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Crop diversity and storage structures in the settlement of Crastoeiro (Northwest Iberia): new approaches*

Diversidad de cultivos y estructuras de almacenaje en el poblado de Crastoeiro (Noroeste de la Península Ibérica): nuevos enfoques

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ABSTRACT

The Iron Age site of Crastoeiro (Mondim de Basto, Vila Real, North Portugal) revealed an interesting set of pits opened in the bedrock. Soil samples were collected from these and a carpological study was carried out in order to obtain information about crop diversity and characterize the storage structures. Nineteen samples from 4 pits yielded important results for the understanding of agriculture and storage practices in Crastoeiro. Spelt wheat (*Triticum spelta*) was the predominant crop in the studied pits. The presence of spikelets suggests grain was stored partially processed, which might have been a strategy to allow long-term storage. Broomcorn millet (*Panicum miliaceum*), hulled barley (*Hordeum vulgare*), rye (*Secale cereale*) and foxtail millet (*Setaria italica*) were also found. Radiocarbon dates on rye grains are the oldest in the Iberian Peninsula, suggesting rye was introduced in the region in the end of the Iron Age, at the time of early Roman contacts. In a regional perspective the results from Crastoeiro highlight the use of undemanding crops well adapted to harsh environments, including cold climate and poor soils.

RESUMEN

*El yacimiento de la Edad del Hierro de Crastoeiro (Mondim de Basto, Vila Real, Norte de Portugal) reveló un interesante conjunto de fosas excavadas en la roca. De su interior se recogieron muestras de sedimento y se realizó un estudio carpológico con el objetivo de obtener información sobre la diversidad de cultivos y prácticas agrícolas y de caracterizar las estructuras de almacenamiento. Los resultados del estudio de 19 muestras procedentes de 4 fosas son relevantes para la comprensión de la agricultura y las prácticas de almacenaje en el Crastoeiro. La espelta (*Triticum spelta*) fue el cultivo predominante en el interior de las fosas estudiadas. La presencia de espiguillas sugiere que el grano se almacenó parcialmente procesado, o bien se trató de una estrategia que permitía un almacenaje a largo plazo. Se han encontrado otros cereales, entre ellos, el mijo (*Panicum miliaceum*), la cebada vestida (*Hordeum vulgare*), el centeno (*Secale cereale*) y el panizo (*Setaria italica*). Fechas de radiocarbono a partir de granos de centeno mostraron que éstos son los más antiguos de la Península Ibérica, lo que sugiere que el centeno se introdujo en la región hacia el final de la Edad del Hierro, en el marco de los primeros contactos con los romanos. Desde una perspectiva regional los resultados obtenidos en el yacimiento de Crastoeiro se corresponden con el uso de cultivos poco exigentes, bien adaptados a entornos adversos, incluyendo los climas fríos y suelos pobres.*

Key words: Iron Age; Carpology; Agricultural Practices; Storage Strategies; NW Iberia.

Palabras clave: *Edad del Hierro; Carpología; Prácticas agrícolas; Estrategias de almacenamiento; Noroeste de la Península Ibérica.*

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1. INTRODUCTION

The hillfort of Crastoeiro (Mondim de Basto) is a well-known archaeological site located in Northern Portugal. Due to its Iron Age chronological sequence and associated artifacts (Dinis 2001) and to the Neo-Calcolithic Atlantic rock art respected and used by the Iron Age inhabitants (Rey Castiñeira and Soto-Barreiro 2001; Dinis and Bettencourt 2009) the site has been widely cited in studies focusing on the Iron Age of Northwest Iberia (*e.g*., Queiroga 2003; Bettencourt 2005; Dinis 2009a). In addition, Crastoeiro has been frequently mentioned in regional syntheses as an example of storage practices due to the presence of Iron Age pits with cereals (*e.g*., Bettencourt[1]; Oliveira[2]; Tereso 2012). The importance of the pits from Crastoeiro was well understood from the moment these structures and their carpological remains were first published (Dinis 1993-1994; Dinis 2001; Pinto da Silva 2001) because, although pits were found in other sites, Crastoeiro was one of the first Iron Age hillforts in the region where crops were actually found inside the pits and studied by archaeobotanists. (Pits with carpological remains were later found at S. João de Rei (Póvoa de Lanhoso): Bettencourt 2000, 2005). The presence of direct evidence for agriculture in well-defined and dated archaeological contexts makes Crastoeiro a determinant site in addressing Iron Age agriculture in Northwest Iberia (Bettencourt 2001; Tereso 2012).

Pits are not the only type of storage facilities found in Iron Age Northwest Iberia. Crops and wild fruits were also recovered in wattle and daub storage structures at As Laias (Cenlle) (Tereso 2012; Tereso, Ramil-Rego, Álvarez González *et al*. 2013) and possibly Castrovite (A Estrada) (Carballo Arceo 1998; Rey Castiñeira *et al*. 2011) and in *horrea* at Castelinho (Torre de Moncorvo) (Santos *et al*. 2012) and Quinta de Crestelos (Mogadouro) (Pereira *et al.* 2015). The carpological study from these *horrea* is ongoing.

It is clear that Iron Age agriculture was based on a significant diversity of crops, particularly cereals (Dopazo Martínez *et al.* 1996; Tereso 2012). Hulled wheat (*Triticum spelta*, *Triticum dicoccum* and, more rarely, *Triticum monococcum*) has been found in several sites in the region. Naked wheats include *Triticum aestivum*, identified through rachis fragments at As Laias (Tereso, Ramil-Rego, Álvarez González *et al.* 2013), as well as *T. aestivum/durum/turgidum* grains. Hulled barley (*Hordeum vulgare* subsp. *vulgare*) is frequent in Iron Age sites, but naked barley (*Hordeum vulgare* var. *nudum*) is rare. Broomcorn millet (*Panicum miliaceum*) is also one of the main crops in the region.

Among the pulses, only *Vicia faba* and *Pisum sativum* have been retrieved to date and the latter is not very common (Dopazo Martínez *et al.* 1996; López-Merino *et al*. 2010; Teira-Brión 2010; Tereso 2012). *Quercus* acorns are the only remains of wild seeds and fruits that appear consistently in the Iron Age sites. The role of acorns in human subsistence has been frequently addressed (Oliveira *et al.* 1991; Mason 1992; Teira-Brión 2010; Tereso *et al*. 2011; Šálková *et al.* 2012) and it is widely assumed that these were important to human subsistence, but within a strategy mostly based on domestic plants and animals. The variety of crops corresponds to a need for functional diversity, so that it is quite common to find in the same sites crops with different life-cycles and necessities in terms of nutrients, water and sun exposure and resistance to drought or frost, among other factors (Tereso 2012). Data available for the Roman Period derives mostly from 1st century BC and 1st century AD levels in hillforts, that is, an early stage in the Romanization of the region and suggests a high degree of continuity in terms of crops between the Iron Age and the Roman Period (Tereso, Ramil-Rego and Almeida-da-Silva 2013; Tereso, Ramil-Rego, Álvarez González *et al.* 2013).

However, interpretive models regarding agricultural activities, plant consumption and storage are still based in few archaeological sites and many of these provided scarce carpological remains. New carpological studies should be a priority in the Iron Age archaeology of Northwest Iberia.

The existence of unstudied pits in Crastoeiro stands out as an opportunity to make new advances in this matter. The early carpological studies of Crastoeiro were carried out by Pinto da Silva (Dinis 2001; Pinto da Silva 2001) and focused exclusively on one pit. Other pits with abundant plant macroremains were found in later field campaigns and remained unstudied until 2015, when one of the authors (LS) started this study. Considering the relevance of Crastoeiro and their previous carpological and archaeological studies mentioned above, the main goal of this paper is to present the results of this study and to discuss the characterization of storage practices and crop diversity in the site and their significance on a regional level.

The carpological study here presented is not a revision of previous carpological data. Data from the unpublished storage pits was studied in detail, following new analytical and interpretative approaches, not available in the first study. These aimed at getting new information concerning the seeds and fruits that

[1] Bettencourt, A. M. S. 1999: *A paisagem e o homem na bacia do Cávado durante o II e o I milénios AC.* PhD thesis. Universidade do Minho. Braga.

[2] Oliveira, M. 2000: *O registo paleocarpológico do NO peninsular entre o IIIº e o Iº milénios a.C. Contributo para o estudo da alimentação pré e proto-histórica.* MSc thesis. Universidade do Minho. Braga.

were consumed by local communities, as well as their processing, management and storage. New radiocarbon dates permitted a revision of the storage pit chronology.

2. THE SITE

The settlement of Crastoeiro is located on the municipality of Mondim de Basto, district of Vila Real, in Northern Portugal (Fig. 1). It is placed on a spur at the base of the slope of Monte Farinha (7.9294 W / 41.4147 N), 453 m high, in the left margin of the river Tâmega, a tributary of Douro basin. Its position provides an excellent control over a section of the Tâmega valley and over small valleys formed by several watercourses that rise in Monte Farinha.

The presence of domestic and defensive structures, the reutilisation of old rock engravings and the ceramic material at the surface triggered the excavations, which confirmed the site's great scientific potential. Four phases of excavation (1985-1987, 1997-1999, 2005-2009 and 2016-2017) were coordinated by António Pereira Dinis. The fieldwork had the purpose of protecting and promoting the site as well as characterizing its occupation and long-term history.

Up to now, three main occupation phases were detected at Crastoeiro, covering a time-span from the 4th century BC to the 1st century AD. Radiocarbon dates support this chronology (Tab.1) (Dinis 2001, 2009b).

The first moment of occupation (4th century BC to the 2nd century BC) was characterized by the presence of huts built with perishable materials, clay floors, hearths, and several pits opened on the granitic bedrock (Dinis 2001). In the second phase (2nd century BC to the 1st century BC) a stone wall was raised and other

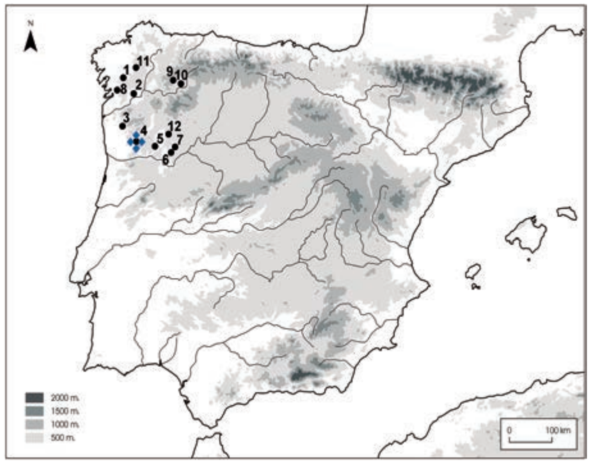

Fig. 1. Sites in Northwest Iberia, mentioned in the text: 1. Castrovite (A Estrada); 2. As Laias (Cenlle); 3. S. João de Rei (Póvoa de Lanhoso); 4. Crastoeiro (Mondim de Basto); 5. Crasto de Palheiros (Murça); 6. Castelinho (Torre de Moncorvo); 7. Crestelos (Mogadouro); 8. Penalba (Campo Lameiro); 9. El Castrelín (Borrenes); 10. La Corona (Barjas); 11. Castro Pedro (Melide); 12. Terronha de Pinhovelo (Macedo de Cavaleiros).

domestic structures were built of stone, coexisting with huts made in perishable materials (Dinis 2001). The houses showed some architectural variability: circular houses with and without vestibules, houses with irregular plant and sub-rectangular houses with rounded corners all were in use at the same time (Dinis 2001).

In the last phase, from the 1st century BC to the 1st century AD, there are clear signs of Roman influence, namely rectangular houses, Roman material such as fragments of amphora, *sigillata*, glass, and Roman denarii (Dinis 2001). However, like other archaeological

Structure	Lab. Reference	Data BP	Date Cal. BC-AD (1 σ)	Date Cal. BC-AD (2 σ)	Material
Pit V	Ly-4936	2175 ± 40	356-172 BC	366-111 BC	Charcoals and seeds (not identified)
Pit V	ICEN - 45	2210 ± 45	360-205 BC	387-174 BC	
Pit X	Beta - 239988	2120 ± 70	349-47 BC	363 BC-5 AD	Seeds (not identified)
Pit XVI	Beta - 239989	2080 ± 40	163-49 BC	201 BC-5 AD	Charcoals (not identified)
Pit XVIII.1	Beta - 239990	2210 ± 40	359-206 BC	382-184 BC	Acorns
Pit XVIII.1	D-AMS 016318	2132 ± 31	204-105 BC	351-53 BC	Rye grains
Pit XVIII.2	D-AMS 011304	2027 ± 25	52 BC-6 AD	103 BC-30 AD	Rye grains
Hut II	Beta 154646	2050 ± 60	162 BC-5 AD	341 BC-74 AD	Acorns
Hut VI	Beta 154645	2210 ± 60	361-204 BC	398-112 BC	Charcoals (not identified)

Tab. 1. Radiocarbon dates from Crastoeiro (Mondim de Basto). Calibration Oxcal 4.2 software, Intcal 13 calibration curve (Reimer *et al.* 2013).

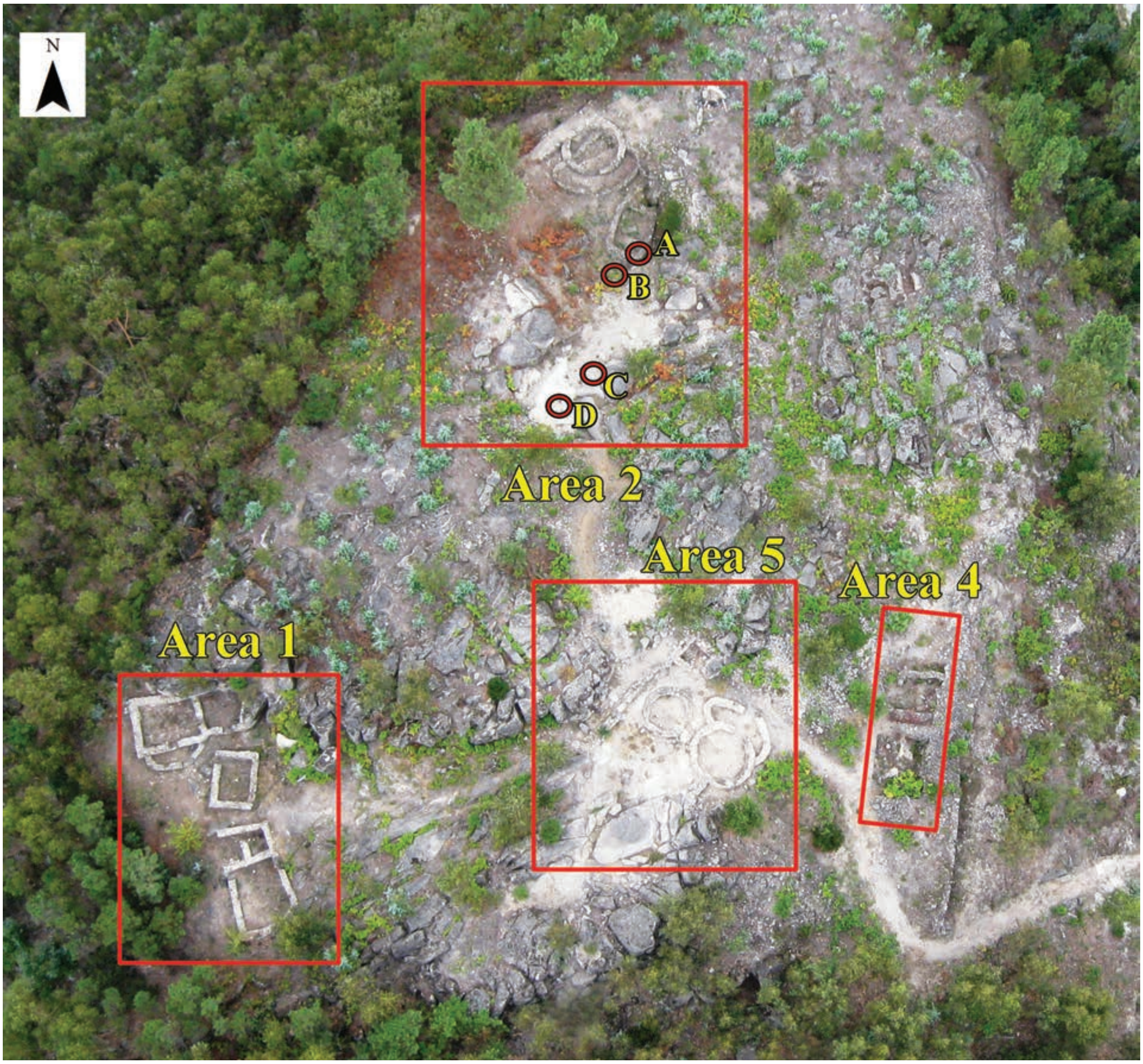

Fig. 2. Crastoeiro (Mondim de Basto). Location of the areas and the pits mentioned in the paper. Pits: A- Pit IV; B- Pit V; C- Studied pits; D- Other pits. Photo credit: António Dinis (in colour in the electronic version).

sites in the region, this may have been a short-term occupation preceding the abandonment of the settlement (Dinis 2001).

Previous archaeological studies included archaeobotanical analyses. Charcoal analyses were carried out by Isabel Figueiral[3]. Data from the first occupation phase derives from Pit V (Fig. 2B) in Area 2 (located in the quadrant northwest of the acropolis); remains from the second phase were retrieved in Area 4, next to the wall; and charcoal from the Roman phase came from two hearths in Area 1 (a small platform located south of the acropolis (Fig. 2). Data differ in each context but overall there is a predominance of *Erica*, Leguminosae and deciduous *Quercus* which led to the conclusion that landscape surrounding the settlement was deeply humanized and was most likely characterized by the predominance of shrubby formations (Dinis 2001; Figueiral 2001).

The first carpological analyses were carried out by Pinto da Silva (Dinis 1993-1994; Pinto da Silva 2001).

[3] Figueiral, I. 1990: *Le nord-ouest du Portugal et les modifications de l'ecosysteme, du Bronze final à l'époque romaine, d'aprés l'anthracoanalyse de sites archéologiques.* PhD thesis. Université des Sciences et Techniques du Languedoc. Montpellier.

He only studied the grains recovered in Pit V (Fig. 2B) from the oldest Iron Age level of the site. Most grains were identified as *Triticum turgidum* spp. *parvicoccum* (Kislev) Kislev but great amount of grains from *Panicum miliaceum* were also retrieved. *Triticum dicoccum* and *Avena* were rare, the same as *Vitis* pips.

Carpological data available from the second Iron Age level is restricted to the presence of *Quercus* acorns, which were used for radiocarbon dating (Dinis 2001).

3. MATERIALS AND METHODS

3.1. Studied contexts and sampling strategy

Area 2 is located in the northwest part of the settlement, which was probably used by human communities throughout the whole time-span archaeologically documented at the site, i.e., the three occupation phases described above. Several structures were identified here, including one circular house a with vestibule and another sub-rectangular one with rounded corners (Dinis 2001; Dinis and Bettencourt 2009). Inside this last one, a small pit –Pit IV (Fig. 2A)– was identified and excavated, but no plant remains were recovered. Plant remains were recovered in Pit V (Fig. 2B) and archaeobotanical studies were carried out (see above). This pit was located inside a badly-preserved, difficult to interpret structure with an irregular outline.

In the 2005 and 2006 campaigns, other pits were found in Area 2. These are cut in the granitic bedrock, on a higher platform located south of pits IV and V and the houses mentioned above (Fig. 2C). This platform is a reasonably flat area where surface runoff would be easier to control. No relationship with housing or other structures was perceived during the fieldwork. However, it is surrounded by many rock outcrops engraved with Atlantic rock carvings (Fig. 3).

This study focuses on the carpological content of some of these pits. Other pits (Fig. 2D), whose function is still unknown, were identified in the area but no botanical remains were recovered.

During the archaeological work, there were problems in differentiating the pits: some were opened cutting previous ones, making it difficult to know the limits of each structure. Thus, it is not possible to know the exact shape of some of the pits, although clearly some had depths and mouths with different dimensions.

Seventeen soil samples from ten stratigraphic units and four pits were studied and two other samples were handpicked during the excavation. In the field, some of the samples were sieved and others floated, using 0.2 mm and 0.5 mm meshes. Sadly, the original volume of the samples was not recorded on site (Tab. 2).

– Pit XVIII: filled with nine different deposits showing distinct texture and colour. In this work we studied six samples from four of deposits. Unfortunately, we don´t know the exact shape and size of this pit.

– Pit XVIII.1: eight samples from two stratigraphic units were studied. The pit had circular mouth (0.74 m diameter), 0.80 m depth and concave walls. This was the best preserved pit (Fig. 4).

– Pit XVIII.2: one sample was collected and studied from the single stratigraphic unit of this pit. Its shape and size are unknown.

– Pit XVIII.5: four samples from three stratigraphic units were studied. It was the deepest pit, but like Pit XVIII and XVIII.2 we don´t know its shape and size.

Fig. 3. Crastoeiro (Mondim de Basto). Area 2. Location of the pits in study, surrounded by many rock outcrops engraved with Atlantic rock carvings (in colour in the electronic version).

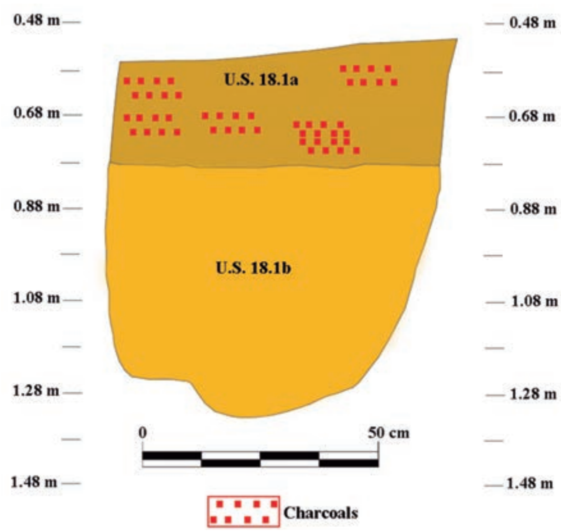

Fig. 4. Crastoeiro (Mondim de Basto). Area 2. Pit XVIII.1 (East profile) (in colour in the electronic version).

					Weight		
Sample	U.S.	Pit	Sediment Process	Sub-sample	4 mm	Riffle box	Sorting
1	18a	XVIII	No information	No			
2	18b	XVIII	No information	No			
3	18c	XVIII	Sieved	Yes	38 g	87 g	9,94 g
4	18c	XVIII	Sieved	Yes	43 g	111 g	13,78 g
5	18c	XVIII	No information	Yes	42 g	116 g	45,98 g
6	18d	XVIII	Sieved	Yes	34 g	86 g	21,10 g
7	18.2a	XVIII.2	Sieved	Yes	62 g	261 g	36 g
8	18.5a	XVIII.5	No information	No			
9	18.5a	XVIII.5	Manual collection	No			
10	18.5a´	XVIII.5	Floating	No			
11	18.5b	XVIII.5	Floating	No			
12	18.1a	XVIII.1	No information	Yes	31 g	130 g	29 g
13	18.1a	XVIII.1	No information	Yes	37 g	167 g	9,95 g
14	18.1a	XVIII.1	Sieved	Yes	426 g	266 g	16,34 g
15	18.1a	XVIII.1	No information	Yes	472 g	198 g	11,94 g
16	18.1b	XVIII.1	Sieved	Yes	363 g	161 g	9,56 g
17	18.1b	XVIII.1	Manual collection	No			
18	18.1b	XVIII.1	No information	Yes	257 g	267 g	14,15 g
19	18.1b	XVIII.1	No information	Yes	316 g	200 g	24,67 g

Tab. 2. Crastoeiro (Mondim de Basto). Area 2. Information about the origin of the samples and their processing.

3.2. Laboratory methods

The size of the lighter fractions varied considerably and larger samples were subsampled with a "riffle box", the method that better ensures the representativeness of the subsamples (Van der Veen and Fieller 1982).

The laboratory work was carried out at CIBIO (Research Center in Biodiversity and Genetic Resources) member of InBIO (Research Network in Biodiversity and Evolutionary Biology Associate Laboratory).

The taxonomic diagnosis was performed using a stereoscopic microscope with the aid of reference collections of the University of Porto Herbarium (PO) and CIBIO, as well as through comparison with morphological atlases and other specialized bibliography (Beijerinck 1947; Castroviejo 1986-2012; Hillman *et al*. 1996; Buxó 1997; Marinval 1999; Jacomet 2006; Nesbitt 2006; Tereso 2007, 2012; Zohary *et al.* 2012).

Spikelets and glume bases of *Triticum spelta* and *Triticum dicoccum* were distinguished according to the criteria of G. Hillman *et al.* (1996), R. Buxó (1997) and S. Jacomet (2006). Sometimes the distinction was difficult and a designation *T. dicoccum/spelta* was adopted. Small chaff fragments were identified at genus level.

A similar procedure was followed in the case of millet grains. The designation *Panicum/Setaria* was adopted whenever distinction was not possible but grain morphology suggests one of these two species. Designation at tribe level – Panicoideae – was used when grains could not be securely ascribed to one of the two already mentioned species. Panicoideae may include domestic or wild species.

For this work complete caryopses, seeds and fragments with scutellum or hilum, respectively, were considered units. Spikelet bases were considered complete provided the two glume bases were preserved. Single glume bases were counted as a half spikelet base. Rachis fragments were considered separately. Spikelets and grains were accounted separately for comparison purposes (see below), even when spikelets were found with their respective grains.

Since a large quantity of *Triticum* chaff was recovered, a test was carried out to find the proportion between spikelet bases and grains inside the pits. Two half bases represented one entire base. Results are presented in form of a ratio half-spikelets:grains with values rounded to one decimal place (see below).

4. RESULTS

Results are presented in tables 3, 4 and figure 5. The samples collected in the pit XVIII.5 provided few carpological remains. Considering results do not differ from other pits these are not represented graphically in the figure 5.

The carpological results showed a predominance of cereals (Tab. 3). In the case of the grains, spelt is largely dominant (Fig. 5A). This result is homogenous throughout the studied samples. Grains from other cereals were recovered, namely broomcorn millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), hulled barley (*Hordeum vulgare* subsp. *vulgare*) and rye (*Secale cereale*).

Due to their fragmentation, a considerable amount of grains was identified at the tribe level, i.e. Triticeae and Panicoideae. The good preservation of other remains, more fragile than grains (see below), together with the visually fresh aspect of the sections in the fragmented areas suggests fragmentation occurred mostly during the excavation and processing of samples.

Broomcorn millet is the second most represented cereal, but very far from the amount of spelt grains recovered. Grains of broomcorn millet are sometimes found with lemma and palea, in other cases millet grains are found in small agglomerations with barley. Few examples of oxtail millet (*Setaria italica*) were identified.

Secale cereale was regulary present, pit XVIII.2 providing the sample with more grains (Tab. 3). This cereal is not common in the carpological record of the region and most authors consider that the introduction of rye in Northwest Iberia, as well as in the rest of the Iberian Peninsula, occurred in the Roman period (Ramil-Rego and Fernández Rodríguez 1999; Alonso 2005; Buxó 2005; Tereso 2012; Tereso, Ramil-Rego and Almeida-da-Silva 2013). Its presence in the pits was, therefore surprising, considering a radiocarbon sample on *Quercus* sp. acorns from Pit XVIII.1 (Dinis 2009b) gave a date in the 4th or 3rd century BC (Tab. 1). The same pit also provided grains of rye. In the context of this study two radiocarbon dates were obtained over grains of rye from Pit XVIII.1. These indicate a date in the 1st century BC (Tab. 1, see discussion section).

Grains of *Avena* are not considered among the cultivated species. Although the cultivation of *Avena* seems to date back to the Iron Age (Buxó 1997; Tereso 2012; Tereso, Ramil-Rego, Álvarez González *et al.* 2013), some grains in Crastoeiro were found with floret bases

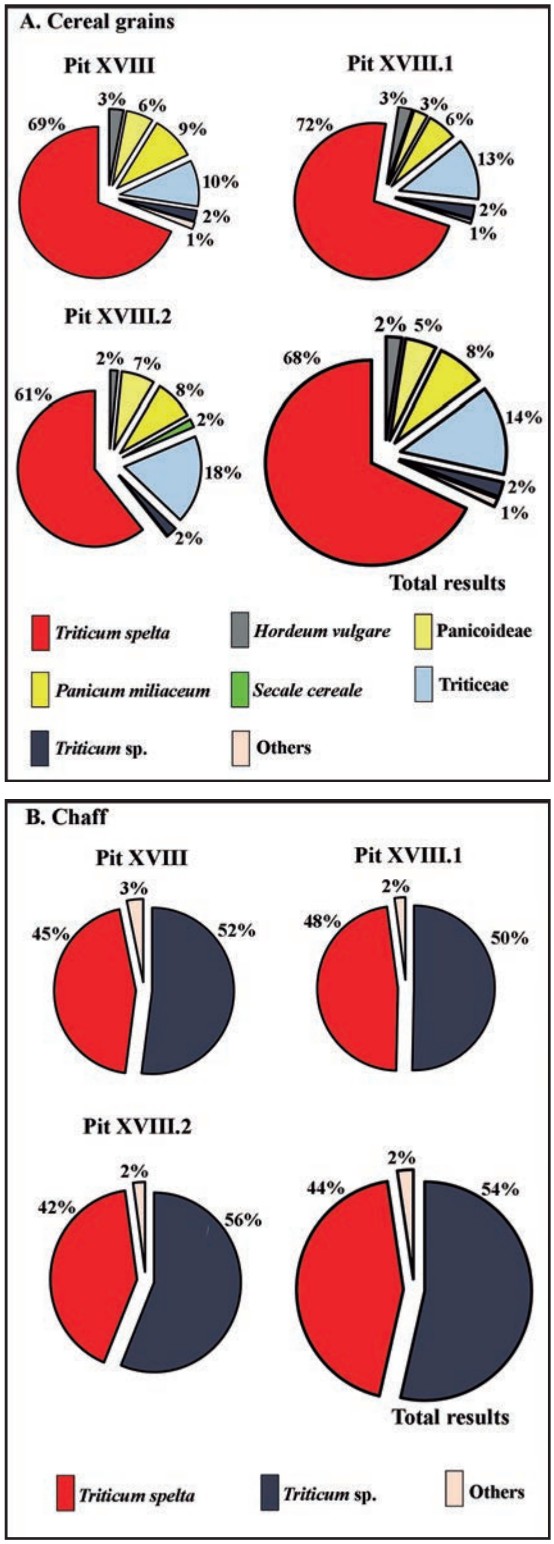

Fig. 5. Carpological results from the pits, Area 2, Crastoeiro (Mondim de Basto): A. Cereal grains; B. Chaff (in colour in the electronic version).

Pit	**XVIII**						**XVIII.2**	**XVIII.5**				**XVIII.1**							
U.S.	18a	18b	18c	18c	18c	18d	18.2a	18.5a	18.5a	18.5a´	18.5b	18.1a	18.1a	18.1a	18.1a	18.1a	18.1b	18.1b	18.1b
Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Cereals (grains)																			
Hordeum vulgare	3	4	127	50	117	84	312			4	1	110	151	67		19		415	33
Panicoideae	10	9	18	161	247	245	1421					287	420	16		34		19	41
Panicum miliaceum	12	11	53	396	326	347	1689					686	705	131	17	1		115	57
Panicum miliaceum (agglomerate)			18			4						1						1	
Panicum/Setaria		2			13	8	7			1		9							
cf. *Secale cereale*			9							1				16					
Secale cereale			44	16	15	20	348					49	84	1		1		38	8
Setaria italica	9	4		8	10	4						4							
Triticeae	11	21	499	209	252	225	3734	2	1	15	1	914	1376	118	33	85		962	105
Triticum sp.	3	8	123	72	65	8	435	1		4		216	218	20		4		267	26
Triticum dicoccum/spelta		1					7					4		16					
Triticum spelta	40	84	2599	1881	2002	1901	12347	4	16	70	25	3499	4675	1091	84	454		9750	927

Tab. 3. Crastoeiro (Mondim de Basto). Area 2. Total results (cereal grains).

Pit	**XVIII**						**XVIII.2**	**XVIII.5**				**XVIII.1**							
U.S.	18a	18b	18c	18c	18c	18d	18.2a	18.5a	18.5a	18.5a´	18.5b	18.1a	18.1a	18.1a	18.1a	18.1a	18.1b	18.1b	18.1b
Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Chaff																			
Hordeum vulgare (rachis segment with 1 node)	1	1		8	10	4	109					27	17						
Secale cereale (rachis segment with 1 node)							7												
Triticum sp. (spikelet base)	11	18	9	451	638	501	3690					986	1007	16		34		38	24
Triticum sp. (1/2 spikelet base)	14	22	18	395	436	277	4278					870	1208	16					16
Triticum aestivum/durum (rachis segment with 1 node)				16	18	12	15					22							
Triticum aestivum/durum (rachis segment with 2 nodes)	1	1			5		22			2		8							
Triticum dicoccum (spikelet base)		1			23	8	7					9							
Triticum dicoccum (1/2 spikelet base)		2		16	25	12	138					54	50						
Triticum spelta (spikelet base)	8	11	105	272	305	375	1928			3		524	541	83		67		236	91
Triticum spelta (1/2 spikelet base)	17	36	44	460	553	530	4757					1242	1259	117	33	101		57	57

Tab. 4. Crastoeiro (Mondim de Basto). Area 2. Total results (chaff).

of *Avena sterilis* type (Tab. 5), a wild autochthonous species that until recently was a common weed (Aguiar 2000).

Besides the grains, this study revealed a large quantity of chaff, especially spikelet bases of *Triticum spelta* (Fig. 6) and *Triticum* sp. (Tab. 4). The large amount of chaff fragments identified at genus level –*Triticum* sp.– is a result of their fragmentation. Chaff from *T. aestivum/durum*, *T. dicoccum*, *Hordeum vulgare* and *Secale cereale* were also identified. Results from chaff do not totally agree with those of the grains. Rachis fragments of naked wheat and spikelet bases of *T. dicoccum* were

Pit	XVIII						XVIII.2	XVIII.5				XVIII.1							
U.S.	18a	18b	18c	18c	18c	18d	18.2a	18.5a	18.5a	18.5a´	18.5b	18.1a	18.1a	18.1a	18.1a	18.1a	18.1b	18.1b	18.1b
Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Other Gramineae																			
Avena sp. (grain)				8	5	4	15					9							
Avena sterilis type (grain and floret base)																			8
Gramineae *Bromus* type (grain)		1																	
Gramineae undetermined (grain)	2	1		8	5	24	15												
Leguminosae																			
Vicia sp. (seed)	2				5		30												
Leguminosae undetermined (seed)	8	5		24	15	8	36					4							
Wild fruits																			
Quercus sp. (cotyledon)	1	1	29	22	18	22	147			1		38	55	3	1	7	12	99	9
Quercus sp. (cupule)		1	1		1	6	7					9				17		40	
Rubus sp. (seed)	4	5		24	20	12	7					18	17						
Rubus sp. (drupe)				8															
Others																			
Caryophyllaceae (seed)												4	17						
Galium sp. (mericarp)		1			8		7												
Galium aparine (mericarp)	2	10			5														
Malva sp. (seed)		1		8	3														
Malvaceae (seed)				8															
Plantaginaceae (seed)												4							
Polygonaceae (achene)	1				3							4							
Polygonum sp. (achene)	7	22			18		15					4							
Polygonum aviculare (achene)	8	8																	
Rumex sp. (achene)		1			5														
Rumex acetosella (achene)					3	4													
Sambucus sp. (stone)	1	1			5														
Solanum sp. (seed)	1	1					7					4							
Vitis vinifera (seed)	2			8	10				1										
Undetermined		1			4	4	3					4							

Tab. 5. Crastoeiro (Mondim de Basto). Area 2. Other carpological remains (results).

Fig. 6. *Triticum spelta* from pit XVIII.1, Area 2, Crastoeiro (Mondim de Basto): Spikelet base (left), grain (center), half spikelet base (right).

recovered, but no grains of these species were identified. Although it may reflect actual differences in the composition of the assemblages of grains and spikelets, it is possible that some identification bias occurred, considering the well-known difficulties in the identification of wheat grains.

Nevertheless, combined analysis of grains and spikelets highlight *T. spelta* as the major crop in the assemblage. To address this issue in detail a further analysis of the spikelet and grain assemblages was carried out.

Its specific purpose was to determine the ratio between chaff and grains in the pits (see section 3). Considering the difficulty in distinguishing the different pits in the fieldwork it is probable that plant remains ascribed to specific pits may reflect, in fact, the content of more than one pit. While this makes the interpretation of the assemblages difficult, the homogeneity of the results of different samples makes an overall analysis of data feasible (see section 5 for further considerations). Thus, results from half spikelets/grains ratio presented in table 6 were obtained over the sum of all remains, from the different pits. The first column represents the actual grains identified in the carpological study; the second column represents the number of half spikelet bases found. Since a spikelet usually has two grains, each complete spikelet should present a ratio of one grain per each glume base (half spikelet).

	Cereals (grains)	Number of half spikelets	Ratio
Triticum sp.	1470	22396	
Triticum dicoccum	—	393	
Triticum dicoccum/spelta	28	—	1
Triticum spelta	41449	18361	
Total	42947	41150	

Tab. 6. Relation between cereal grains and half spikelets recorded. Area 2, Crastoeiro (Mondim de Basto).

Results show that spelt spikelet bases found in the pits would carry less than half of the grains actually present in the samples. The contrary is noticed in the case of remains identified at the genus level: there is an overwhelming presence of spikelet bases when compared with grains. This may be the result of an identification bias. The same occurs with emmer. 393 half spikelet bases of *T. dicoccum* theoretically represent 393 grains, but, as mentioned before, no grains of these species were identified in the samples. The same happens with naked wheat, not included in table 6.

An overall analysis of spikelet bases and grains of all wheat remains (*Triticum* spp.) is problematic because it sums remains from different pits and different species. Still, if we sum all grains identified as hulled wheat and those identified at genus level and we do the same to the spikelet bases, results clearly show similarities and the ratio grain/spikelet is 1,0 (if rounded to one decimal place). Adding *Triticum* sp. grains may be problematic because of the presence of *T. aestivum/durum* rachis fragments and the fact that naked wheat is more prone to be stored without chaff. Still, the overwhelming presence of chaff of *T. spelta* and *T. dicoccum* makes us consider that wheat grains identified at genus level have a higher chance of being from hulled species.

As such, the amount of grains (hulled wheat and *Triticum* sp.) recovered is similar to the amount of grains that would be provided by the amount of spikelet bases recovered. Chaff from naked wheat is not enough to alter this perspective in a significant way, at least not enough to alter the main conclusion: the grains from hulled wheat were more likely all stored inside the spikelets.

The other carpological remains are much rare and derive from wild plants (Tab. 5). Acorns are the most abundant and ubiquitous. Acorns are easily collected and should have been widely available, considering oaks are dominant in regional climactic forests. Their presence is common in Iron Age and Roman settlements in the Northwest Iberia (Rey Castiñeira *et al*. 2011; Tereso 2012; Tereso, Ramil-Rego, Álvarez González *et al*. 2013). Besides the cotyledons, we identified cupules and pericarp fragments.

Seeds of *Rubus* sp. are also quite common in the samples. We must highlight the surprising find of a half fruit (compound drupe) of *Rubus*. This is an extremely fragile fruit, easily destroyed by pressure or by fire (Fig. 7). *Sambucus* fruits could also have been collected for human consumption.

Of great importance is the identification of some grape pips (*Vitis vinifera*). However, their scarcity did not allow a proper biometric study and it is not clear if we are dealing with remains of wild or domestic plants.

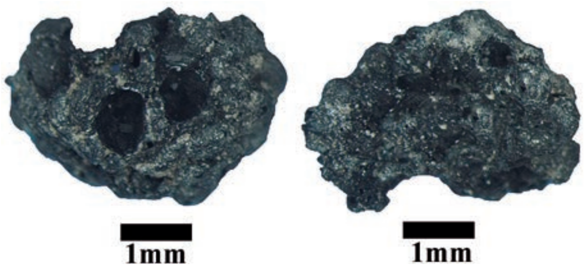

Fig. 7. Half fruit (drupe) of *Rubus* sp. from pit XVIII, Area 2, Crastoeiro (Mondim de Basto).

Wild grasses appeared, but in small numbers. Other wild species are not frequent and did not provide identifications with good taxonomic detail. *Avena* sp., *Avena sterilis* type and other Gramineae identified at family level may have been weeds in the fields where the identified cereals were harvested. The same may be true of *Rumex acetosella*, considering its current ecology (Aguiar 2000). On the other hand, *Galium aparine* is a weed well adapted to different soils but more common with garden-crops, in paths and other environments rich in nutrients. Genera and family of other wild species include several weeds but also species in other type of environments.

5. DISCUSSION

5.1. Storage structures and cereal processing

Any approach to the storage structures in Crastoeiro must be done with due caution, considering the difficulties in distinguishing the content of each pit. Differences in radiocarbon dates suggest the place may have been used for storage at least in two different moments, one in the $4^{th}/3^{rd}$ centuries BC and the other in the mid-1^{st} century BC. However, these dates represent merely two different fires which caused the carbonization of plant remains, it is unclear wether the area was used for storage before and/or throughout the whole period covered by the radiocarbon dates. Still, it is not possible to distinguish the different moments within the carpological assemblage. The overall perspective is, thus, based on the homogeneity of results from the different samples, which suggest that, independently of the time-span represented, little changes may have occurred in the crops chosen for storage in the area.

Storage of grains in pits has been a common practice since prehistoric times and has been documented in different geographical areas, both archaeologically and ethnographically (*e.g.*, Reynolds 1974; Gast and Sigaut 1979; Gast *et al.* 1981; Gast *et al*. 1985; Tereso 2012; Peña-Chocarro *et al*. 2015, Tereso *et al.* 2016). Such approaches demonstrate the use of underground storage for keeping crops for long periods of time can be reproduced in different and successful ways, (*e.g*., Reynolds 1974; Miret i Mestre 2008; Peña-Chocarro *et al*. 2015). However, these considerations do not allow us to interpret all carpological remains found in pits as resulting from storage nor all archaeological pits as storage structures. Several authors have stressed that, although pits were used for storage from prehistoric times to the medieval ages (Parcero Oubiña and Ayán Vila 2009; Tereso 2012; Tereso *et al*. 2016), they could be used for other purposes (Gast and Sigaut 1979; Van der Veen 2007; Alonso 2008; Tereso *et al.* 2016; Martín-Seijo *et al.* 2017). They often include charred plant remains, usually corresponding to secondary or tertiary refuse (*sensu* Fuller *et al.* 2014) or even to natural depositions resulting from the erosion and transport of nearby sedimentary contexts.

In the case of the pits presented here, we propose that carpological remains were placed inside the pits for storage and were later carbonized accidentally or deliberately. Although the great amount of wood charcoal found inside the pits could suggest otherwise, the large quantities of cereals found, the homogeneity of the findings and the fact that very few ceramic fragments or other artifacts were retrieved from inside the pits, suggests these were used for storage. Secondary or tertiary depositions are expected to be more heterogeneous. Wood charcoal found could derive from structural parts of the storage structures, such as the cover and compartmentation of the pits or even the structure that would have been covering the whole storage area: posts, walls and roofing, probably all made of wood. Post-holes found in the surrounding of the pits, suggests the existence of such a structure. It was a crucial element to ensure the preservation of food in the pits as the importance of sealing the pits properly cannot be underestimated.

The sealing of the pit was necessary to create an environment with low oxygen, to diminish insect attacks and provide the structure with stable temperature and humidity levels, extremely important for preserving the crops (Reynolds 1974; Burch and Sagrera 2009; Gracia Alonso 2009; Peña-Chocarro *et al*. 2015). The grains themselves are crucial in the achievement of an almost anaerobic atmosphere inside the pit. The upper layer of grains sprouts and through respiration releases carbon dioxide. Thus, if the pit stayed correctly sealed, most grains would reach a state of dormancy, guaranteeing they were edible and suitable for germination for a long time (Reynolds 1974; Peña-Chocarro *et al*. 2015).

The combined storage of fruits and seeds with different sizes is also a good strategy to lower the oxygen levels and prevent the dissemination of insects. In this sense, millet grains, due to their small size could be added to other cereals in order to reduce spaces between grains. That was the interpretation of an assemblage composed of broomcorn millet, spelt wheat and barley found in an Iron Age storage pit at the site of Thiais (Val-de-Marne, France) (Marinval 1992; Buxó and Piqué 2008). A similar assemblage, with emmer, instead of spelt, was found at the Iron Age site of Ville-Saint-Jacques (Seine-et-Marne, France) and interpreted in the same way (Issenmann *et al.* 2012). Aggregated grains of barley and broomcorn millet were found in Crastoeiro, suggesting there was no physical separation between both inside the structure and, thus, similar practices to those at the two sites in northern France.

Before storage, crops and other edible plants need to be collected and processed. The remains found in storage facilities or other archaeological contexts can provide information regarding such stages. Traditional approaches to storage strategies and the processing of crops often include ethnographic studies in areas where traditional methods are still used. Examples are the pioneering work of Gordon Hillman in Turkey (*e.g*., Hillman 1981, 1984) and Glynis Jones in Greece (Jones 1984). More recently, Leonor Peña-Chocarro, Lydia Zapata and others carried out investigations in Morocco and Spain, especially focusing hulled wheats (*e.g*., Peña-Chocarro 1996, 1999; Peña-Chocarro *et al*. 2009). These investigations not only give us a better understanding of the different stages of crop processing prior to storage and consumption, they also provide parallels for to the carpological assemblages found in other archaeological contexts, such as Crastoeiro.

Ethnographic research document threshing cereals with sledges, trampling, lashing or flailing (for full description see Hillman 1981 or Peña-Chocarro 1999). These could be followed by a series of different steps (*e.g*., winnowing, raking, coarse sieving, fine sieving).

Still, data from Crastoeiro suggests that hulled wheat –both spelt and emmer– was stored as spikelets. Previous studies, mentioned above, demonstrate that when threshed, the ears of hulled wheats break into spikelets and consequently the grains remain inside the husks. To remove the chaff and free the grain, further processing is necessary (Nesbitt and Samuel 1996; Peña-Chocarro 1999; Peña-Chocarro and Zapata 2003; Van der Veen and Jones 2006).

Decisions to limit the early processing of hulled cereals to the disarticulation of spikelets imply that other stages would be carried out at a daily basis. This has been interpreted in different ways. Hillman (1981) suggests climatic conditions were a determinant factor in wet areas, where the time-consuming tasks necessary to the full processing of crops, including their drying, were not achievable in the time available. However, the storage of hulled wheats in spikelets has been documented in warm and dry areas (Jones 1984; Peña-Chocarro 1999; Peña-Chocarro *et al*. 2009). Fuller *et al*. (2014) suggest that the limiting factor was not climate but workforce, i.e., that communities did not have enough man-power to fulfil all processing stages immediately after the harvest.

Nevertheless, it is well-known that spikelets protect the grain against fungi and insects (Buxó and Piqué 2008; Gracia Alonso 2009) and as Fuller *et al.* (2014) admit, that could explain why communities chose to store partially processed cereals. We find it likely that such option was, in fact, part of a strategy to build resilience (Tereso 2012).

Free-threshing cereals (naked wheat and rye) and hulled barley were also identified in Crastoeiro. In the case of naked wheat and rye, threshing and winnowing, followed by sieving, are sufficient to produce free grain. Although rachis fragments of naked wheat were found in the pits of Crastoeiro, these are very rare which suggests grain was practically clean when stored. Some weeds and rachis fragments can survive winnowing and coarse sieving and could be recovered through fine sieving. For hulled barley, further steps are required to remove the lemma and palea (Nesbitt and Samuel 1996; Peña-Chocarro 1999; Peña-Chocarro and Zapata 2003; Van der Veen and Jones 2006; Alonso *et al*. 2014). Barley grains from Crastoeiro were mostly clean, thus contrary to hulled wheats, barley grains were fully processed before storage.

Ethnographic work has also focussed on the processing of millets (*e.g*., Reddy 1997; Vázquez Varela 2000; Moreno-Larrazabal *et al.* 2015). According to these studies, the procedures necessary to process millet grains are the same for *Panicum miliaceum* and *Setaria italica,* but depending on the use farmers give to the crop, it may vary significantly. After the harvest, the threshing could involve different processes like trampling, beating or rubbing (see full description Moreno-Larrazabal *et al*. 2015). In the end, clean grains are easily obtained. Unsurprisingly, millet grains in Crastoeiro are dehusked. Only very occasionally are small fragments of lemma and palea found adherent to the grains, which is insufficient to suggest millets were stored with husks.

The stage in which transport of the crops to the settlement would occur could depend on distance and could even vary according to the crops, but early processing stages, when the largest amount of waste is produced, are more likely to occur near the fields (Hillman 1981, 1984; Peña-Chocarro 1999; Fuller *et al*. 2014). Some of the last processing stages could occur on a daily basis. As mentioned before, that would be the case of dehusking spelt and emmer grains that were stored as spikelets. Hulled barley, millet and naked wheat were stored as clean grain.

As mentioned above, the storage of spelt as spikelets is a good strategy to assure long-term preservation of the grains, but the same strategy could be applied for short-term storage. This practice implies that the final stages of processing take place daily prior to consumption, thus would have profound impact on the day-to-day activities of people inhabiting the settlement. The storage of hulled wheat in spikelets is common practice and has been identified at As Laias, where spelt was stored in wattle and daub structures during the Iron Age and the transition to the Roman Period (Tereso, Ramil-Rego, Álvarez González *et al.* 2013) and at Penalba (Campo Lameiro), where emmer was stored in vessels during a transitional phase between the Late Bronze Age and the Early Iron Age (Aira Rodríguez *et al.* 1990).

The integration of storage facilities on-site and storage practices in the social organization of the community that inhabited Crastoeiro is difficult to address with the available data. At other sites, such as As Laias (Tereso, Ramil-Rego, Álvarez González *et al.* 2013), El Castrelín (Borrenes) and La Corona (Barjas) (Fernández-Posse and Sánchez-Palencia 1998), it is possible to discuss the social aspects of crop production and storage, but data from Crastoeiro is much less straightforward.

In Crastoeiro storage could have taken place in at least two different settings. The storage structures presented here were located in an elevated part of the hillfort. They were not connected to any specific family compound. In a nearby residencial unit, previous work discovered a pit with crops has been found, showing there also was household storage. However, the platform where the pits are located (Fig. 2 and 3) can hardly be compared to the large storage areas (communitarian or not) found at other sites.

Unfortunaley, the exact shapes of the pits here presented are unknown making it impossible to determine their volumes and compare with other pits in the site. More data is necessary to fully understand storage structures and storage practices at Crastoeiro.

Another point is the great number of Neo-Chalcolithic Atlantic rock carvings, some of them with overlays and additions, found in this area of the settlement (Dinis and Bettencourt 2009; Dinis 2009a). All the pits at Crastoeiro are close to these carved outcrops, and the pits presented here were even surrounded by them (Fig. 3). Thus, there may have existed a symbolic interrelationship between rock art and storage of the grain that was a fundamental to the survival of the people living at Crastoeiro, a good needing protection. It is important to remember that the inhabitants of the Iron Age and the earlier Roman phases did not destroy the old motifs, although they reused them by adding and overlapping new signs.

5.2. Crop diversity

Carpological data suggests that spelt wheat was a very important crop for the inhabitants of Crastoeiro. Still, we must take into account the specificities of the contexts that were studied and ask to what extent the content of storage pits is representative of overall agricultural strategies. In fact, it is possible that pits were not the only storage solutions, but the ones preferred for cereals, which would make it them unrepresentative of agricultural strategies as a whole. This could explain the absence of pulses and other non-cereal crops in Crastoeiro. An eventual preservation bias regarding non-cereal crops, particularly pulses, has been suggested (Tereso 2012; Tereso, Ramil-Rego, Álvarez González *et al.* 2013). If so, data from Crastoeiro seems to be suitable to address Iron Age cereal crops, being quite relevant in this matter.

The most abundant crop in the pits of Crastoeiro is, as mentioned before, spelt. It has been recovered in Iron Age sites in the region, like As Laias (Cenlle) (Tereso, Ramil-Rego, Álvarez González *et al.* 2013), Castrovite (A Estrada) (Rey Castiñeira *et al*. 2011) and Crasto de Palheiros (Murça) (Figueiral 2008), as well as in Roman levels from Castro Pedro (Melide) (Criado Boado 1991) and Terronha de Pinhovelo (Macedo de Cavaleiros) (Tereso 2007). At As Laias, as at Crastoeiro, spelt wheat was the dominant cereal. The presence of spelt wheat at Castrovite was more residual (Rey Castiñeira *et al*. 2011) and at Crasto de Palheiros no distinction was made between grains of *Triticum spelta* and *Triticum dicoccum,* although chaff from both species was recovered. Spikelets in the Iron Age levels were not very abundant (Figueiral 2008).

T. dicoccum is common in NW Iberia. It has been recovered in more sites than spelt, but usually in small amounts, both in Iron Age and Roman sites (Tereso 2012; Tereso, Ramil-Rego, Álvarez González *et al*. 2013). Naked wheat was also found in several sites but, overall, there is a predominance of hulled wheat over the naked species (Tereso 2012).

Current archaeobotanical record suggests spelt wheat was introduced in Northwest Iberia during the Iron Age and soon became an important crop (Tereso 2012; Tereso, Ramil-Rego, Álvarez González *et al.* 2013). It is a hulled wheat, well adapted to poor soils, higher altitudes, humidity and cold (Buxó *et al*. 1997; Van der Veen and Palmer 1997), and is more productive than *T. dicoccum* if there are low winter temperatures (Van der Veen and Palmer 1997). Its cultivation since the Iron Age, together with *T. dicoccum*, has been partially interpreted as an adaptation to the colder conditions that seem to have existed in the beginning of the second half of the first millennium BC. Spelt was retained as an important crop since then, even during the Roman Period (Tereso 2012). This could have been enhanced by the Iron Age settlement pattern in the region, which did not always privilege the presence of good soils near settlements. This could justify the use of several crops that are not demanding in terms of soils and climate, such as hulled wheat, millet and hulled barley. All these are recorded in Crastoeiro.

The broomcorn millet, a spring crop, was certainly important for the communities of Crastoeiro and all Northwest Iberia. This cereal was recorded at several Iron Age sites (Aira Rodríguez *et al*. 1990; Bettencourt *et al*. 2007; López-Merino *et al.* 2010; Tereso 2012; Moreno-Larrazabal *et al*. 2015;) sometimes in great amounts. Such is the case of Castrovite (Rey Castiñeira *et al*. 2011) and Crasto de Palheiros (Figueiral 2008). It is a spring-crop well adapted to different climatic conditions. Cultivation does not require much effort and, most of all, the plant has a short growing cycle, between 60 and 90 days (Moreno-Larrazabal *et al*. 2015). As such, this crop fits well in rotation systems, allowing communities to obtain two crops a year (Parcero Oubiña 2000; Tereso 2012).

Barley had a secondary importance in Crastoeiro. However, it is a consolidated crop in the Iron Age, as demonstrated by its presence in many archaeological sites from Northwest Iberia (Figueiral 2008; López-Merino *et al*. 2010; Tereso 2012).

In the assemblage of crops at Crastoeiro there is another crop that is usually cultivated in the less fertile soils and in harsh climatic conditions: rye. Although spring varieties exist, it is usually sown as a winter crop, being more resistant and having higher yields than most cereals in unfavourable climatic conditions and in poor, acid and sandy soils (Behre 1992; Alonso 2005). Until now, grains of rye were recovered at few sites in Northwest Iberia, all from the Roman period or other historical times (Martín-Seijo *et al.* 2010; Tereso, Ramil-Rego and Almeida-da-Silva 2013). For that reason, its presence at Crastoeiro is especially interesting.

Taking into account the two radiocarbon dates obtained over grains of rye (Fig. 8, Tab.1), we believe this crop was introduced at least by the mid-1st century cal BC. This is a moment when Roman influences were becoming stronger: the coastal campaign of *D. Iunius Brutus* had already occurred in 138-137 BC (Alarcão 1992; Peña Santos 2005; Lemos 2009; Martins *et al*. 2012).

Roman influence or, at least, early Roman contacts with indigenous communities living in Crastoeiro is suggested by the presence in the site of three Roman denarii with chronologies that can be related to the results of the radiocarbon dates of rye: one Republican denarius, coined in Rome in 60 BC and two Augustan denarii, coined in *Lugdunum* between 2 BC - 4 AD (Dinis 2001). These coins help us understand the chronological settings of the Romanization of this settlement in which rye could have played some part.

Fig. 8. Dated grains of *Secale cereale* (rye).

The idea that rye could have been introduced first as a weed, only being domesticated later, must be considered as that seems to have been the process documented elsewhere (Behre 1992). However, we must emphasize that in the 1st century BC, rye was already being cultivated in several parts of Europe (Behre 1992).

As mentioned before, the small number of grape pips retrieved make it impossible to know whether they come from domestic or wild *Vitis*. Although grape pips have been found at Iron Age and Roman sites from the transition of the Era and the 1st century AD (Tereso, Ramil-Rego and Almeida-da-Silva 2013; Tereso and Cruz 2014), so far there is no clear archaeological or paleoecological evidence to sustain that vine was cultivated during these periods in the region, although this hypothesis must not be excluded.

Regarding wild edible plants, the fruits of *Quercus* and *Rubus* were collected and most likely consumed by Iron Age communities. Such behavior continued throughout the Roman period. Acorns were even an important part of human diet, considering their frequency in Iron Age archaeological sites. Acorns contain large quantities of carbohydrates, fats and fibres. For human consumption it is necessary to remove the tannins that give a bitter taste to the fruit (Oliveira *et al*. 1991; Mason 1992), but their great abundance surely made such task worthwhile. The presence of cotyledons, pericarps and cupules at Crastoeiro suggests that at least some of the acorns were stored unprocessed which would be a good solution to prevent oxidation (Oliveira *et al*. 1991).

6. CONCLUSIONS

Carpological data obtained from Crastoeiro is particularly relevant to understand crop diversity and storage strategies in the Tâmega valley and in Northwest Iberia. Despite the problems in distinguishing the content of different pits, the carpological data is very homogeneous which suggest some degree on continuity in the crops and storage during the Iron Age and the transition to the Roman period.

The use of pits as storage facilities was a common strategy in Northwest Iberia and it was not exclusive to the Iron Age (Parcero Oubiña and Ayán Vila 2009; Tereso 2012; Tereso *et al.* 2016). In Crastoeiro, the radiocarbon dates obtained over two of the studied pits (XVIII.1 and XVIII.2) demonstrate this place was used for storage at least in two moments: during the initial phase of occupation and in the 1st century BC when the earliest evidence of Roman contacts becomes clear.

Spelt was, by far, the dominant crop and it was stored as spikelets, probably to allow long-term storage and spread its processing stages throughout the year. Emmer, barley, rye, naked wheat and millet were also present in the pits, demonstrating the existence of some diversity in the cereals that were cultivated.

The carpological assemblage of winter crops and millet (a spring crop) suggests communities grew two crops a year. Cereals can be adapted to become spring crops, but, the great value of rye, for instance, is that it is prolific in the poorest soils and also tolerates harsh climates, including winter frosts. It is not very likely that it was being grown as spring crop. The same is true for spelt.

Data from Crastoeiro fits well with other carpological and archaeological data available in the region. With exception of rye, crops found in Crastoeiro are common in other Iron Age sites in Northwest Iberia. Most are not very demanding in terms of soils and are well adapted to harsh climatic conditions. The regular cultivation of such crops has been interpreted as an adaptation to the colder climate that existed in the beginning of the Iron Age and as a strategy to take full advantage of all soils – including the less fertile – by fully sedentary populations (Tereso 2012). This implies that Iron Age communities had a good knowledge of the characteristics of the crops.

The presence of rye in at least the 1st century BC is a novelty. The radiocarbon dates obtained over grains of rye are the oldest in the Iberian Peninsula up to now. As such, the chronology of rye's introduction must be redefined. The mid-1st century BC is a transition phase in the region. Roman influence is clear at several sites, although communities largely maintain their ways of life (Alarcão 1992; Peña Santos 2005; Lemos 2009; Martins *et al*. 2012). That is visible also in the carpological record: with exception of rye it remains almost unchanged during Early Imperial times (Tereso, Ramil-Rego and Almeida-da-Silva 2013; Tereso, Ramil-Rego, Álvarez González *et al*. 2013).

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