexts	Nr. of remains in charred state
Weeds and ruderals			
Galium aparine s.l.	2	2	6
Woodland edges and clearings			
Rubus fruticosus	1	1	1
Rubus idaeus	1	1	2
Maquis formations			
Olea europaea var. sylvestris	1	3	177
Pistacia lentiscus	1	1	2
Woodland: diverse			
Abies alba	1	1	2
Corylus avellana	2	2	3
Pinus sylvestris	1	1	1
Quercus sp.	1	1	1
Riverside			
Vitis vinifera subsp. *sylvestris*	1	1	2

Fig. 5.44. Evaluation of the wild taxa identified in the NE of the Iberian Peninsula for the Middle Neolithic period: number of settlement phases and contexts in which they were found and number of remains according to preservation type.

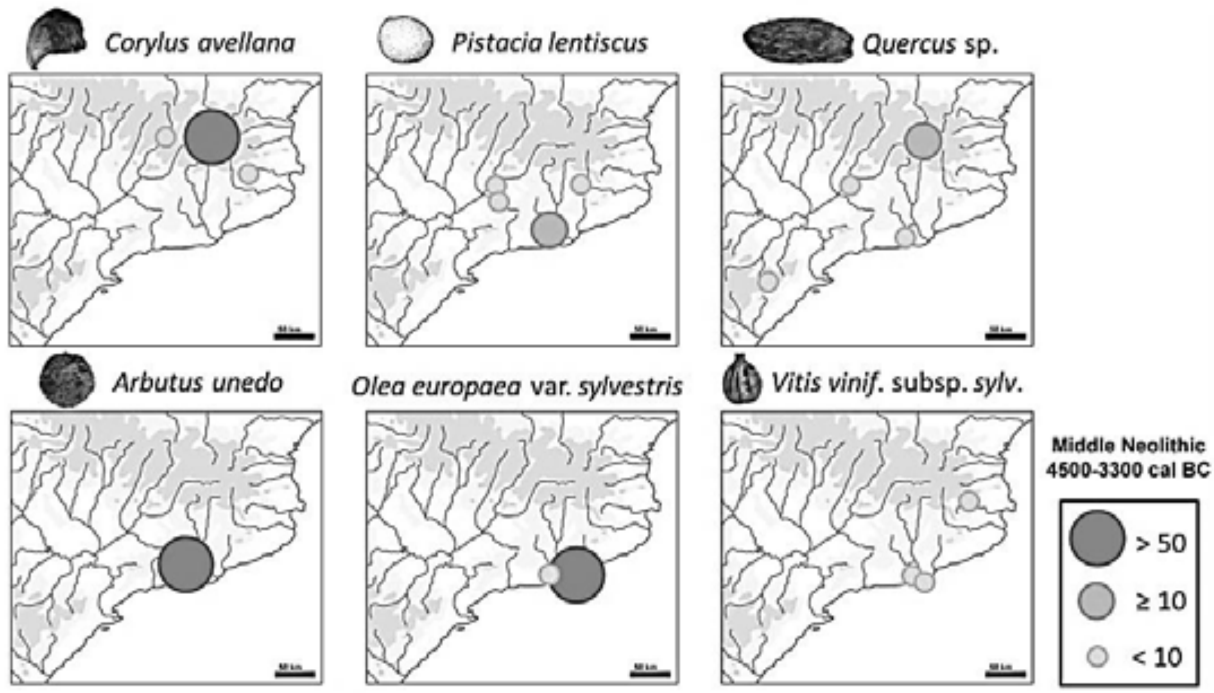

Fig. 5.45. Spatial representation of the total amount of remains recovered per site for the most significant wild taxa of the Early Middle and Middle Neolithic period in the NE of the Iberian Peninsula.

On a regional perspective, a similar pattern to that of the Early Neolithic is observed. The ecological differences between the sites of the central coast and the western plain with respect to those in the north and the southern mountains increased during this phase. On the other hand, large numbers of charred wild fruits were also recovered in the central coast, which was not observed in the previous periods. This might be related to the development of maquis vegetation in this region during the Vth millennium cal BC.

5.3.5. The Late Neolithic (3200-2300 cal BC)

The available data for the Late Neolithic period are meagre (Fig. 5.46). Woodland taxa were most frequently found. *Corylus* and *Vitis* were only identified in the northern areas (Fig. 5.47). The continuity of the presence of wild fruits in anthropogenic contexts indicates that they were probably still exploited. Nevertheless, the lack of archaeobotanical data is an important drawback for the general palaeoeconomic characterization of this period.

3200-2300 cal BC	Nr of settlement phases	Nr of contexts	Nr of remains in charred state
Weeds and ruderals			
Galium aparine s.l.	1	1	6
Maquis formations			
Pistacia lentiscus	1	1	1
Woodland: diverse			
Abies alba	1	1	13
Corylus avellana	3	3	3
Quercus sp.	4	4	6
Riverside			
Vitis vinifera subsp. *sylvestris*	2	2	3

Fig. 5.46. Evaluation of the wild taxa identified in the NE of the Iberian Peninsula for the Late Neolithic period: number of settlement phases and contexts in which they were found and number of remains according to preservation type.

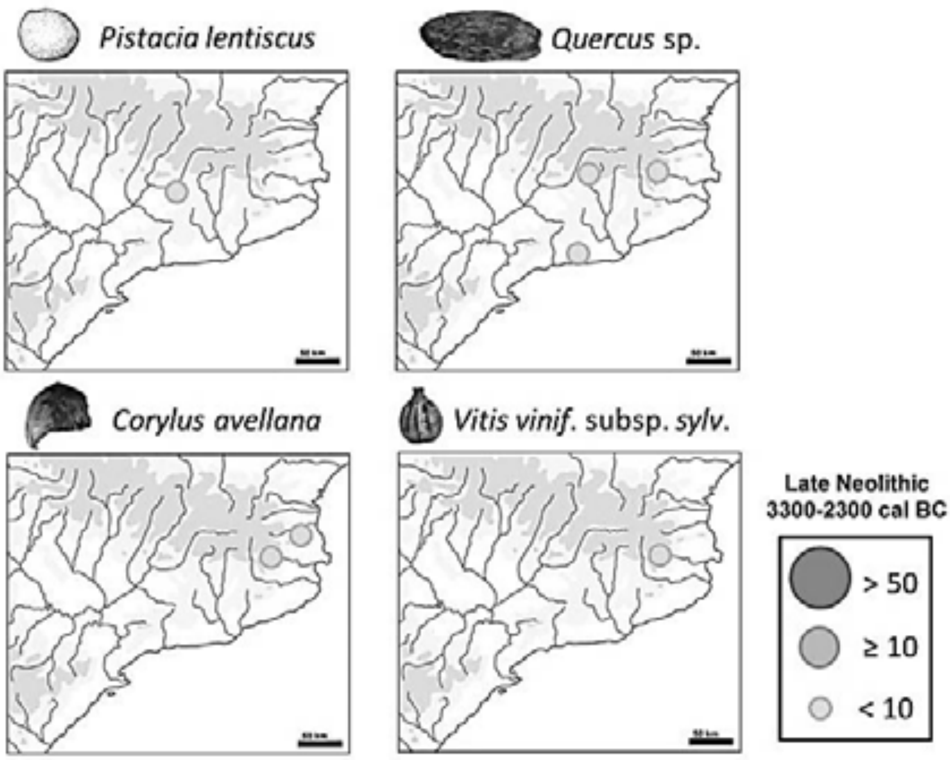

Fig. 5.47. Spatial representation of the total amount of remains recovered per site for the most significant wild taxa of the Late Neolithic period in the NE of the Iberian Peninsula.

5.3.6. Discussion of the results. Wild plant gathering strategies in the NE of the Iberian Peninsula

Wild plant gathering strategies are still difficult to characterize for the region under analysis but the results presented in this work allow some interesting interpretations as well as lines for future investigation.

The interpretation of the charred seed and fruit remains of wild taxa was problematic when considering some of the results from La Draga. Some taxa like *Corylus avellana* and *Prunus spinosa* did not appear in charred state in sector D, while other taxa were only scarcely represented in charred form. Most of the remains were preserved through waterlogging. It is likely that this can be considered as a model for most of the dwelling sites in dry mineral soils. Only a small number of charred remains should be expected on such sites, however this should be enough to support the gathering of wild fruit at the site, especially if their ubiquity is high.

Concentrations of charred wild plant remains were also observed. These mainly involved acorns and hazelnuts, but also strawberry tree and wild olive tree. For the acorns and hazelnuts it is very likely that these concentrations correspond to by-products from roasting. For the strawberry tree (only found in Can Sadurní cave, in the Early Middle Neolithic layers), it is thought that the fruits were taken to the site along with leafy branches to feed livestock. Finally, the concentration of wild olives in Gavà Mines seems to be part of the fuel (this is the best represented taxon in the charcoal record of the same context). These observations lead to the conclusion that the number of items in charred state does not reflect the importance of a resource but its taphonomic history.

The presented results do not allow the detection of major changes in the most important gathered taxa during the Neolithic period in this region. *Quercus* sp., *Corylus avellana, Vitis vinifera* subsp. *sylvestris* and

Pistacia lentiscus were the most commonly gathered taxa. It seems clear, though, that the exploitation of maquis vegetation increases from the second half of the Vth millennium cal BC onwards. An important decrease in the number of remains recovered for the Late Neolithic was observed. This is observed on the whole archaeobotanical record and it is probably due to the insufficient sampling of contexts from this period.

These results also indicate that wild plant gathering strategies during the Neolithic were rather stable at a regional scale and that they had a regional character, conditioned by the environment (the results match those obtained in the charcoal record, see Figs. 2.8, 2.9, 2.10. *Corylus avellana* was only identified in sites above 900 m a.s.l. (both in the north and southern areas) as well as in the north-eastern sector. *Pistacia, Olea* and *Arbutus unedo* were found at the central coast area and *Pistacia* was also present at the Western Plain. *Vitis* was only found in the eastern region, mostly linked to riverine or lakeshore sites. Different species of *Quercus* sp. were identified in the entire studied region.

The sites from the Pyrenean and north-eastern regions have more in common with the sites from the Maestrat mountains than with the in-between lowland areas (both on the coast and further inland). This might not only be visible in the consumed taxa, but also in the way the fruits were processed and stored. Larger amounts of acorns and hazelnuts were only found in mountain areas. Other comparable examples for similar chronologies can be found in Chaves Cave, in the Central Pyrenees, where relatively large amounts of acorns in charred state were recovered (Zapata, Baldellou & Utrilla 2008). It could be interpreted that there was a different wild fruit management strategy in mountain areas. The roasting of acorns and hazelnuts would have probably taken place to facilitate their storage. Such practices were not documented, to date, in any of the sites of the central coast or the western plain of the north-east of the Iberian Peninsula.

Storage of wild fruits is hardly ever detected in dry mineral sites. In some lakeshore sites, where preservation of uncharred shells and acorn bases is possible, some patterns have been detected. For instance, particular households were specialized in the gathering and processing of wild fruits, like in Arbon Bleiche 3 (Hosch & Jacomet 2004) or Torwiesen II in Southern Germany (Maier & Harwath 2011). In this particular case, it is possible that some individuals (or households) were in charge of these resources while others would focus on cereals and herds.

A recent revision of the archaeobotanical findings of hazelnut in the Iberian Peninsula demonstrates that their use is widely attested until the Bronze Age but mainly in the northern regions, where it was available (Berihuete & Antolín in press).

5.3.7. Were wild fruit gathering practices during the Neolithic (5400-2300 cal BC) in the NE of the Iberian Peninsula "simple regular systems"?

The results presented in this work concerning wild fruit management show that, even though agriculture was practiced (probably) in all of the analysed sites, wild fruits were almost always present. One could say that such a pattern allows the conclusion that wild fruits were gathered in all sites and regions. To what extent? Their representation never exceeds that of the cultivated crops, neither in the archaeobotanical record nor in the archaeological record in general. It is for this reason very likely that wild fruits were an important risk-reducing strategy but also a secondary dietary resource. In areas where edible wild fruits were not so easily available (e.g. in the Western Plain), agriculture could have played a prominent role. Nevertheless, we lack the appropriate data for this region.

Wild fruits were not only gathered for human alimentary consumption, but probably also for other purposes. At La Draga, the production of beads on stones of cherries demonstrates that other uses were given to these resources. Besides, wild plants were also used in other economic activities, such as for fuel or as livestock foddering, as mentioned above. Practices like livestock foddering require an important investment of labour and are mostly compatible with intensive models of agriculture. In extensive models, grass can be grown to feed the livestock during winter months, for instance.

The rich record of wild fruits observed in the Pyrenean and Maestrat areas, as well as that of La Draga, is well in accordance with what should be expected in simple regular systems (*sensu* O'Shea 1989), see chapter 2.2.2). The case of Camp del Colomer is paradigmatic, where several roasting pits could have been made in a particular area of the site, showing planification and repetition of these actions. On the other hand, the exploitation of Mediterranean vegetation in the central coast area and in the Western Plain is also interesting for our questions. Such local/regional patterns could be interpreted as a sign of a very local, self-sufficient strategy of wild fruit procurement. This can be considered as supporting evidence for a sedentary, rather autonomous and intensive model of plant husbandry.

5.4. Social and economic implications of the plant food economy during the Neolithic in the NE of the Iberian Peninsula

As shown in chapter 2, the social and economic implications of an intensive mixed farming economy can be of major significance. These will not be reconsidered in detail here (see especially chapters 2.3 and 2.4). The evaluation of the archaeobotanical data presented above brought out two important issues to the discussion of the Neolithic period in the region under study. The first one concerns permanence of field cultivation and the observation of regional differences in the organization of plant food economy. The second one concerns the intensity of crop husbandry practices and their apparent decrease towards the Middle and Late Neolithic.

One of the most significant conclusions of this work is that Neolithic agriculture in the NE of the Iberian Peninsula, as observed for other regions of Europe, was carried out on permanent fields. This fact has important implications for the interpretation of the arrival and spread of agriculture in the region. As mentioned in chapter 2.4.2.2., many authors had used the preconception that the earliest agriculture was not very sophisticated or successful in order to explain the spread of farmers along the territory. According to some authors this would lead to settlements with short lives. Our results reverse these assumptions and put forward new interpretations. Neolithic farmers were experienced farmers who were specialized on self-sufficient intensive farming. This was practiced on an intensive scale and, consequently, villages were small and are difficult to detect archaeologically. The same situation is observed in one mountain site, Camp del Colomer. This would go against the assumption that mountain sites were marginal and linked to herding and wild fruit gathering.

Furthermore, two different agricultural traditions were identified from the onset of farming in the region: one in the north-east and one in the central coast. The central coast crop spectrum is more similar to what has been considered more typical of the Ligurian *Impressa* culture, that is to say, a diversity of crops dominanted by glume wheats (unfortunately, the available archaeobotanical record of the earliest Neolithic phases for the north-western Mediterranean coast is still meagre). In the north-eastern region, there seem to be important connections, at least considering the site of La Draga, with central Italy. This resulted in the larger significance of naked wheat. More archaeobotanical investigations are needed in the Italian coast in order to locate the potential area of influence with certainty.

The existence of networks of villages would be necessary to survive bad yields, and to maintain the system of production and reproduction. This resulted in the development of the regional differences observed in the crops that were cultivated and the wild fruits that were gathered. It was possible to observe that glume wheats and hulled barley remained as crops in the central coast region for around 1400 years at least (from 5400 to 4000 cal BC). On the other hand, glume wheats never had a significant role in the north-eastern area, where free-threshing cereals prevailed during the whole Neolithic period. The north-eastern region seemed more prone to accept novelties from northern regions (Southern France). This is observed in potsherd traditions, funerary practices and also crop assemblages. Thus, naked barley was adopted in the Vth millennium cal BC (while hulled barley was still important in the central coast region) and hulled barley could also have arrived through similar routes during the IIIrd millennium cal BC.

The hypothetical development of agriculture during the Middle Neolithic period in relation to Bòbila Madurell was not confirmed in our analyses. The record obtained for this site was, in general terms, comparable to that of Camp del Colomer, dated c. 400 years older. The spatial distribution of the pits and their archaeobotanical composition was used to propose the existence of a small number of dispersed households, rather than a large village, in Bòbila Madurell. At the same time, no evident rupture with the subsequent period of occupation was observed. The same crops were identified for the Late Neolithic period, for which it seems feasible that some continuity between both phases existed.

The second major issue raised after this work concerns the possibility that farming practices became more and more extensive towards the Late Neolithic. This was based on the meagre weed assemblage of Bòbila Madurell and the apparent reduction of the crop spectrum in favour of hulled barley as the main crop, along with other archaeological evidence like the identification of large scale processing techniques (threshing sledge) in one site of the Iberian Peninsula, or the potential increase in house(hold) size (see chapter 2.4.2.6.). The extensification of agricultural practices is interpreted by some authors as evidence of success in crop husbandry techniques (Stevens & Fuller 2012) or more economic and social stability (Pérez-Jordà & Carrión 2011). But one should take into account other explanations which might not be so optimistically perceived on a social scale. Why would agricultural practices become more extensive? Was it due to a population increase? Or to the cultivation of new soils of lower quality? Or to the appearance of local authorities who managed to control the mode of production? The available archaeological and archaeobotanical data do not allow a reliable interpretation of this issue, but one should take into account that social changes might have occurred along with agricultural extensification. The extensification of agricultural practices is usually linked to the increase of the household size and the nucleation of habitat, as well as the extensification of livestock management strategies. These, as stated by some researchers (Boserup 1967, Boserup 1986, Alonso in press), may end up with the minimization of the female role in productive activities and their reduction to reproductive activities. Men would take the main role in production. Therefore, the extensification of agricultural practices can increase social inequality.

6. Conclusions

This dissertation aimed to answer several questions concerning plant food production in the Neolithic in the NE of the Iberian Peninsula. The aims can be summarized in the following question: was plant food economy of the intensive type? As presented in **chapter 2**, this interpretation was solidly put forward for the Neolithic period in West-Central Europe (Bogaard 2004b) after applying a new method of evaluation of the ecology of weed assemblages (the FIBS method). This question falls into a deeper theoretical background in which intensive agriculture is linked to sedentism, nuclear households, the organization of labour at a household scale and the prominent role of women in plant food production. For the Mediterranean region, some authors proposed, on a theoretical basis, a similar type of agriculture (Bernabeu, Aura & Badal 1993), but more recent work is proposing other models (of the extensive type) mostly without considering any archaeobotanical evidence (e.g. Rojo et al. 2008, Bocquet-Appel et al. 2011, Alday et al. 2012). A critical revision of some of the most significant statements concerning farming in the Neolithic in the NE of the Iberian Peninsula was carried out. This allowed the discussion of inconsistent argumentations, like e.g. the practice of pastoralism.

In order to contribute to such a discussion, an increase of the available archaeobotanical database was necessary. Archaeobotanical analyses of Neolithic sites were carried out by several authors. Nevertheless, large regions and several phases were not covered, and weeds were particularly absent from the record. Therefore, a reliable approach to plant food economy in the area was not possible. In order to provide an accurate approach to these questions, a considerable emphasis was put on the systematization of the methods available to approach site formation processes from the archaeobotanical record. These were outlined in **chapter 3**. For the definition of the methodological basis, existing literature, ethnographic reference data and experimental data were taken into consideration. This had positive and negative outcomes. On the one hand, a whole set of potentially significant variables was presented and some initial hypotheses on their archaeological relevance were put forward. This allowed the accurate description of the seed and fruit assemblages from all the analysed sites. On the other hand, a complex and time-consuming method was designed. This could discourage other researchers to use it. Furthermore, some of the questions aimed to answer with these variables would require a lot more experimentation. This was far beyond the working capacity of this researcher within this dissertation.

Particular emphasis was put on the proposal of quantification methods in order to reach a minimum number of individuals or a comparable counting unit. These methods are also time consuming but they could contribute to a more exact comparison of archaeobotanical and reference ethnographic data, as well as a more systematic comparison between different sites.

The analyses of the archaeobotanical macroremains (seeds and fruits) from 17 archaeological sites (34 settlement phases) from the NE of the Iberian Peninsula dating to the Neolithic period (5400-2300 cal BC) were presented and discussed in **chapter 4**. Even though all periods and areas within the studied region were targeted, it was not possible to obtain representative data for two chronological phases: 5000-4500 cal BC and 3200-2300 cal BC; and two regions: the western plain and the southern areas. Fortunately, the remaining periods and areas were rather well represented and some hypotheses were put forward for the worst represented periods and areas. A total of 107 new taxa were identified and more than 100.000 plant macroremains were retrieved from 213 different contexts, after taking and processing around 1200 samples (over 7000 litres of sediment).

Among the most significant results, one should highlight the site which occupies a large number of pages, the lakeshore settlement of **La Draga** (5300-5000 cal BC). For the first time, adequate sampling and soil processing strategies were applied to the site in order to recover a representative record of both the charred and the waterlogged assemblages. The exceptional archaeobotanical and archaeological record allowed a detailed reconstruction of the crop husbandry techniques and wild fruit management strategies at the site. It was proposed that naked wheat fields would have been sown in rows or with a medium density, they would probably be naturally manured by livestock during late autumn and winter months, they would be harvested above the first culm node (high harvesting), and evidence of domestic scale of crop processing were discussed for one particular burnt storage from sector D. A large diversity of wild fruits was identified, mainly in waterlogged state. This was used to propose that similar conditions of preservation should be expected for dry mineral sites, which would explain the low number of wild fruits in charred state that are usually recovered in these contexts.

Other remarkable studies concern those carried out in **areas for which no previous data were available**, like the sites in the actual province of Lleida, including Sardo Cave (located around 1800 m a.s.l.), El Collet, Pla del Gardelo and Espina C. The results obtained were meagre but they seemed to support general trends observed in the rest of the region, for which this area does not seem to be isolated during the Neolithic period.

The identification of cultivars in all **mountain sites** (Fosca Cave, Camp del Colomer and Sardo Cave) was of major significance, since it opens the door to interpretations towards mixed farming and intensive economies in these areas. Camp del Colomer gave the most concluding results in this sense. Naked barley and pea, along with poppy, flax, and possibly several varieties of wheats, were grown in permanent fields. Woodland resources were well documented in these and other sites in altitude. It was proposed that roasting would have been systematically practiced in mountain areas, which would favour the better representation of wild fruits on these sites. Once more, Camp del Colomer provided concluding evidences in this sense, with the identification of several features as roasting pits, which would have been used either for acorns or hazelnuts.

The database was particularly increased for the **period between 4500 and 3200 cal BC**, with the analyses of Camp del Colomer, Can Sadurní Cave and Bòbila Madurell. These new data allowed detecting the important spread of naked barley in the area during the Vth and the IVth millennia cal BC. The connections between the archaeobotanical record (concerning cultivated crops) between Camp del Colomer and Bòbila Madurell were of major significance and should be further explored from other perspectives. Can Sadurní provided interesting evidence of the systematic collection of leaf foddering for livestock. This hypothesis should be confirmed by a more interdisciplinary approach.

The final evaluation of all the available data for the Neolithic period in the NE of the Iberian Peninsula was performed in **chapter 5.** It was shown that the sampling strategies applied, in general, allowed a good representation of plant food economy in most of the sampled sites. It was observed that, despite the similar number of sampled sites for all periods (around 9 except for the Middle Neolithic for which only five were sampled), insufficient data were obtained for two periods: 5000-4500 cal BC and 3200-2300 cal BC. This is probably due to taphonomic issues which we can not explain at the present state of research (probably a combination of crop processing and storage practices, as well as the strategies of management of residues). Similar observations could be made for two of the areas within the region, for which the available data are still meagre.

Nevertheless, the important amount of data obtained was enough to put forward some interpretations of the **evolution of agriculture** in the area during the Neolithic period. Several regional trends were observed: the central coast region, on the one hand; and the northern areas (Pyrenees and northeastern area), on the other hand. The central coast region presented larger amounts and ubiquities of glume wheats during the VIth and Vth millennia cal BC, while naked wheat prevailed in the northern areas during the first centuries and was later replaced, in the Vth millennium cal BC, by naked barley. This taxon appears as a main crop in the central coast in the IVth millennium cal BC, along with naked wheat. Shortly after, hulled barley seems to replace naked barley in the northern areas of the region. Both shifts observed in the northern areas could have originated through contacts with southern France. While some scanty references of the importance of naked barley in this region are available (Gassin et al. 2010), the data for the late Neolithic were not available to this author, for which any potential relationship between both areas is impossible to demonstrate from the archaeobotanical point of view.

Concerning **crop husbandry strategies**, it was concluded that the evidence for the VIth and Vth millennia cal BC support an intensive gardening type of management of the plots. The data for the last two millennia of the Neolithic are not conclusive. Nevertheless, the expansion of hulled barley and the apparent reduction in the diversity of cultivated legumes during the Late Neolithic would suggest less intensive management practices. This would be in accordance to the evidence of repeated use of pastures in high mountain areas (Cunill 2010, Cunill et al. 2012), which would be indicative of more extensive herding practices.

Wild fruit management during the Neolithic had never been directly addressed for the region under analysis, due to the scanty data available. Slightly over 2000 remains in charred state and 18000 in waterlogged state were identified within this work. This allowed a first approach and some first interpretations of the role of wild fruits in Neolithic economy. The obtained results did not allow detecting major changes in the most important gathered taxa during the Neolithic period in the region: *Quercus* sp., *Corylus avellana, Vitis vinifera* subsp. *sylvestris* and *Pistacia lentiscus* were the most commonly gathered taxa. Differences in their processing techniques according to altitude were observed, as already mentioned. The exploitation of maquis vegetation increases from the second half of the Vth millennium cal BC onwards. An important decrease in the number of remains recovered for the Late Neolithic period was observed. It was interpreted that gathering practices were rather stable at a regional scale, largely conditioned by the environmental availability but also by cultural choices. Wild fruits were present in most of the sites where crops were identified, although the record is somewhat scarcer for the Western Plain area. They probably constituted an important complementary resource that would be regularly obtained, not only for human consumption but possibly also for livestock foddering. These evidences are considered to support a **model of intensive farming economy**.

Several of these conclusions were considered of major significance for archaeological discussions, especially those aspects related to regional traditions and field permanence. The first one would confirm the latest theories concerning the arrival of several groups to the Iberian coast in the earliest phases of the Neolithic (Guilaine & Manen 2007, Bernabeu et al. 2009, García-Atiénzar 2010). The archaeobotanical record of the central coast area seems to be more in accordance with the crop set of the first colonizers of the Ligurian tradition. On the other hand, the record recovered at La Draga is clearly related to central Italy and the other lakeshore site known in the area, La Marmotta (Rottoli 1993). These traditions seem to be maintained over centuries in the central coast, while the northeastern region was more prone to incorporate novelties, like the cultivation of naked barley as the main crop in the Vth millennium cal BC.

The characterization of the plots as permanently cultivated has further implications into the same direction. Against what was assumed by many archaeologists (Rojo et al. 2008, Bocquet-Appel et al. 2011, Alday et al. 2012), agriculture during the first centuries of the Neolithic seems to be of permanent and intensive character. Groups established long-lasting networks in particular regions where they developed their own traditions and cultures. These networks would be necessary for the subsistence of the production and reproduction practices of these populations. The semi-nomadism that is assumed by most authors for these early phases is, thus, not confirmed by the archaeological data.

This dissertation does not solve all the questions initially presented for all the phases and regions under analysis, but supplied hypotheses were proposed and guidelines for future research were outlined. More interdisciplinary works and the application of new research techniques like isotope or ancient DNA analyses will bring new elements into many of the issues raised here. Nevertheless, the continuation of the basic work in archaeobotany is of absolute necessity in order to improve the representativity of the record and approach further social questions which were not possible to answer here (e.g. such as differences in access of households to plant food resources or more detailed spatial approaches to intra-site activities such as crop processing and cooking).

7. Conclusions *(traducció al català)*

Aquest treball pretenia respondre diverses questions en relació a la producció d'aliments d'origen vegetal al Neolític al NE de la Península Ibèrica. Els objectius es poden resumir en la següent pregunta: era la gestió de les plantes amb valor alimentari de tipus intensiu? Tal i com s'ha presentat al **capítol 2**, aquesta interpretació ha estat sòlidament desenvolupada per al Neolític del centre-oest europeu (Bogaard 2004b), després d'aplicar un nou mètode d'avaluació de l'ecologia dels conjunts de males herbes (el mètode conegut com a FIBS). Aquesta qüestió s'imbrica en un rerefons teòric en el qual l'agricultura intensiva es vincula al sedentarisme, a les unitats familiars de tipus nuclear, a l'organització del treball a nivell domèstic i al rol prominent de la dona en la producció d'aliments d'origen vegetal. Per a la regió mediterrània, alguns autors han proposat, sobre bases teòriques, un model similar d'agricultura (Bernabeu, Aura & Badal 1993), però treballs més recents proposen altres models (de tipus extensiu), generalment sense prendre en consideració les evidències arqueobotàniques (Alday et al. 2012, Rojo et al. 2008, Bocquet-Appel et al. 2011). S'ha dut a terme una revisió crítica de les teories més significatives al voltant de les pràctiques agrícoles i ramaderes al NE de la Península Ibèrica. Això ha permès discutir argumentacions de poca consistència com, per exemple, les referents a la pràctica del pastoralisme.

Per tal de contribuir a aquesta discussió es feia necessari incrementar el volum de dades arqueobotàniques. Ja es disposava d'estudis arqueobotànics de jaciments neolítics de la zona realitzats per diversos autors. Malgrat això, grans regions i diverses fases no havien estat investigades amb prou intensitat, i el registre de males herbes era pràcticament nul. Per aquest motiu, una aproximació fiable a la producció de plantes per a l'alimentació no era possible. Per tal de proporcionar una aproximació acurada a aquestes qüestions, s'ha posat èmfasi en la sistematització dels mètodes disponibles per aproximar-nos als processos de formació del registre arqueobotànic des del propi registre. Aquests mètodes han estat descrits al **capítol 3**. Per a la definició de la base metodològica s'ha tingut en consideració la bibliografia disponible, dades de referència de tipus etnogràfic i dades experimentals. Se n'han obtingut resultats positius i negatius. D'una banda, han estat presentades un conjunt de variables potencialment significatives i s'han proposat una sèrie d'hipòtesis explicatives pel que fa a la seva rellevància per a l'arqueologia. Això ha permès dur a terme acurades descripcions dels conjunts de llavors i fruits dels jaciments analitzats. D'altra banda, el mètode dissenyat és complex i requereix d'una gran inversió de temps. Aquest fet podria desanimar altres investigadors d'utilitzar-lo. A més, caldria dur a terme més experimentacions per dirimir totes les qüestions que aquests experiments volien respondre. Resoldre aquestes qüestions, tanmateix, estava fora de la meva capacitat de treball en el marc d'aquesta dissertació.

S'ha incidit particularment en la proposta de mètodes de quantificació per tal d'aconseguir un nombre mínim d'individus o una unitat de comptatge que pugui ser comparable entre estudis. Els mètodes resultants també requereixen d'una certa inversió de temps però contribueixen a fer possible una comparació més exacta entre el registre arqueobotànic i les dades etnogràfiques de referència, així com una comparació més sistemàtica entre els resultats de diferents jaciments.

Les anàlisis de macrorestes arqueobotàniques (llavors i fruits) procedents de 17 jaciments (34 fases d'ocupació) del NE de la Península Ibèrica datats al període Neolític (5400-2300 cal ANE) s'han presentat al **capítol 4**. Malgrat que s'ha intentat analitzar conjunts de tots els períodes i zones dintre del territori en estudi, no ha estat possible aconseguir dades representatives per a dues fases cronològiques: 5000-4500 i 3200-2300 cal ANE; i dues zones dintre de la regió, la plana occidental i el sud. Afortunadament, la resta de zones i períodes es troben relativament ben representats i s'han pogut proposar hipòtesis per als que ho estaven menys. Un total de 107 tàxons han estat identificats i més de 100.000 macrorestes vegetals han estat obtingudes, procedents de 213 contextos arqueològics diferents, després de processar unes 1200 mostres (més de 7000 litres de sediment).

D'entre els resultats més significatius, caldria destacar el jaciment que ocupa un major nombre de pàgines al treball, l'assentament lacustre de **La Draga** (5300-5000 cal ANE). Per primera vegada, una recollida de mostres adequada i un sistema de processat de les mostres idoni han estat aplicats al jaciment per tal de recuperar un registre representatiu, tant pel que fa a les restes carbonitzades com a les que es troben embegudes en aigua. L'excepcional registre arqueològic i arqueobotànic del jaciment ha permès una reconstrucció detallada dels sistemes agrícoles, així com de les estratègies de gestió dels fruits silvestres. S'ha proposat que els camps de blat nu segurament haurien estat adobats de forma natural pels ramats durant els mesos entre finals de la tardor i l'hivern, s'haurien sembrat en fileres o amb una densitat mitjana, deurien ser segats per sobre del primer nus de la palla (una sega alta), i s'haurien processat a nivell domèstic, on també s'emmagatzemarien. S'ha identificat una gran varietat de fruits silvestres, principalment preservats per imbibició. Aquest fet s'ha utilitzat per proposar que condicions de preservació similars s'haurien d'esperar en els jaciments en medis secs, la qual cosa explicaria el reduït nombre de fruits silvestres carbonitzats que s'hi recuperen habitualment.

Altres estudis remarcables són aquells que s'han dut a terme en **àrees per a les quals no hi havia dades** disponibles prèviament, com les dels jaciments localitzats en l'actual província de Lleida com Cova del Sardo (ubicada a uns 1800 m s.n.m.), El Collet, Pla del Gardelo i Espina C. Els resultats obtinguts han estat pobres però semblen donar suport a les tendències generals observades a la regió, cosa que demostraria que aquestes àrees no es trobaven aïllades durant el Neolític.

La identificació de cultius en **jaciments en zones de muntanya** (Cova Fosca, Camp del Colomer i Cova del Sardo) té una gran rellevància, ja que obre la porta a interpretacions sobre l'existència d'una economia agroramadera mixta i economies de tipus intensiu en aquestes àrees. Camp del Colomer ha proporcionat les dades més concloents a aquest respecte. S'han identificat restes d'ordi nu, pèsol, cascall, lli, a més d'altres varietats de blat, que es podrien haver cultivat en camps permanents. Els recursos forestals s'han documentat en abundància en aquests i altres jaciments en altitud. En conseqüència, s'ha proposat que es podria haver practicat la torrefacció de glans i avellanes en aquestes zones de muntanya, fet que incrementaria les possibilitats de preservació de les restes mitjançant la carbonització. Novament, Camp del Colomer ha proporcionat les evidències més sòlides al respecte, amb l'aparició de diverses fosses que s'haurien utilitzat per rostir glans i avellanes.

La base de dades disponible s'ha incrementat considerablement per al **període entre el 4500 i el 3200 cal ANE**, amb les anàlisis de Camp del Colomer, la Cova de Can Sadurní i Bòbila Madurell. Aquestes noves dades han permès detectar la important distribució de l'ordi nu en aquesta àrea durant el Vè i el IVt mil·lenni cal ANE. Les connexions entre el registre arqueobotànic (en referència a les plantes cultivades) entre Camp del Colomer i Bòbila Madurell són especialment significatives i haurien de ser explorades des d'altres perspectives. La Cova de Can Sadurní ha aportat evidències interessants sobre la recol·lecció de brancatge per a l'alimentació del bestiar, que també haurien de ser investigades des d'una perspectiva interdisciplinar.

L'avaluació final de totes les dades disponibles per al Neolític al NE de la Península Ibèrica s'ha exposat al **capítol 5**. S'ha mostrat que les estratègies de mostreig aplicades, en general, permeten una bona representació de la gestió dels recursos alimentaris d'origen vegetal en la majoria dels jaciments estudiats. S'ha observat que, malgrat que es disposa d'un nombre similar de jaciments mostrejats per a cada període (al voltant de 9, excepte per al Neolític Mitjà, amb només 5 jaciments estudiats), les dades són insuficiens per a dos períodes: 5000-4500 i 3200-3000 cal ANE. Aquest fet es deu probablement a qüestions tafonòmiques que no podem explicar en l'estat actual de la recerca (probablement una combinació entre les tècniques de processat i emmagatzematge, així com del tipus de gestió dels residus). Observacions similars s'han fet al voltant de dues àrees concretes dintre de la regió, la plana occidental i l'àrea sud, per a les quals les dades disponibles són encara escadusseres.

Malgrat tot, la important quantitat de dades obtingudes ha estat suficient per proposar interpretacions sobre **l'evolució dels cultius** a l'àrea durant el període Neolític. S'han observat diverses tendències per zones dintre de la regió: la costa central, d'una banda; i les àrees nord (Pirineus i el nord-est), per l'altra. La costa central presenta un registre abundant de blats vestits durant el VIè i Vè mil·lennis cal ANE, mentre que el blat nu té un domini a les àrees del nord durant els primers segles i és substituït, a partir del Vè mil·lenni per l'ordi nu. Aquest tàxon sembla ser el principal cultiu durant el IV mil·lenni cal ANE, juntament amb el blat nu. Poc més tard, l'ordi vestit sembla que podria començar a substituir l'ordi nu a les àrees del nord. Els dos canvis observats a les àrees del nord podrien haver-se originat a través de contactes amb els territoris del sud de França. Tot i que hi ha algunes referències a la importància de l'ordi nu en aquesta regió (Gassin et al. 2010), no he trobat referències a dades del Neolític final, motiu pel qual qualsevol relació potencial entre les dues àrees és impossible de demostrar des del punt de vista de l'arqueobotànica.

Pel que fa a la **gestió dels cultius**, s'ha conclòs que les evidències per al VIè i Vè mil·lennis cal ANE indiquen que existia una gestió intensiva dels camps de tipus hortícola. Les dades per als dos darrers mil·lennis del Neolític no són concloents. Malgrat tot, l'expansió de l'ordi vestit i l'aparent reducció de la diversitat de lleguminoses cultivades durant el Neolític final suggeriria pràctiques agrícoles menys intensives. Aquest fet es trobaria en consonància amb les evidències de l'aprofitament repetitiu de pastures d'alta muntanya durant aquesta fase (Cunill 2010, Cunill et al. 2012), el qual seria un indicador de l'existència de pràctiques ramaderes de tipus més extensiu.

La gestió dels fruits silvestres durant el Neolític no havia estat mai adressada directament per a la regió en estudi, degut a l'escassetat de restes disponibles. En aquest treball s'han identificat més de 2000 restes carbonitzades i 18000 preservades per imbibició, el que ha permès realitzar-hi una aproximació i fer algunes primeres interpretacions sobre el rol dels fruits en l'economia neolítica. Els resultats obtinguts no han permès detectar grans canvis en els tàxons recol·lectats més significatius durant tot el període a la regió en estudi: *Quercus* sp., *Corylus avellana, Vitis vinifera* subsp. *sylvestris* and *Pistacia lentiscus*. S'han observat diferències en les tècniques de processat en funció de l'alçada a la qual es troben els assentaments, com ja s'ha esmentat. L'explotació de les formacions vegetals de màquia creix a partir de la segona meitat del Vè mil·lenni cal ANE. Hi ha una important reducció del registre al Neolític final. S'ha interpretat que les pràctiques de recol·lecció es mantindrien estables a escala regional, principalment condicionades per l'oferta ambiental, així com per les seleccions culturals. S'han documentat fruits silvestres a la majoria d'assentaments on s'han identificat restes de cultius, tot i que el registre és més reduït a la plana occidental. Probablement van constituir una aportació important com a recurs complementari, el qual s'obtindria regularment no només per a l'alimentació humana sinó també per a la del bestiar. Aquestes evidències donen suport a un **model de gestió dels recursos alimentaris d'origen vegetal de tipus intensiu.**

Algunes d'aquestes conclusions són de gran rellevància per a les discussions arqueològiques, especialment en referència als aspectes relacionats amb les tradicions regionals i la permanència dels camps (i, per extensió, dels assentaments). La primera confirmaria les teories més recents referents a l'arribada de diversos grups a la costa peninsular en la fase inicial del Neolític (García-Atiénzar 2010, Guilaine, Manen 2007, Bernabeu et al. 2009). El registre arquebotànic de la costa central sembla coincidir amb el que s'atribueix als primers colonitzadors de la tradició Ligur. D'altra banda, el registre recuperat a La Draga, es troba clarament relacionat amb la Itàlia central i amb l'altre (i únic) jaciment lacustre que es coneix a l'àrea, La Marmotta (Rottoli 1993). Aquestes tradicions semblen mantenir-se durant segles a la costa central, mentre que les àrees nord podrien ser més receptives a l'hora d'adoptar novetats, com el cultiu de l'ordi nu durant el Vè mil·lenni cal BC.

La caracterització dels camps com a permanents té també implicacions en la mateixa direcció. En contra del que s'havia assumit per part de molts arqueòlegs (e.g. Alday et al. 2012, Rojo et al. 2008, Bocquet-Appel et al. 2011), l'agricultura sembla ser de caràcter permanent i intensiu durant els primers segles del Neolític. Els grups estableixen xarxes de llarga durada en regions particulars on desenvolupen les seves pròpies tradicions i cultures. Aquestes xarxes serien necessàries per a la supervivència dels sistemes de producció i reproducció d'aquestes comunitats. La inestabilitat de les estructures i els territoris d'hàbitat que molts autors proposen per a aquestes fases inicials no està, doncs, confirmat per les dades arqueològiques disponibles.

Aquest treball no ha trobat una solució a totes les preguntes que s'han presentat al seu inici, però ha permès formular hipòtesis amb fonamentació i proporcionar directrius per a la recerca futura. La realització de treballs de caire més interdisciplinari i l'aplicació de noves tècniques com l'anàlisi d'isòtops estables o d'ADN antic aportarien nous elements als diversos debats oberts en aquest text. Això no obstant, cal continuar amb el treball arqueobotànic de base per tal de millorar la representativitat del registre i abordar altres qüestions socials que no s'han pogut respondre aquí, com ara les diferències en l'accés als productes alimentaris d'origen vegetal per part de cada llar, o aproximacions espacials a més petita escala que permetin investigar les activitats que es duien a terme dintre dels assentaments, com, per exemple, el processament de la collita i el processament culinari.

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