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Plant Resources from the Bronze Age and the first Iron Age in the northwestern arc of the Mediterranean Basin

Ressources végétales de l'âge du bronze et du premier âge du fer dans le Nord-Ouest du Bassin méditerranéen

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ABSTRACT

This paper updates the question of plant resources during the Bronze Age and First Iron Age in the northwestern Mediterranean Basin. Among the cereals, six-row hulled barley is dominant throughout the territory, whereas naked and hulled wheats take on greater or lesser roles from region to region. Millet cultivation developed during the Bronze Age and became widespread in the First Iron Age. Apart from cereals, pulses, oil species and fruit appear to be secondary. Results from the study of archaeobotanical remains on wetland sites, however, lead us to question this finding, as oil plants and fruits are much better represented in waterlogged conditions. The cultivation of vine began in the First Iron Age. In spite of a number of characteristics common to plants throughout the study area, regional differences, evident in the Bronze Age, seem to dissipate in the First Iron Age.

RÉSUMÉ

Cet article propose une nouvelle synthèse concernant les plantes exploitées pour leur intérêt économique dans l'arc nord-occidental de la Méditerranée, au cours de l'âge du bronze et du premier âge du fer. L'orge polystique vêtue s'impose dans tout le territoire, alors que blés nus et vêtus prennent un rôle plus ou moins marqué en fonction des régions. La culture des millets se développe au cours de l'âge du bronze et se généralise au premier âge du fer. La présence des légumineuses, des oléagineuses et des fruits apparaît secondaire. L'étude de sites de milieu humide conduit cependant à relativiser quelque peu ce constat, les oléagineuses et les fruits étant bien mieux représentés dans le matériel gorgé d'eau que parmi les restes carbonisés par rapport aux céréales. La culture de la vigne débute au premier âge du fer. Au-delà de ces caractéristiques communes, des différences régionales apparaissent clairement au cours de l'âge du bronze. Celles-ci semblent largement se diluer au premier âge du fer.

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1. Introduction

The northwestern Mediterranean is characterised by river valleys and lowlands, bordered by saltwater lagoons (Fig. 1). Its two main rivers (and their tributaries) are the Rhône to the east and the Ebro to the west. The Pyrenees massif, oriented east–west and roughly perpendicular to the coastline, is the main mountain range. The Albères Massif, its easternmost extension, varies in altitude from over 2000 m to sea level, and literally runs into the Mediterranean. This range divides the study area in two main sectors that roughly correspond to Catalonia in the South and Languedoc in the North.

This region's agrarian economy in historical times was Mediterranean with the most common crops in the plains being vine, olives, a variety of fruits and winter cereals (naked wheat, barley). This agricultural tradition can be traced to Neolithic settlements dating back to 5800–5600 cal BC in Languedoc and to about 5500 cal BC in Catalonia (Antolín, 2016; Guilaine and Manen, 2007). These early populations already combined the cultivation of crops and livestock husbandry with the exploitation of natural resources. Most of the archaeobotanical record dating back to the Neolithic consists of cereals: naked wheat (*Triticum aestivum/turgidum*), emmer (*T. dicoccum*), einkorn (*T. monococcum*), naked barley (*Hordeum vulgare* var. *nudum*), and hulled barley (*H. vulgare var. vulgare*) (Antolin, 2016; Antolín et al., 2015; Buxó, 2007; Marinval, 1993). Local crop traditions and specificities seem therefore to have their roots in Prehistory, 3000 years before the Bronze Age.

The goal of this paper is to identify and study the continuities, changes and regional specificities of agricultural resources throughout the region inferred from archaeobotanical analyses from the end of the Neolithic to the beginning of Antiquity. This period corresponds to a period of about 1500 years comprising the Bronze Age and First Iron Age. The end of the First Iron Age was chosen as the study's stopping point because it coincides with the arrival of the first Greek, Etruscan and Phoenician colonies in both Catalonia and Languedoc, settlements that ushered in western Mediterranean's integration into the agricultural economy of Antiquity.

The study of the regional characteristics of agriculture is particularly interesting because, besides geographical differences, this territory was split up into different cultural units that varied over time and often experienced different external influences (Py, 2012). It must be noted that these archaeobotanical analyses present a number of challenges stemming for the most part from the spatial and temporal heterogeneity of the corpus, as well as the heterogeneous nature of the data.

2. Materials and methods

The vast arc-shaped study area between the Ebro and Rhone Rivers includes both coastal and inland sites throughout what are currently the administrative districts of Languedoc-Roussillon (Gard, Lozère, Hérault, Aude, and the Pyrénées-Orientales departments) and Catalonia (Girona, Barcelona, Tarragona, and Lleida) (Fig. 1). Most of the archaeobotanical data comes from excavations carried out in the four following regions (Table 1): Languedoc, Pyrenees, eastern Catalonia, and western Catalonian plain.

The chronological framework includes all the sites dated to between the early second millennium BC and the middle of the first millennium BC, roughly from 2100 to 500 BC. This timeframe corresponds to several chrono-cultural periods that vary in nomenclature and range from region to region:

- South of France: Early Bronze Age (2100–1700 cal BC), Middle/Late Bronze I (1600–1400 cal BC), Late Bronze Age II–III (1400–725 cal BC), First Iron Age (750–500 cal BC);
- eastern Catalonia: Initial Bronze Age (2300–1300 cal BC), Late Bronze Age (1350–750 cal BC), First Iron Age (700–550 cal BC);
- western Catalonian plain: Full Bronze Age (2100–1650 cal BC), Segre–Cinca Group I (1650–1250 cal BC), Segre–Cinca Group II (1250–1000 cal BC), Segre–Cinca Group III (1000–800/750 cal BC), First Iron Age (750–550 cal BC).

To facilitate the analysis, the sites were grouped in the following broad chronological periods:

- Period 1 (2100–1350/1250 cal BC): corresponding roughly to the Early/Middle Bronze Age, Initial Bronze Age, and Full Bronze/Segre–Cinca Group I;
- Period 2 (1350/1250–750 cal BC): corresponding roughly, depending on the area, to the Late Bronze Age or the Segre–Cinca Group II and III;
- Period 3 (750–600/500 cal BC): corresponding roughly to the First Iron Age.

The archaeobotanical samples were collected on 67 sites over the last several decades. Some of these sites have multiple levels of occupation with different chronological phases corresponding to the list of periods cited above (Fig. 1 and Table 2). Open settlements, sometimes fortified, are the most common type of site. Their number increases in the later chronological phases, while cave dwellings decline to only 9% in the First Iron Age (Fig. 2).

The methodology and the sampling systems also varied from site to site, giving rise, in some cases, to uneven results. In fact, 35% of the analyses are based on a single sample (for the whole site or for specific levels), while 40% of the analyses do not surpass 10 samples. The methods of sample processing generally allowed recovery of all types of remains. Yet, the size of the smallest sieving mesh was not specified in the publications of a dozen sites. Furthermore, fine sieving at ten sites was not undertaken, leading to incomplete archaeobotanical registers. Most of the seeds and fruits recovered are preserved in a charred form. Yet well-preserved waterlogged remains at several settlements in southern France (La Conque, La Fangade, La Motte, Port Ariane) afford a more complete view of the plant resources.

From the methodological perspective, this paper presents an overview of the plant taxa of economical value from the different studies. These plants are listed according to their ubiquity by chronological phase and by region

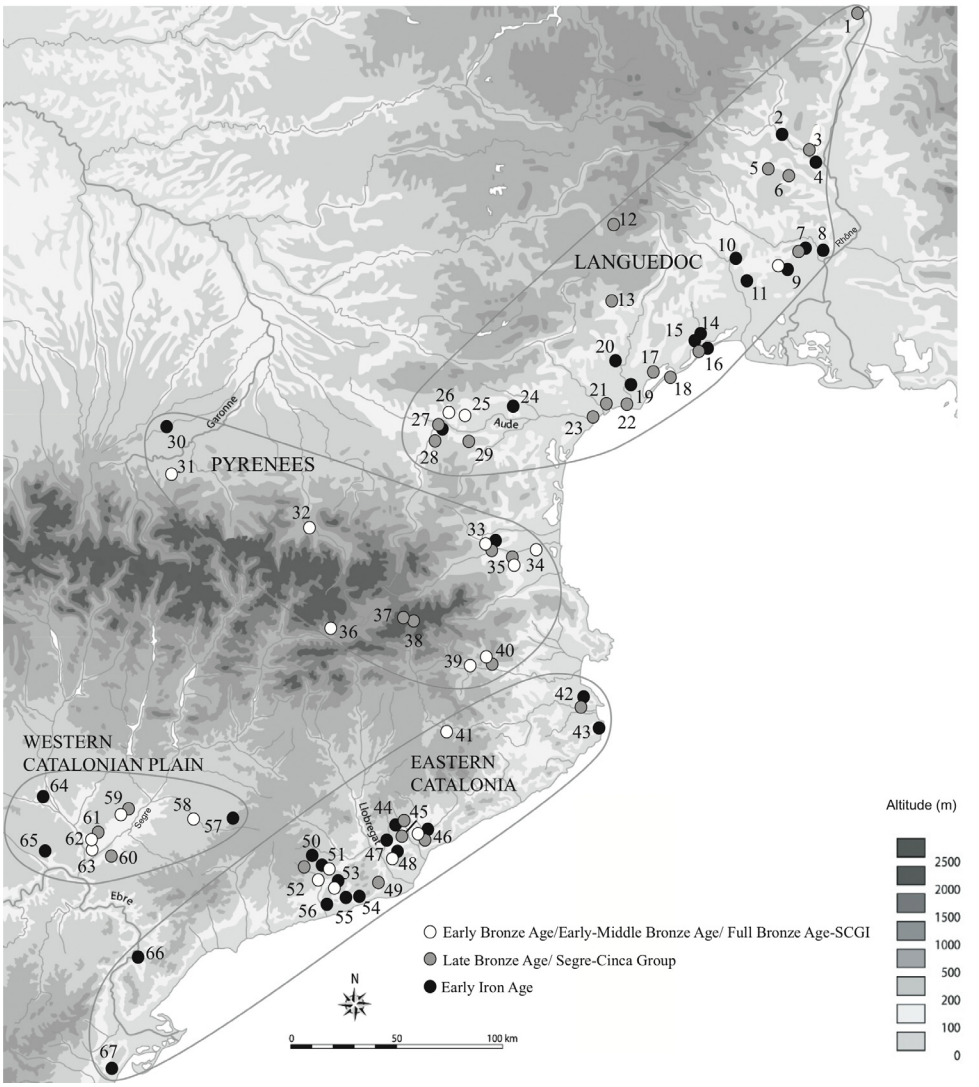

Fig. 1. Bronze Age and First Iron Age sites in the northwestern Mediterranean arc with archaeobotanical studies (see Table 2 for listing).
Fig. 1. Sites de l'âge du bronze et du premier âge du fer, avec études archéobotaniques (voir Tableau 2 pour la liste).

Table 1
Table summarising of the number of sites par period and region.
Tableau 1
Tableau résumé du nombre de sites par période et par région.

	Languedoc	Pyrenees	Eastern Catalonia	Western Catalonian Plan	
Number of sites	29	11	18	9	67
Period 1 (2100–1350/1250 cal BC)	3	9	5	4	21
Period 2 (1350/1250–750 cal BC)	18	5	6	3	32
Period 3 (750–600/500 cal BC)	14	2	13	3	32
	35	16	24	10	

(Table 3). We also conducted a deeper analysis on how the carpological data is structured chronologically and geographically based on a Correspondence Factor Analysis (CFA) following the method proposed by Bouby (2014). Yet to conduct this research and attain reliable results, it was necessary that the data set, gleaned from work of different researchers, be standardised and purged of "noise". Therefore, prior to the analyses, it was necessary to standardise the terminology (Colledge, 2001; Valamoti, 2004). For instance, if a certain species was common among the data (e.g., *Triticum dicoccum*), then other less precise identifications (e.g., *Triticum cf. dicoccum*) due, for example, to problems of preservation, were merged into the group so as to not create two different taxa.

Table 2
Sites represented in Fig. 1 and general archaeological and archaeobotanical data. Region: L: Languedoc; P: Pyrenees; EC: Eastern Catalonia; WCP: Western Catalonian Plan. Chronology: EBA: Early Bronze Age; MBA: Middle Bronze Age; IBA: Initial Bronze Age; GSC: Segre–Cinca Group; LBA: Late Bronze Age; IA: First Iron Age.
Tableau 2
Sites représentés sur la Fig. 1 et données archéobotaniques générales. Région : L : Languedoc ; P : Pyrénées ; EC : Est de la Catalogne ; WCP : Plaine occidentale catalane. Chronologie : EB : Bronze ancien ; MB : Bronze moyen ; IB : Bronze initial ; GSC : Groupe du Segre–Cinca ; LB, Bronze final ; IA : premier âge du fer.

	Site	Municipality	Region/Departmen	Chronology	Bibliography	Type of site	No. remains	No. samples	Volume samples (liters)	Smallest mesh (mm)
1	Brégoule	Soyons	L: Ardèche (07)	LBA/IA	Marinval, 1988, Bouby, 2010	Open air settlement	3522	1	Indet	1 o 2
2	Pontiar	Vallon Pont d'Arc	L: Ardèche (07)	IA 1 (late)	Erroux, unpublished	Cave/abri	Indet	1	Indet	2?
3	Saint-Marcel (Gte)	Saint-Marcel-d'Ardèche	L: Ardèche (07)	LBA 2	Erroux, 1988	Cave/abri	21	1	Indet	Indet
4	St Etienne Dions	St Marcel d'Ardèche	L: Ardèche (07)	IA 1 (late)	Bouby, 2010	Fortified settlement	5	1	0.1	0.5
5	Prével supérieur	Montclus	L: Gard (30)	LBA 2a	Erroux (in Roudil, 1972)	Cave/abri	Indet	?	Indet	?
6	Hasard	Tharaux	L: Gard (30)	LBA 2b	Erroux, 1993	Cave/abri	335	1	Indet	2?
7	Marduel	Saint-Bonnet-du-Gard	L: Gard (30)	LBA 3b	Marinval, 1988	Fortified settlement	18	1	Indet	0.5
7	Marduel	Saint-Bonnet-du-Gard	L: Gard (30)	IA 1 (late)	Marinval, 1988	Fortified settlement	112	1	Indet	0.5
8	Sables	Théziers	L: Gard (30)	IA 1 (late)	Bouby, 2010	Open air settlement	227	1	10	0.5
9	Mas Vignole 10	Nîmes	L: Gard (30)	IA 1 (late)	Bouby, 2010	Open air settlement	227	3	90	0.5
9	Mas Vignole 9	Nîmes	L: Gard (30)	MBA	Figueiral, unpublished	Open air settlement	2	1	25	0.5
10	Arriasse (L')	Vic-le-Fesq	L: Gard (30)	IA 1 (early)	Marinval, 1985	Open air settlement	67	2	> 5	0.5 i 2
11	Liquière	Calvisson	L: Gard (30)	IA 1 (early)	Erroux, 1984	Fortified settlement	> 573	5	Indet	2?
12	Baume Layrou	Trèves	L: Gard (30)	LBA 2b	Bouby et al., 2005	Cave/abri	159276	6	19.5	0.5
13	Abri-St-Étienne	St-Étienne-de-Gourgas	L: Hérault (34)	LBA 2	Erroux, 1981	Cave/abri	18	1	Indet	Indet
14	Cougourlude	Lattes	L: Hérault (34)	IA 1 (late)	Figueiral and Bouby, unpublished	Open air settlement	> 10000	8	49	0.5
15	Lycée Technique	Montpellier	L: Hérault (34)	IA	Erroux, 1966	Open air settlement	Indet	1	Indet	Indet
16	Port Ariane	Lattes	L: Hérault (34)	LBA	Alonso et al., 2007	Open air settlement	27299	5	347	0.5
16	Port Ariane	Lattes	L: Hérault (34)	IA 1 (early)	Alonso et al., 2007	Open air settlement	701	8	450	0.5
17	Conque (La)	Mèze	L: Hérault (34)	LBA 2b/3a	Bouby et al., 1999	Open air settlement	35	2	0.75	0.5
18	Fangade (La)	Sète	L: Hérault (34)	LBA 2–3	Bouby et al., 1999	Open air settlement	1720	10	25.5	0.25 i 0.5
18	Fangade (La)	Sète	L: Hérault (34)	Late MBA/LBA1	Bouby et al., 1999	Open air settlement	3600	6	21.05	0.25 i 0.5
19	Mont Joui	Florensac	L: Hérault (34)	IA 1 (late)	Bouby, 2010	Fortified settlement	1055	3	26	0.5
20	Garennes (Les)	Tourbes	L: Hérault (34)	IA 1 (late)	Figueiral unpublished	Open air settlement	180	1	Indet	0.5
21	Acropole (Rue)	Villeneuve/Béziers	L: Hérault (34)	LBA 2b/3a	Bouby, 2010	Open air settlement	3632	1	8	0.5
22	Motte (La)	Agde	L: Hérault (34)	LBA 3b	Bouby (in Moyat et al., 2007)	Open air settlement	70	1	Indet	0.5
23	Portal Vielh	Vendres	L: Hérault (34)	LBA 2b/3a	Bouby et al., 1999	Open air settlement	586	6	> 64	0.5 i 2
23	Portal Vielh	Vendres	L: Hérault (34)	LBA 3b	Bouby et al., 1999	Fortified settlement	5074	7	> 45	0.5 i 2
24	Cayla	Mailhac	L: Aude (11)	IA	Erroux, unpublished	Open air settlement	Indet	Indet	Indet	Indet
25	Buffens	Caunes-Minervois	L: Aude (11)	MBA	Hopf (in Guilaine and Hopf, 1984)	Cave/abri	221	1	Indet	Indet
26	Cazals (Gte des)	Sallèles-Cabardès	L: Aude (11)	MBA	Zeist Van et al., 1983	Cave/abri	9416	1	< 1	0.5

Table 2 (*Continued*)

	Site	Municipality	Region/Department	Chronology	Bibliography	Type of site	No. remains	No. samples	Volume samples (liters)	Smallest mesh (mm)
27	Carsac	Carcassonne	L: Aude (11)	LBA 3	Erroux unpublished	Fortified settlement	6	1	Indet	Indet
27	Carsac	Carcassonne	L: Aude (11)	IA 1	Erroux unpublished	Fortified settlement	Indet	1	Indet	Indet
28	Gravette (La)	Cavanac	L: Aude (11)	LBA 3a	Marinval unpublished	Open air settlement	3		Indet	1
29	Laouret (Le)	Floure	L: Aude (11)	LBA 3a	Marinval unpublished	Open air settlement	78	1	Indet	2
30	Sous Rideaux	Lespugue	P: Hte Garonne (31)	IA 1 (early)	Bouby, Ruas unpublished	Cave/abri	1093	9	71	0.5
31	Khépri	Ganties	P: Hte Garonne (31)	MBA	Bouby, unpublished	Funerari en cova	5793	27	> 10.3	1
32	Grotte des Églises	Ussat	P: Ariège (09)	EBA/MBA	Erroux, 1982	Cave/abri	Indet	1	Indet	Indet
33	Bélesta	Bélesta de la Frontière	P: Pyrenées Or (66)	MBA	Buxó, 1993	Cave/abri	4	1	10	1
33	Bélesta	Bélesta de la Frontière	P: Pyrenées Or (66)	LBA 2/3	Buxó, 1993	Cave/abri	228	2	120	1
33	Bélesta	Bélesta de la Frontière	P: Pyrenées Or (66)	IA 1	Buxó, 1993	Cave/abri	138	1	30	1
34	Carrerrassa	Perpignan	P: Pyrenées Or (66)	EBA	Bouby, unpublished	Open air settlement	173	16	448.5	0.5
35	Montou	Corbère-les-Cabanes	P: Pyrenées Or (66)	EBA	Buxo, 2006	Cave/abri	5309	138	Indet	2
35	Montou	Corbère-les-Cabanes	P: Pyrenées Or (66)	MBA	Buxo, 2006	Cave/abri	566	92	Indet	2
35	Montou	Corbère-les-Cabanes	P: Pyrenées Or (66)	LBA	Buxo, 2006	Cave/abri	373	113	Indet	2
36	Cova d'Anes	Prullans	P: Cerdanya (Lleida)	IBA	Alonso, 1995	Cave/abri	99	1	Indet	Indet
37	Le Menhir	Eyne	P: Pyrenées Or (66)	LBA 3	Bouby, Ruas unpublished	Open air settlement	328	7	Indet	2
38	Lo-Lo Ladre	Llo	P: Pyrenées Or (66)	LBA 3	Ruas et al., 2009	Open air settlement	13428	5	12	0.5
39	Cova 120	Sadernes	P: Garrotxa (Gi)	IBA	Agustí et al., 1985	Cave/abri	27	1	Indet	0.5
40	Bauma Serrat del Pont	Tortellà	P: Garrotxa (Gi)	IBA	Buxó and Català, 1997	Cave/abri	7	1	75	0.5
40	Bauma Serrat del Pont	Tortellà	P: Garrotxa (Gi)	LBA	Buxó and Català, 1994	Cave/abri	130	33	961	0.5
41	Institut de Manlleu	Manlleu	EC: Osona (B)	IBA	Buxó, 1997	Open air settlement	226	15	728	0.5
42	Sant Martí d'Empúries	St. Martí d'Empúries	EC: Alt Empordà (Gi)	IA	Buxó, 1999	Hàbitat: fortificat	1223	39	Indet	0.5
42	Sant Martí d'Empúries	St. Martí d'Empúries	EC: Alt Empordà (Gi)	LBA	Buxó, 1999	Hàbitat: fortificat	85	5	Indet	0.5
43	Illa d'en Reixac	Ullastret	EC: Baix Empordà (Gi)	IA	Buxó, 1997	Hàbitat: fortificat	458	2	140	0.5
44	Torrebonica	Terrassa	EC: Vallès Occ. (B)	IBA	López, 2007a, unpublished	Open air settlement	33	2	32	0.5
45	Bòbila Madurell	St. Quirze del Vallès	EC: Vallès Occ. (B)	LBA	Buxó, 1997	Open air settlement	79	9	109	0.5
45	Bòbila Madurell	St. Quirze del Vallès	EC: Vallès Occ. (B)	IA	Buxó, 1997	Open air settlement	299	32	557	0.5

Table 2 (*Continued*)

	Site	Municipality	Region/Department	Chronology	Bibliography	Type of site	No. remains	No. samples	Volume samples (liters)	Smallest mesh (mm)
46	Can Roqueta	Sabadell	EC: Vallès Occ. (B)	IA	Rovira-Buxó, 1999	Open air settlement	301	15	242	0.5
46	Can Roqueta	Sabadell	EC: Vallès Occ. (B)	BAI	Rovira-Buxó, 1999	Open air settlement	12	4	22	0.5
46	Can Roqueta	Sabadell	EC: Vallès Occ. (B)	LBA	Rovira-Buxó, 1999	Open air settlement	1512	19	542	0.5
47	Can Gambús 2	Sabadell	EC: Vallès Occ. (B)	IA	Hinojo and López, 2008	Open air settlement	658	13	919	0.5
48	Sitges de la UAB	Cerdanyola del Vallès	EC: Vallès Occ. (B)	IA	Alonso and Buxó, 1991 and Alonso, 2008a	Open air settlement	417	15	288	0.5
49	Can Sadurní	Begues	EC: Baix Llobregat (B)	LBA	Kraus-Kashani, 1991	Cave/abri	11	1	Indet	0.5
50	Sta. Maria dels Horts	Vilafranca del Penedès	EC: Alt Penedès (B)	IA	López, 2010a, unpublished	Open air settlement	81	2	97	0.5
51	El Bordellet	Vilafranca del Penedès	EC: Alt Penedès (B)	IBA	López, 2010a, unpublished	Open air settlement	6	3	134	0.5
51	El Bordellet	Vilafranca del Penedès	EC: Alt Penedès (B)	LBA	López, 2010a, unpublished	Open air settlement	62	3	232	0.5
52	Cinc Ponts	Vilafranca del Penedès	EC: Alt Penedès (B)	IBA	López, 2010b, unpublished	Open air settlement	50	9	840	0.5
53	Mas d'en Boixos	Pacs del Penedès	EC: Alt Penedès (B)	IBA	López, 2007b, unpublished	Open air settlement	224	16	337	0.5
53	Mas d'en Boixos	Pacs del Penedès	EC: Alt Penedès (B)	IA	López, 2007b, unpublished	Open air settlement	178	7	181	0.5
54	Solicrup	Vilanova i la Geltrú	EC: Garraf (B)	IA	López 2005, unpublished	Open air settlement	154	3	404	0.5
55	Turó Font de la Canya	Avinyonet del Penedès	EC: Alt Penedès (B)	IA	López, 2004	Fortified settlement	10134	7	1109	0.5
56	Olèrdola	Olèrdola	EC: Alt Penedès (B)	IA	Alonso and Canal, 2009	Fortified settlement	24	2	Indet	0.5
57	Els Vilars	Arbeca	WCP: Les Garrigues (Ll)	IA	Alonso, 1999	Fortified settlement	271	29	771	0.5
58	Minferri	Juneda	WCP: Les Garrigues (Ll)	IBA	Alonso et al., 2006	Open air settlement	5884	58	4559	0.5
59	El Vilot	Alcarràs	WCP: Segrià (Ll)	GSCI	Alonso et al., 2002	Open air settlement	207	1	300	0.5
59	El Vilot	Alcarràs	WCP: Segrià (Ll)	GSCIII	Alonso et al., 2002	Open air settlement	4303	20	1371	0.5
60	Genó	Aitona	WCP: Segrià (Ll)	GSCII	Alonso, 1999	Open air settlement	171	1	40	0.5
61	Vincamet	Fraga	WCP: Baix Cinca (Hu)	GSCII	Alonso et al., 2006	Open air settlement	1336	12	375	0.5
62	Cova de Punta Farisa	Fraga	WCP: Baix Cinca (Hu)	GSCI	Alonso and Buxó, 1995	Cave/abri	993	1	82	0.5
63	Masada de Raton	Fraga	WCP: Baix Cinca (Hu)	GSCI	Alonso, 1999	Open air settlement	1182	4	192	0.5
64	La Codera	Alcolea de Cinca	WCP: Baix Cinca (Hu)	IA	Alonso, 2008b	Fortified settlement	323	2	404	0.5
65	Tozal de los Regallos	Candasnos	WCP: Baix Cinca (Hu)	IA	Alonso, 1999	Open air settlement	115	5	143	0.5
66	Barranc de Gàfols	Ginestar	EC: Ribera d'Ebre (T)	IA	Cubero, 1998	Open air settlement	60	6	10	0.5
67	Sant Jaume	Alcanar	EC: Montsià (T)	IA	López et al., 2011	Fortified settlement	1318	20	562	0.5

Table 3
Ubiquity of taxa with economic value represented by period and by region (only charred remains). (Period 1: 2100–1350/1250 cal BC; period 2: 1350/1250–750 cal BC; period 3: 750–600/500 cal BC).
Tableau 3
Ubiquité des taxons à valeur économique par phase chronologique et région (seulement restes carbonisés). (Période 1 : 2100–1350/1250 cal BC ; période 2 : 1350/1250–750 cal BC ; période 3 : 750–600/500 cal BC.).

Region	LANGUEDOC			PYRENEES			EASTERN CATALONIA			WESTERN CAT. PLAIN			TOTAL
Period	Period 1	Period 2	Period 3	Period 1	Period 2	Period 3	Period 1	Period 2	Period 3	Period 1	Period 2	Period 3	
Number of sites	4	17	14	9	5	2	6	5	12	4	3	3	84
Cereals, seeds													
Hordeum vulgare var. *nudum*	1	3	1	7	2	1	1	3	3	–	–	–	22
Hordeum vulgare var. *vulgare*	3	13	13	6	5	2	6	5	13	4	3	3	75
Hordeum sp.	–	2	1	3	2	–	2	2	1	1	–	–	14
Panicum miliaceum	–	5	5	3	1	1	–	2	8	3	3	3	34
Secale sp.	–	–	–	–	1	–	–	–	–	–	–	–	1
Setaria italica	–	2	2	1	–	1	–	1	9	3	2	2	23
Triticum aestivum/turgidum	2	11	7	7	4	2	5	3	11	4	2	2	59
Triticum dicoccum	3	10	9	7	3	1	4	3	11	4	3	3	60
Triticum monococcum	3	8	5	2	2	–	1	1	4	–	1	–	26
Triticum spelta	–	1	–	–	–	1	–	–	–	–	–	–	2
Triticum sp.	1	7	8	4	2	1	3	1	1	1	1	2	32
Cereals, chaff													
Hordeum vulgare	2	6	2	–	1	1	–	–	1	4	–	2	19
Triticum aestivum/turgidum	–	3	1	–	1	–	–	–	1	3	1	2	12
Triticum dicoccum	2	7	7	2	–	1	–	1	3	3	1	1	28
Triticum monococcum	1	5	1	–	–	–	–	–	–	–	1	–	8
Triticum spelta	–	2	–	–	–	–	–	–	–	–	–	–	2
Triticum hulled	1	5	4	1	–	1	1	–	–	2	–	1	16
Triticum sp.	–	–	–	–	–	–	–	–	–	2	1	1	4
Pulses, oil plants													
Lathyrus cicera/sativus	–	3	1	–	1	–	–	–	2	–	–	–	6
Lens culinaris	–	1	4	1	–	–	–	2	7	1	–	2	17
Medicago sativa	–	–	–	–	–	–	–	1	1	–	–	–	2
Pisum sativum	–	1	–	1	3	1	–	1	6	1	–	–	13
Vicia ervilia	–	1	2	–	–	–	1	–	1	–	–	–	4
Vicia faba	1	2	–	–	–	–	–	1	2	–	–	–	6
Vicia sativa	–	–	–	–	1	–	–	–	2	–	–	–	3
Oil plants													
Camelina sativa	–	–	3	–	–	–	–	–	–	–	–	–	3
Linum usitatissimum, seeds	1	1	–	–	–	–	–	–	2	2	–	1	7
Linum usitatissimum, capsule	1	–	–	–	–	–	–	–	–	–	–	–	1
Papaver somniferum	–	3	–	–	–	–	–	–	–	–	–	–	3
Fruits gathered													
Arbutus unedo	–	1	–	–	–	–	–	–	–	–	–	–	1
Cornus mas	–	1	1	–	–	–	–	–	–	–	–	–	2
Corylus avellana	–	2	–	1	2	1	–	–	–	–	–	–	6
Ficus carica	–	–	1	–	–	–	1	–	3	–	–	2	6
Malus sp.	–	–	1	1	–	–	–	–	–	–	–	–	2
Olea europaea	–	–	–	3	1	–	–	–	2	–	–	–	6
Pistacia lentiscus	1	–	–	–	–	–	1	–	1	2	1	–	6
Prunus sp.	–	1	–	–	–	–	–	–	–	–	–	–	1
Prunus spinosa	–	–	–	–	–	–	–	–	–	1	–	–	1
Quercus sp.	1	4	3	4	4	2	–	1	4	1	1	1	25
Rosa sp.	–	–	–	–	1	–	–	–	–	–	–	–	1
Rubus fruticosus	–	1	–	–	–	1	–	1	1	1	–	–	5
Sambucus ebulus	–	2	2	–	–	1	–	–	–	–	–	–	5
Sambucus sp.	–	2	–	–	–	–	–	–	1	–	–	–	3
Vitis vinifera	–	5	4	2	3	1	2	1	8	1	1	2	29

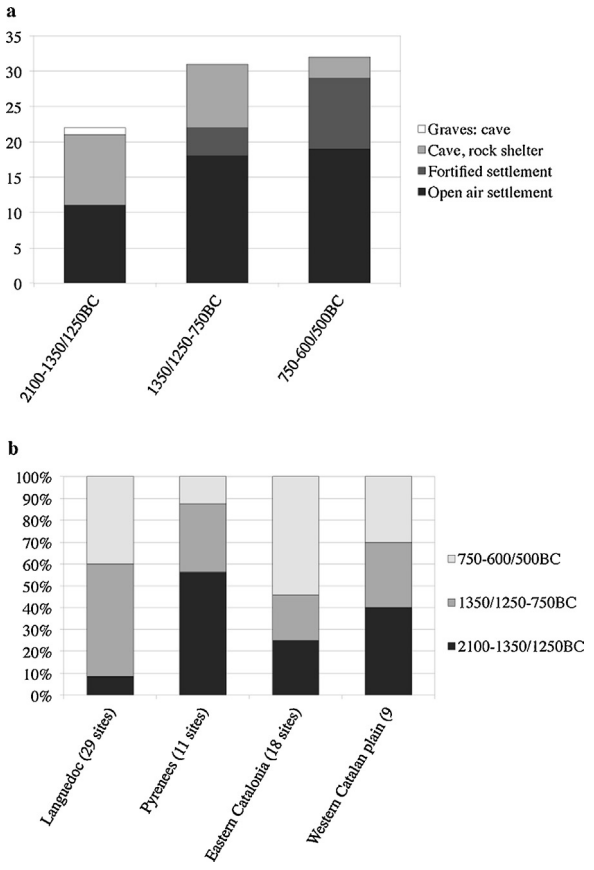

Fig. 2. Stacked histogram indicating the number of sites with archaeobotanical studies by chronological period (a) and region (b).
Fig. 2. Histogramme empilé indiquant le nombre de sites avec des études archéobotaniques par période chronologique (a) et région (b).

The unit of analysis to carry out the CFA of the sites was the chronological phase if the site were to contain more than one. Each phase brings together all the samples that analysed at the site for that peculiar chronological period. In order to obtain a representative range of data, only the phases with a minimum of 50 plant remains were retained (van der Veen, 1992), reducing the number of CFA assemblages from 84 to 52. By the same token, so as to assure the proper perception of the structure of the data, it was necessary to eliminate unusual taxa producing detrimental "noise". Therefore, only the plants present in at least 5% of the assemblages were retained (Valamoti, 2004; van der Veen, 1992) thus restricting the analyses to 32 taxa, of which five were supplementary (chaff of hulled wheat, chaff of undetermined wheat, grains of undetermined wheat and barley, seeds of cultivated pulses). These were, in fact, inaccurate identifications that could lead to bias due to the diversity of encoding methods of the different researchers.

Furthermore, the CFA could not be applied to the total number of remains since it reflects above all the quantity of samples carried out at the sites, as well as the random nature of preservation of plant remains (Pearsall, 2000). Therefore, the number of remains was converted into percentages and then transformed into scores of abundance according to a semiquantitative scale of four classes (1 = up to 2%; 2 = 2–15%, 3 = 15 to 50%, 4 ≥ 50%), a method that allows a better comparison of the variety of types of sites and sampling procedures (Bouby and Marinval, 2004; Jacomet, 2006; Robinson, 2003).

A second approach was also conducted using a Principal Component Analysis (PCA) on data quantified by the Index of Relative Abundance (IRA) following the research of Hastorf et al. (2005). The advantage is that it combines the concepts of taxa abundance and ubiquity into a single index. The PCA results are not presented because, on the one hand, the use of the IRA would reduce the range of data to only 29 assemblages, and secondly, the results confirm the CFA without offering more.

3. Results

3.1. Preliminary regional and chronological approach

Based on the plants remains from the different sites, we can make headway into understanding the general changes of cultivated plants according to their regional and chronological ubiquity (Table 3).

3.1.1. Languedoc

Although the number of sites with seed and fruit remains is scarce in Languedoc in the Early/Middle Bronze Age (Period 1), this period offers a variety of cereals such as hulled barley (*Hordeum vulgare*), naked barley (*Hordeum vulgare* var. *nudum)*, naked wheat (bread wheat or durum wheat, *Triticum aestivum/turgidum*), and hulled wheat (emmer, *Triticum dicoccum* and einkorn, *Triticum monococcum*). Hulled barley and hulled wheat are predominant during the Late Bronze Age and the First Iron Age, whereas naked wheat is equivalent to emmer. The Late Bronze Age (Period 2) sees the introduction of cultivated millet, especially common millet (*Panicum miliaceum*) followed by Italian millet (*Setaria italica*). The emergence of spelt (*Triticum spelta*), recovered in large quantities at Baume Layrou (Bouby et al., 2005), is noteworthy (Fig. 3). Naked barley *(Hordeum vulgare* var. *nudum*), in turn, is residual. Chaff, in particular that of emmer and einkorn, is also considerable throughout all the chronological phases. Barley and naked wheat chaff, on the contrary, are less common.

Broad bean (*Vicia faba*) is the only pulse that has been identified in the Early/Middle Bronze Age (Period 1) sites, while this variety in the Late Bronze (Period 2) and First Iron Age (Period 3), although more common, is random, and apparently does not play an important role. Lentil (*Lens culinaris*) and grasspea (*Lathyrus cicera/sativus*) are probably the most common pulses. Flax (*Linum usitatissimum*) is found in the Early/Middle Bronze Age (Period 1) and the Late Bronze Age (Period 2) in the form of seeds and capsules. Furthermore, opium poppy (*Papaver somniferum*) is known in the Late Bronze Age (Period 2) and camelina (*Camelina sativa*) in the First Iron Age (Period 3). These last two taxa have been detected only in Languedoc partly due to their presence at wetland sites. In this region, their ubiquity is similar to that of pulses.

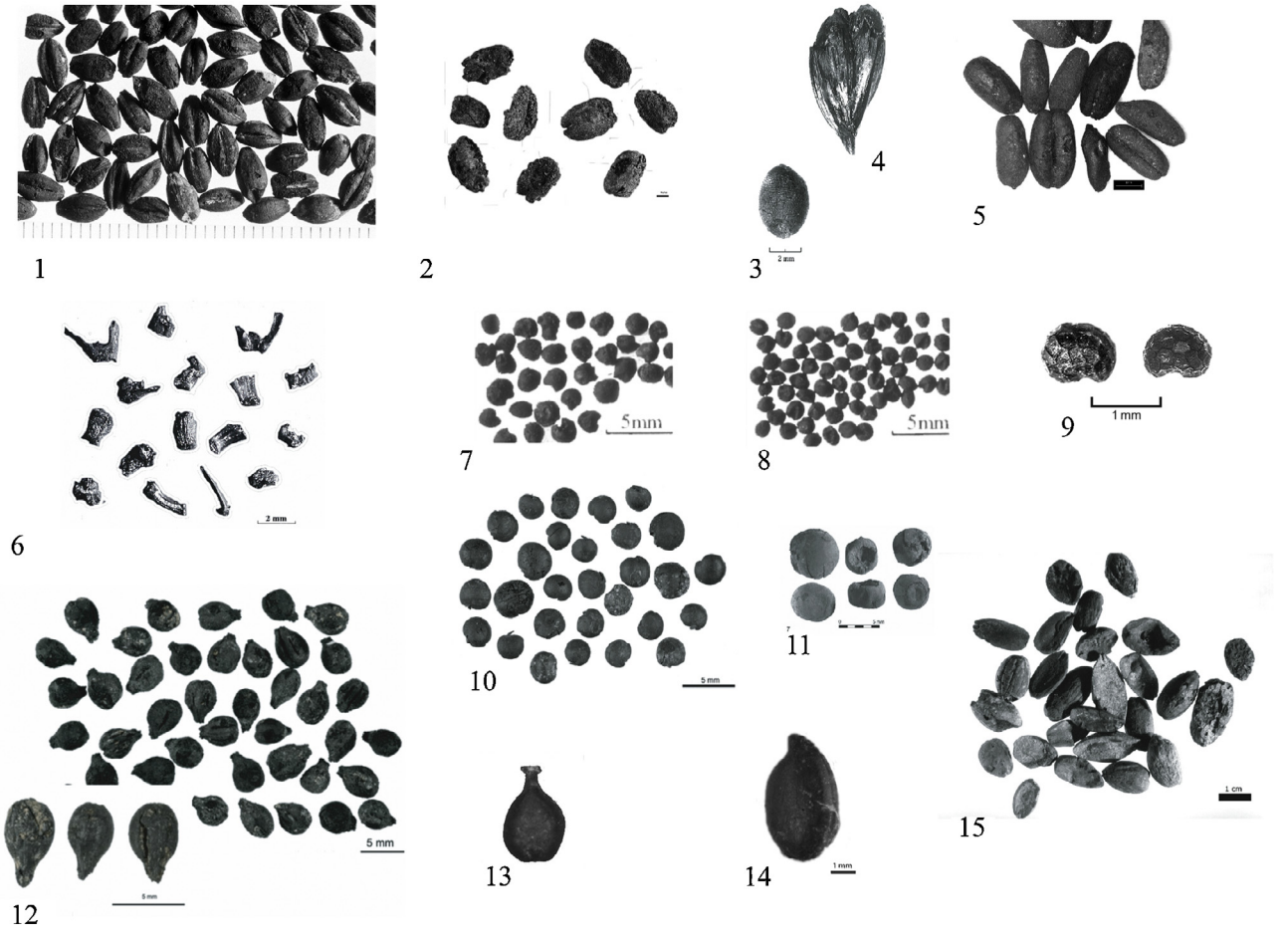

Fig. 3. (1) Hulled barley, *Hordeum vulgare* (Lattes Port Ariane) [photo: L. Damelet]; (2) naked wheat, *Triticum aestivum/turgidum* (Minferri) [photo: SRI, UDL]; (3) naked barley, *Hordeum vulgare* var. *nudum* (La Brégoule) [photo: L. Bouby]; (4) emmer, *Triticum dicoccum* (Grésine) [photo: L. Bouby]; (5) spelt, *Triticum spelta* (Baume Layrou) [photo: L. Bouby]; (6) wheat and barley chaff (El Vilot) [photo: SRI, UDL]; (7) millet, *Panicum miliaceum* (Cova de Punta Farisa) [photo: MAC]; (8) Italian millet, *Setaria italica* (Cova de Punta Farisa) [photo: MAC]; (9) Poppy, *Papaver somniferum* (Grésine) [photo: L. Bouby]; (10) lentils, *Lens culinaris* (Turó de la Font de la Canya) [photo: SRI, UDL]; (11) peas, *Pisum sativum* (Llo) [photo: L. Bouby]; (12) charred grape pips, *Vitis vinifera* ssp. *vinifera* (Turó de la Font de la Canya) [photo: D. López]; (13) waterlogged grape pips, *Vitis vinifera* ssp. *vinifera* (Cougourlude) [photo: L. Bouby]; (14) flax, *Linum usitatissimum* (Minferri) [photo: SRI, UDL]; (15) acorns, *Quercus* ('boulevard périphérique nord', Lyon, France) [Photo: A. Guey].

Fig. 3. (1) Orge vêtue, *Hordeum vulgare* (Lattes Port Ariane) [photo : L. Damelet] ; (2) blé nu, *Triticum aestivum/turgidum* (Minferri) [photo : SRI, UDL] ; (3) blé nu, *Hordeum vulgare* var. *nudum* (La Brégoule) [photo : L. Bouby] ; (4) blé amidonnier, *Triticum dicoccum* (Grésine) [photo : L. Bouby] ; (5) épeautre, *Triticum spelta* (Baume Layrou) [photo : L. Bouby] ; (6) chaff de blé et d'orge (El Vilot) [photo : SRI, UDL] ; (7) millet, *Panicum miliaceum* (Cova de Punta Farisa) [photo : MAC] ; (8) Millet des oiseaux, *Setaria italica* (Cova de Punta Farisa) [photo : MAC] ; (9) pavot somnifère, *Papaver somniferum* (Grésine) [photo : L. Bouby] ; (10) lentille, *Lens culinaris* (Turó de la Font de la Canya) [photo : SRI, UDL] ; (11) peas, *Pisum sativum* (Llo) [photo : L. Bouby] ; (12) pépins de raisin carbonisés, *Vitis vinifera* ssp. *vinifera* (Turó de la Font de la Canya) [photo : D. López] ; (13) pépins de raisin imbibés, *Vitis vinifera* ssp. *vinifera* (Cougourlude) [photo : L. Bouby] ; (14) lin, *Linum usitatissimum* (Minferri) [photo : SRI, UDL] ; (15) glands, *Quercus* (boulevard périphérique nord de Lyon) [Photo : A. Guey].

Flax and poppy are represented mainly by waterlogged remains in wetland contexts and rarely in a charred state on dry sites. The waterlogged remains date to the later phases of the Middle Bronze Age and the Late Bronze Age on the banks of Thau Basin (Periods 1 and 2) (Bouby, 2014; Bouby et al., 1999).

Preservation due to wet conditions has also resulted in a wide variety of fruit in this area, notably many types that are not present elsewhere. This is the case of strawberry tree (*Arbutus unedo*), cornelian cherry (*Cornus mas*) and danewort (*Sambucus ebulus*). The most common fruit harvested, found mostly in charred conditions, are acorns (*Quercus* sp.), hazelnuts (*Corylus avellana*) and grapes (*Vitis vinifera*). They date specifically to the Late Bronze and First Iron Age (Periods 2 and 3). The charred acorns at Portal Vielh (Bouby, 2014) is the most remarkable fruit concentration (Fig. 3).

The dioecious wild grapevine is indigenous to the western Mediterranean and Europe and still present today in Languedoc (This et al., 2001). The domestic form of grape is identified at La Cougourlude (550–475 BC) by morphometric analyses of the pips (Figueiral and Bouby, unpublished). Modern wild and domesticated grapevines bear pips of different shape that can be distinguished with a high degree of statistical confidence by geometric as well as traditional morphometry (Bouby et al., 2013).

3.1.2. Pyrenees

The data available for the Pyrenees are mainly from the Bronze Age. There are, in fact, only two sites with archaeobotanical remains from the First Iron Age. Cereals dominate in the Early to Middle Bronze Age (Period 1) and persist in later periods. They comprise for the most part hulled and naked barley, naked wheat and emmer. It is noteworthy that naked barley is just as common as other cereals, yet suffers a clear decline in the Late Bronze Age (Fig. 3). Millet, both common and Italian, is present from the Early/Middle Bronze Age (Period 1). Chaff, especially barley and emmer, are sporadic and less frequent in the Pyrenees than in Languedoc. The absence of chaff could be explained, at least in part, by the fact that sieving with a 0.5 mm mesh was not carried out systematically in the Pyrenees.

Traces of rye (*Secale cereale*) are recorded in the Late Bronze Age (Period 2) at Llo (Ruas et al., 2009). These remains, probably weeds, are, to date, the only indication of this cereal in the Late Bronze Age (Period 2). Spelt, in turn, is identified in Iron Age (Period 3) context.

Pulses are fairly diversified. Vetch (*Vicia sativa*) is only known in the Late Bronze Age (Period 2) of the northwestern Mediterranean at Montou (Buxó, 2006). This single example, as in the case of rye, is probably adventitious and not indicative of cultivation. The most characteristic Pyrenean legume is pea (*Pisum sativum*), known from the Early to the Middle Bronze Age (Period 1). It was recovered in a concentration (corresponding to storage) in a Late Bronze Age context at Llo (Ruas et al., 2009) (Fig. 3).

Acorn is the most common fruit. A concentration from the First Iron Age (Period 3) was brought to light at Abrisous-les-Rideaux (Bouby and Ruas, unpublished) along with hazelnuts and grapes. Wild apple was also known in the Early Bronze Age (Period 1) and is represented by a fruit at Cova 120 (Agustí et al., 1985).

3.1.3. Eastern Catalonia

Sampling took place fairly systematically in eastern Catalonia, especially at sites of the First Iron Age (Period 3). As noted above, these sites are concentrated specifically in the central coastal region.

Cereals are well represented especially by hulled barley. Emmer and naked wheat are balanced from the point of view of ubiquity. As in the case of Languedoc, millet and Italian millet were introduced in the Late Bronze Age (Period 2). These two types of millet were, in fact, strongly represented at most sites of this area in the First Iron Age (Period 3), whereas naked barley and einkorn are rare.

Chaff is rarely recorded. It is only present in two cases (hulled barley and naked wheat). However, in the First Iron Age (Period 3), the quantity of emmer chaff increases. Yet its number is insignificant when compared, for example, to numbers in Languedoc.

The situation of legumes in this region is more complete. Although only bitter vetch (*Vicia ervilia)* has been identified during the Initial Bronze Age (Period 1), in the Late Bronze Age (Period 2), and especially during the First Iron Age (Period 3), legumes increase in number and diversity. The most important are peas and especially lentils, recovered in large concentrations at Turó de la Font de la Canya (López, 2004) (Fig. 3). Faba and vetch, in turn, have only been identified in this area at First Iron Age sites. The same applies to alfalfa (*Medicago sativa*), which in the Late Bronze Age is only identified in this area.

Oil plants are only represented by flax, a species that is documented for the first time in the First Iron Age. Among the fruit is mastic (*Pistacia lentiscus*) and acorns. This last species, in particular, is still most commonly represented by concentrations from the Initial Bronze Age (Period 1) at Can Roqueta (Rovira and Buxó, 1999) and in the First Iron Age (Period 3) at Barranc de Gàfols (Cubero, 1998).

One of the most interesting facts observed in eastern Catalonia, which we will explore further in this study, is the progressive increase of the vine, both in ubiquity – it is present in more than 50% of the First Iron Age sites – and in important concentrations dating back to the 7th century BC at Turó de la Font de la Canya (López, 2004). This fruit is present not only in the form of pips, but also as fragments of pedicels and mesocarps, waste products indicative of wine making (Fig. 3).

3.1.4. Western Catalonian plain

This area, the least extensive and with the lowest number of sampled sites, provides nonetheless a wide variety of cereals from the middle of the second millennium. Hulled barley, naked wheat and emmer, and large numbers of millet and Italian millet are recovered at sites from the Segre-Cinca Group I (Period 1). This balance between cereals will remain almost unchanged until the First Iron Age (Period 3). Naked barley, however, has not been identified and einkorn is residual. Chaff of hulled barley and, above all naked wheat, is well represented (Fig. 3).

Pulses in the form of lentils and peas, on the contrary, are rare. It must be noted that the few finds are very poorly

preserved, making this family difficult to determine when recovered among other common unidentifiable legumes. The only oil plant is flax, identified at Minferri, a site dating back to the Full Bronze Age (Period 1) (Alonso et al., 2006) (Fig. 3). The principal fruit is acorn, recovered in a concentration as is often the case, at Tozal de los Regallos (Alonso, 1999). Mastic and grapes stand out among the other fruit. Mastic, in particular, dates to the Full Bronze Age (Period 1) and may in fact have no relation with fruit consumption, as its branches are known to have been collected for firewood (Alonso et al., 2015).

3.2. Results of the Correspondence Factor Analysis (CFA)

As noted above, a CFA was carried out so as to observe the chronological and geographical structure garnered from the carpological data from 52 sites and 32 taxa following the standards explained above. Compared to the results of the ubiquity of taxa presented above, CFA is rooted on abundance values allowing a comprehensive analysis of the data from all phases avoiding preconceptions regarding the chronological or geographical grouping of sites.

The first two axes of the CFA expressed 23.8% of the inertia. The sites are first organised according to geography, and secondly according to chronology (Fig. 4).

Axis 1 demarcates the sites of the Pyrenees (linked to the positive pole) from those of Languedoc, (in the negative space). The Pyrenees sites are associated with naked barley, naked wheat and pea, whereas those in Languedoc are linked to cereal chaff (mainly hulled wheat), millet, Italian millet, and poppy. Axis 2 initially marks a difference between Languedoc (in the positive space) and the western Catalonian plain (attracted to the negative pole). This last region is linked to mastic, naked wheat, hulled barley chaff, Italian millet, and flax. Eastern Catalonia is halfway between the western Catalonian and the Pyrenees/Languedoc group. In sum, a fairly clean geographic north-east/south-west gradient stands out by the spread of sites around the origin of the graph. Axis 3 (8.85% of inertia, not seen in the figure) can be added to this design since it reveals a disparity between the western Catalonian plain (associated with naked wheat, lentils and fig) and the Pyrenees and Languedoc (for the most part linked to acorn, hazelnut, poppy and fava).

The effect of chronology is added to that of geography in the distribution of the sites in the first CFA plot. There is a gradient from ancient to recent sites that stretches from the positive to the negative pole of axis 1, and from the negative to the positive pole of axis 2. Therefore, the chronological effect is not identical from one region to another. In Languedoc and the Pyrenees – and also perhaps eastern Catalonia – Period 1 is mostly linked to naked barley and naked wheat, while other plants such as hulled wheat, millet and poppy in particular are gaining in importance over time. Yet there is a lag between these two regions as seen by earlier innovative developments taking place in Languedoc. Chronology in Catalonia is marked on axis 2. In eastern Catalonia, the situation during the earliest phase is different from that in the North, especially because of the lack of naked barley. Yet the trend is for the model to proceed in the direction of that of Languedoc. The western Catalonian plain also reveals a different situation, especially due to the absence of naked barley and the early arrival of millet. During the First Iron Age (Period 3), its tendency is to approach the situation of eastern Catalonia and Languedoc.

4. Significance, distribution and chronological changes of plant resources in the northwestern Mediterranean arc

From the data obtained in this study, we can infer that the CFA provides interesting information about early plant exploitation in terms of spatial organisation and chronological changes.

To begin with, the overall results corroborate the important role of cereals compared to that of other taxa such as pulses and fruit. Of course, it must be borne in mind that charring favours the preservation of cereals. Furthermore, there is a marked increase in the use of hulled barley throughout the territory, while naked barley, characteristic of the Pyrenees and Languedoc in the Period 1, suffers a clear decline toward the beginning of the first millennium. A similar situation occurs in eastern Catalonia, although naked barley is not as prevalent in the earlier chronological phases. The western Catalonian plain, in turn, is characterised by its absence.

An increase in hulled wheats throughout the Bronze Age and the First Iron Age is generally recognised throughout all the territory. These cereals, especially emmer, in Languedoc are most often represented by chaff. Naked wheat is characteristic of the Pyrenees and the western Catalonian plain where its chaff, in addition to that of hulled barley, is also abundant. Einkorn is residual and other taxa, such as spelt and rye, appear sporadically in Languedoc and in the Pyrenees.

In spite of the frequency of cereal chaff at some sites and in certain areas, it is not homogeneous in the archaeological record. This lack of uniformity may be related to the taphonomy of the remains and their means of processing (parching or not, carried out in bulk outside of the settlement or little by little day-by-day indoors, etc.) and/or the use of their by-products after harvesting. In addition, an important factor in the question of the preservation of chaff remains depends on their archaeological and sedimentary contexts. Charred remains can, at times, be abundant and will increase in number in waterlogged conditions.

Millet and Italian millet, spring cereals, are introduced from the middle of the second millennium in the western Catalonian plain and in the Pyrenees (Period 1), and from the Late Bronze Age (Period 2) in eastern Catalonia and Languedoc. Although these crops are abundant in the western Catalonian plain in the Segre–Cinca Group I phase (Period 1), it is in the First Iron Age (Period 3) that they will spread throughout all of the territory.

Pulses, in general, can be considered complementary, since, with a few exceptions, they are neither ubiquitous nor numerous. However, several types mark differences between geographical areas. This is the case of the pea in the Pyrenees and the fava in the Pyrenees and Languedoc. Nonetheless, the largest diversity of pulses occurs during the First Iron Age, especially in eastern Catalonia. Yet the

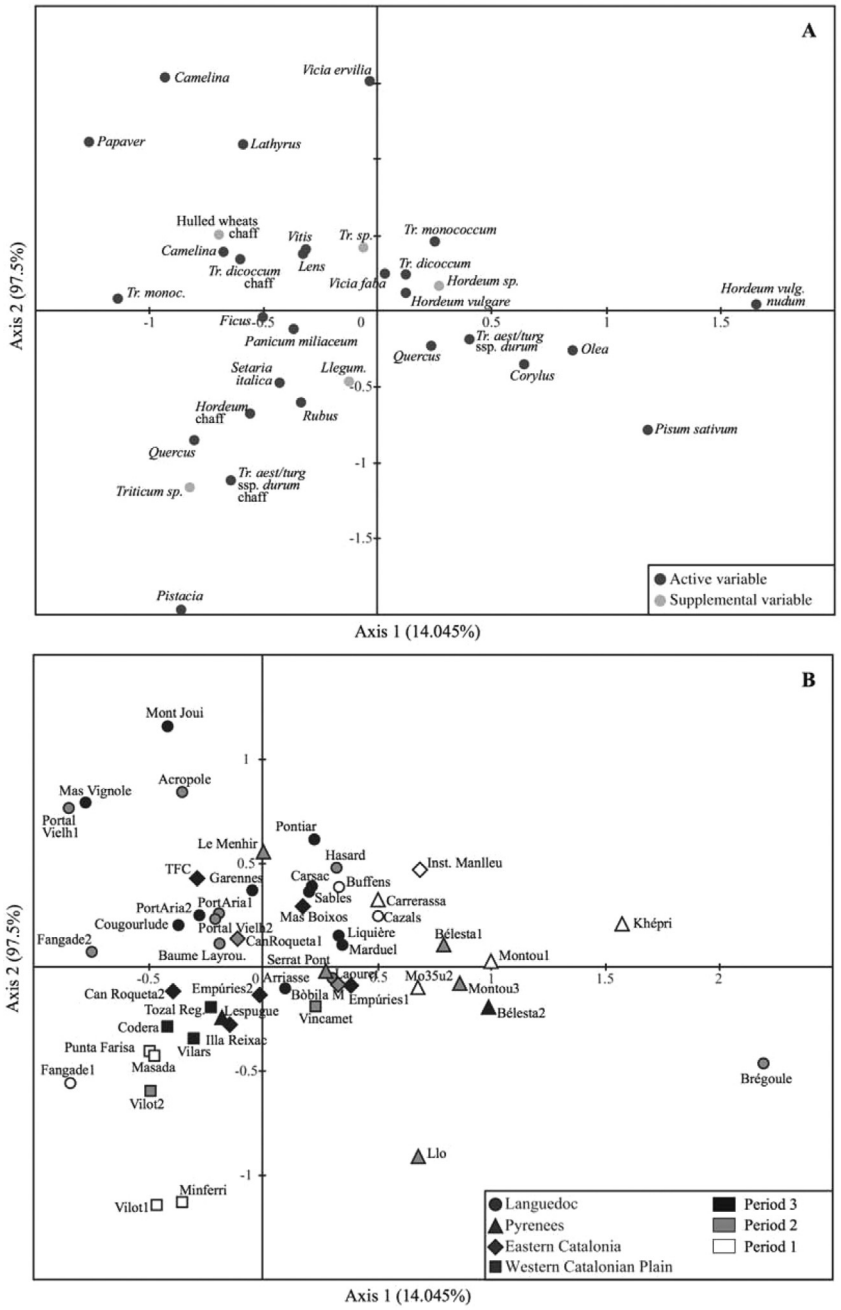

Fig. 4. Graphic representation at the first factorial level of the results of the Correspondence Factor Analysis conducted on taxa with economic value. A: Taxa. B: Sites. (Period 1: 2100–1350/1250 cal BC; Period 2: 1350/1250–750 cal BC; Period 3: 750–600/500 cal BC).
Fig. 4. Représentation au premier plan factoriel des résultats de l'Analyse factorielle de correspondance réalisée sur les taxons à valeur économique. A. Projection des taxons. B. Projection des sites (période 1 : 2100–1350/1250 cal BC ; période 2 : 1350/1250–750 cal BC ; période 3 : 750–600/500 cal BC).

lentil remains the most frequent and abundant throughout the whole archaeological record.

The only oil plant present throughout the different regions is flax. It is known since the second millennium in the western Catalonian plain and in Languedoc. Due to preservation, it is more abundant and diversified on wetland sites in Languedoc, where it coincides with poppy.

Regarding fruit, acorns appear to stand out in all the different regions and certain concentrations can be attributed to storage. The 13 fruit taxa reveal their great diversity and the fact that fruit harvesting played an important role in the economy of the early populations. Due to the conditions of preservation, fruits are probably under-represented at dry sites. Wetland sites along Languedoc's coast, for example, provide a more accurate portrait than charred finds from

dry sites, particularly in the case of fig, mastic, bramble, elder, and grape.

Two species, olive and grapevine, are particularly important due to the value their cultivation will attain during the Iron Age. Olives in the First Iron Age (Period 3) are only known at two settlements with evidence of Greek influence, notably San Martí d'Empúries and Illa d'en Reixach (Buxó, 2008). Although archaeobotanical remains of olives are scarce, it cannot be ruled out that they were cultivated at this time.

Data regarding grapevine are now more abundant and informative. The number of charred grape pip finds is progressively increasing attaining ubiquity values comparable to those of minor cereals (millet) during the First Iron Age (Period 2). This points out to a growing economic significance of vine. The presence of this fruit from the 7th century BC in large quantities at indigenous sites with Phoenician influences such as Turó de la Font de la Canya or Sant Jaume/Mas d'en Serrà (López et al., 2011), and/or in association with certain seeds with clear domestic morphology notably at Cougourlude or at Sant Martí d'Empúries (Figueiral and Bouby, unpublished; Buxó, 2008) indicates that its cultivation already played a significant role at the time.

Other important concentrations of *Vitis* in the Ebro Valley, several hundred kilometres inland from the study area, date to the 7th century BC. This is the case of Cabezo de la Cruz (Zaragoza) (Pérez Jordà 2009) and Alto de la Cruz (Navarra) (Cubero, 1990). These examples serve as evidence of the rapid spread of viticulture in the Iberian Peninsula. These finds reinforce the idea that viticulture was already established in the 7th century in the region and that its increase in ubiquity, although not in all cases quantified by a high number of remains, can correspond to its general expansion. This spread varies in time from site to site. Grape cultivation in southern France, notably in the Rhone Valley and the coastal plain of Languedoc, for example, is not recorded before the second half of the 6th or possibly the 5th century BC (Bouby, 2014; Bouby et al., 2014; Py and Buxó, 2001).

Grapevine cultivation also marks a turning point in the development of agriculture. In fact, throughout all of the Bronze Age, despite several innovations, the agricultural system remained basically unchanged. Fruit trees, initially in the form of grapevines and later olive (and fig) trees, are species with a delayed return that break with an agricultural rhythm that, up to then, was rooted only on obtaining immediate returns, in the form of grains and pulses. The addition of arboriculture by the northwestern Mediterranean population therefore implies long-term ties to their territory because these types of crops require perennial plantations.

The question of whether the cultivation and domestication of grapes resulted from the dynamics of indigenous agriculture or as a consequence of Mediterranean colonial influence is compelling. The archaeological record at this stage cannot provide a clear answer. Nonetheless, it cannot be ruled out that the tradition of indigenous arboriculture was exploited by colonial contacts for wine production.

The increase in relevance of viticulture, together with the expansion of millets, and the consolidation of hulled barley, suggests a uniformity of taxa cultivated in the northwestern Mediterranean arc between the Ebro and Rhone Rivers during the First Iron Age. As gleaned from the CFA analysis, the sites of this period are grouped in the centre of the graph, while differences between the different regions are much more pronounced during the Bronze Age (Fig. 4).

The chronological changes in crop plants that can be tracked from one micro-region to another in Catalonia and Languedoc are in accordance with the global picture of crop plants at the western Mediterranean and European scales. Most of the changes identified during the Bronze Age in these southern regions, such as the spread and proliferation of millets, spelt, hulled barley and oil plants, take place earlier and are more pronounced to the north of the Alps as evidenced in Switzerland and northeastern France (e.g., Bouby, 2014; Bouby et al., in press; Stika and Heiss, 2013). On the other hand, there is no evidence of cultivation of fruit trees in these regions north of the Alps during the Bronze Age and the First Iron Age.

The situation in Italy seems to mirror to some extent that observed in Catalonia and Languedoc with the occurrence of similar changes (Castelletti et al., 2001; Fiorentino et al., 2004; Mercuri et al., 2006, 2015; Stika and Heiss, 2013). Spelt seems to play a significant role only in the Alpine area of northern Italy, while millets appear to increase in prominence during the First Iron Age. As to the role of emmer, there exists likely a similarity between northern Italy and southern Mediterranean France (Bouby, 2014).

Although the picture is not entirely clear, grape cultivation appears to have been introduced earlier in Italy than in southern France or even in Catalonia. Certain authors have even proposed that it was cultivated in northern Italy as early as the Bronze Age (Bellini et al., 2008; Mercuri et al., 2006). Hard evidence from the morphology of pips leads us to suppose it was also cultivated in Sardinia about 1300 BC (Orrù et al., 2013).

Turning to the situation of cereals in the South, that is, in the region of Valencia and Andalusia, there are little changes as naked wheats and barleys remain predominant. A transition from naked barley to hulled barley also takes place in the Bronze Age. This change is not synchronous with that of the region of Valencia as it disappears in the middle of the second millennium, while in Andalusia it remains an important crop until the Late Bronze Age. However, after this period, naked barley also vanishes (Pérez Jordà, 2013; Rovira, 2007; Stika and Heiss, 2013).

Emmer, although present, begins to wane and there is no evidence of spelt. Millet, meanwhile, is very rare until the First Iron Age, appearing sparsely in Andalusia (Rovira, 2007) and unknown in the region of Valencia until the 8th century BC (Pérez Jordà, 2013).

A profound transformation of the agrarian structure is only discernible from the 8th and 7th centuries BC along the Mediterranean coastline south of the Ebro. This is marked mainly by the important pivotal introduction of fruit trees, for the most part grapevine, fig, olive as well as pomegranate and apple/pear. This indicates a diversified fruit production tightly linked to the Phoenician colonial presence (Pérez, 2013, 268).

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