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Changes in the vegetation and human management of forest resources in mountain ecosystems at the beginning of MIS 1 (14.7–8 ka cal BP) in Balma Guilanyà (Southeastern Pre-Pyrenees, Spain)

Changement dans la végétation et gestion humaine des ressources forestières dans des écosystèmes montagnards au début du MIS 1 (14,7–8 ka cal BP) à la Balma Guilanyà (sud-est Pre-Pyrénées, Espagne)

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ABSTRACT

The site of Balma Guilanyà (southeastern Spain) records an extensive human occupation during the beginning of MIS 1, based on a variety of archaeobotanical indicators, although its sequence contains gaps in the record of human occupation. The study of different archaeological proxies recovered from its sequence, especially charcoal, seeds and fruits, allows analysis of the ecological changes that occurred at the southern flanks of the Pyrenees from the Bølling/Allerød amelioration to the Boreal. The analyses also illuminate the strategies developed by hunter-gatherers of the northeastern Iberian Peninsula, and especially of the changes in firewood used at this site over a long time (over 5000 years), which indirectly provide information about the transformation of the plant communities of mountain ecosystems. In parallel, a growing interest in re-collecting wild fruits can be perceived. The results suggest that this activity was widely in use during the early Holocene, although it may go back to the Allerød. These results suggest that despite the limitations of the archaeobotanical record of Balma Guilanyà, we can recognize different patterns in the management of plant resources by the hunter-gatherers that intermittently visited this site.

Mots clés :
Sud est-Pyrénées
Bølling/Allerød
Holocène initial
Changements environnementaux
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Cueillette

RÉSUMÉ

Dans cet article, nous présentons les différents indicateurs archéobotaniques récupérés à la Balma Guilanyà. Ce site enregistre une occupation humaine importante au début du MIS 1, bien que la séquence contienne des lacunes d'occupation. L'étude des différents registres archéologiques récupérés dans cette séquence, en particulier les charbons de bois, les graines et les fruits, nous ont permit de réaliser une analyse des changements écologiques qui se sont produits sur le versant sud des Pyrénées de l'amélioration climatique Bølling/Allerød au Boréal. Les résultats permettent d'analyser les stratégies développées par

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les chasseurs-cueilleurs du nord-est de la Péninsule Ibérique, et plus particulièrement les changements dans la collecte du bois pendant une longue échelle temporelle (5000 ans), qui, indirectement, fournit des informations sur la transformation des communautés végétales dans les écosystèmes de montagne. En parallèle, un intérêt croissant pour la cueillette des fruits sauvages est mis en évidence. Les résultats obtenus suggèrent que cette activité a été largement réalisée au cours de l'Holocène initial, même si elle peut éventuellement avoir commencé à l'Allerød. Ces résultats suggèrent que malgré les limitations présentées par l'assemblage archéobotanique de Balma Guilanyà, ils permettent la reconnaissance de trajectoires différentes concernant la gestion des ressources végétales par les chasseurs-cueilleurs qui visitaient ce site de manière sporadique.

1. Introduction

The climatic changes that occurred during Marine Isotope Stage 1 (MIS 1), in the interval between GI-1e and the 8.2 ka event, affected the hunter-gatherer lifestyle in the ecosystems of the Iberian Peninsula (Gamble et al., 2004). The last hunter-gatherers of the Mediterranean area subsisted on hunting small prey, fishing, and gathering molluscs (Hockett and Haws, 2003; Stiner et al., 2000; Straus, 2006). Plants were increasingly important as fruit and fuel (Allué et al., 2010; Bonzani, 1997; Holden et al., 1995; Jäger and Schäfer, 1999; Mason and Hather, 2002; Revedin et al., 2010; Speth and Spielmann, 1983; Théry-Parisot, 2001).

On the Iberian Peninsula, many archaeobotanical studies of archaeological sequences (e.g., Allué, 2002, 2009; Aura et al., 2005; Carrión-Marco, 2005; Carrión et al., 2010; Heinz and Barbaza, 1998; Marinval, 1995, 2007; Uzquiano, 2000; Zapata et al., 2002) provide various indicators of ecology and subsistence that describe how hunter-gatherers managed these resources. Furthermore, charcoal records from different areas have provided a general overview of forest composition and landscape transformations (Delhon and Thiébault, 2009; Théry-Parisot, 2001; Théry-Parisot and Thiébault, 2005; Vernet, 1997).

Archaeological sequences from the NE Iberian Peninsula between 14.7–8.2 ka cal BP show profound ecological alterations. The plant communities from this area are variable, and although they represent local conditions, they allow characterization of forest ecosystems (Allué, 2009; Burjachs, 2009; Delhon and Thiébault, 2009; Jalut and Turu-Michels, 2009). These archaeobotanical assemblages permit an analysis of the responses developed by human groups in a dynamic setting in which climatic crises triggered important ecological changes.

2. Site description

Balma Guilanyà is a rock shelter located in the Serra de Busa, the first foothills of the Pre-Pyrenees (Navès, Solsonés, Lleida), at 1157m a.s.l. (Fig. 1). Its coordinates are (385087, 4660546) (UTM H31N/ED50). The site is located under a cornice of Oligocene conglomerates of the Berga upper alluvial system (ICC, 2008). Between 2001 and 2008, systematic excavations were carried out here.

Two archaeostratigraphic units are distinguished: an upper and a lower unit separated by successive collapses of the rock shelter wall. This is especially important for the central zone of the deposit. The fallen massive blocks seal the lower unit and are overlain by the upper unit. At the top of the upper unit, another major blockfall is detected, but it does not record later human occupations (Fig. 2).

The sedimentation of the deposit is very homogeneous and is basically composed of a clayey matrix with pebbles and detritic elements of centimetric size originating from the alteration of the cornice conglomerates, without showing relevant litho-sedimentary variations. In the 2.5 m thick sedimentary deposit, five archaeological units are recognized, defined by changes in the density of the vertical distribution of lithic and faunal remains and charcoal. The upper unit consists of very homogeneous sediment in which at least two principal accumulations are distinguished, C and C1, which are continuous in the east-west direction. Their extent towards the exterior of the rock shelter is unknown because these parts were disturbed by the construction of a dirt road. Directly under the collapsed rock in the centre of the stratigraphic column lies level E. It covers the whole rock shelter surface and consists of various occupations (excavated in different ways). A test

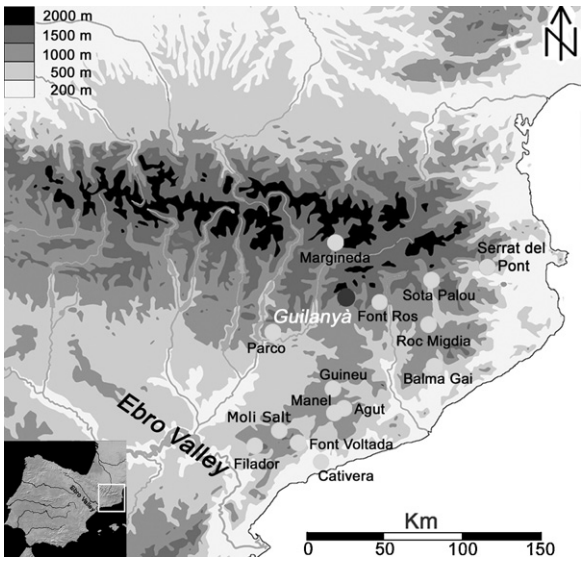

Fig. 1. Location of Balma Guilanyà (Lleida Pre-Pyrenees) and other sites mentioned in the text.
Fig. 1. Localisation de Balma Guilanyà (Lleida Pre-Pyrénées) et d'autres sites mentionnés dans le texte.

Fig. 2. Balma Guilanyà. Upper photo, conglomerate cornice where the site is located. Lower left photo, sedimentary thickness of the Holocene series and its imbrication with the dripline from the top to the base. Lower right photo, detail of the excavation in which can be seen the lower sequence attributed to the chronozone GI-1; whereas in the lower part can be observed the block falling over, upon which the upper unit lay (early Holocene).
Fig. 2. Balma Guilanyà. Photo supérieure, corniche de conglomérat où se trouve le site. Photo inférieure gauche, dépôt sédimentaire de l'Holocène et son imbrication avec la ligne de chute du toit a la base. Photo inférieure droite, détail de la fouille où on peut voir la base de la séquence de la chronozone GI-1 ; alors que dans la partie inférieure, on peut observer la chute des blocs tombés sur l'unité supérieure (Holocène initial).

pit dug in the eastern sector of the rock shelter reached the underlying units EJ and K, which are expected to have lateral continuity for a large part of the deposit (Martínez-Moreno and Mora, 2009).

The archaeological units are up to 20 cm thick and have a limited vertical dispersion. It seems that the collapses of the cornice registered throughout the sequence provoked processes of sedimentary compression that altered the vertical distribution of the archaeological units (Figs. 2 and 3). The geometry of the distribution of artifacts indicates that the basal levels EJ and K could represent sporadic occupations, while the accumulations of levels E, C and C1 display palimpsests produced by an undetermined number of visits (Fig. 3).

Currently, 14 ^{14}C dates are available at different level of chronometric resolution (Martínez-Moreno et al., 2006, 2007, 2011). The temporal distributions define events in which the site registered occupations and discontinuities in its occupation (Fig. 4). Following this premise, it was established that the oldest occupations of the lower sequence (K and EJ) occurred during stage GI-1e (Bølling), while level E corresponds to the end of stage GI-1a (Allerød) and the Younger Dryas (YD) onset (Lowe et al., and INTIMATE group, 2008), Table 1. For the occupations of the upper sequence, C1 is ascribed to the Pre-Boreal and level C to the Boreal. The series documents an undetermined number of visits to the rock shelter between 14.9 and 9 ka cal BP, except during the YD cold pulsation during which, to our knowledge, the site was occupied only at the beginning of this event, or where the deposit of occupations has not been preserved due to erosive processes.

3. Materials and methods

This study is based on the analysis of anthracological remains recovered from five different archaeological levels; charcoal was mainly recovered by hand, although a significant part of the charcoal from lower levels EJ and K was obtained by flotation of the residue (sifting the excavated sediment with the use of water). This study also includes the results of the 1992 excavation (Martínez-Moreno et al., 2006; Parcerisas et al., 2003).

For the taxonomic identification of the anthracological remains, each charcoal fragment was split by hand in order to obtain the three anatomical sections that make up the woody structure, for observation with a metallographic microscope (Olympus BX41). In case of doubt, a wood atlas (Schweingruber, 1990; Vernet et al., 2001) or the current reference collection was consulted.

The macroremains attributed to seeds and fruit within the charcoal complex were put out for analysis, based on morphological comparison with present-day carbonized materials from the reference collection and by consulting specialized publications (Jacquat, 1988; Cappers et al.,

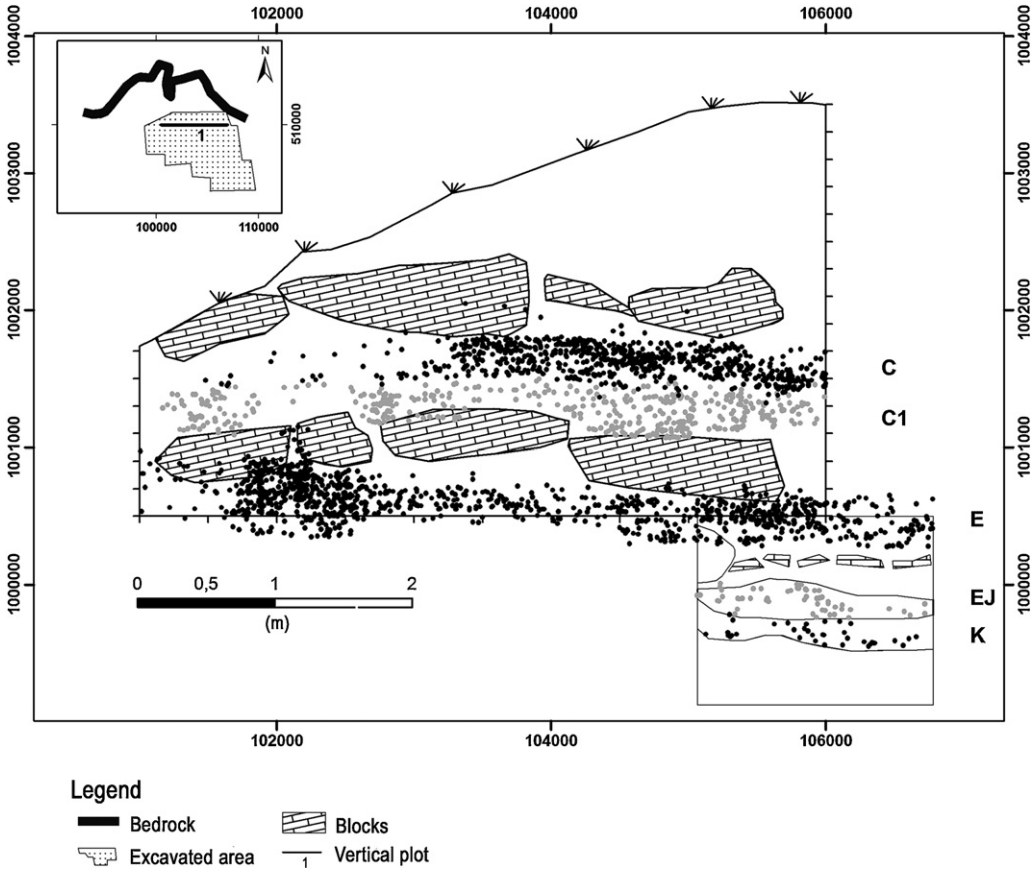

Fig. 3. Archaeostratigraphic plot of the distribution of archaeological materials. We can observe the two main collapses of the deposit cornice, first on the upper unit, and the second in the central part of the stratigraphy that differentiate the upper and lower units. In the right margin, there is the development of levels EJ and K, divided from level E by a lower intense block falling.

Fig. 3. Archaeostratigraphie de la dispersion des matériaux archéologiques. Nous pouvons observer les deux principaux effondrements de la corniche de dépôt, d'abord sur l'unité supérieure, et le second dans la partie centrale de la stratigraphie qui différencie les unités supérieure et inférieure. Dans la marge de droite, développement des niveaux EJ et K, séparés dans le niveau E par une chute inférieur intense des blocs.

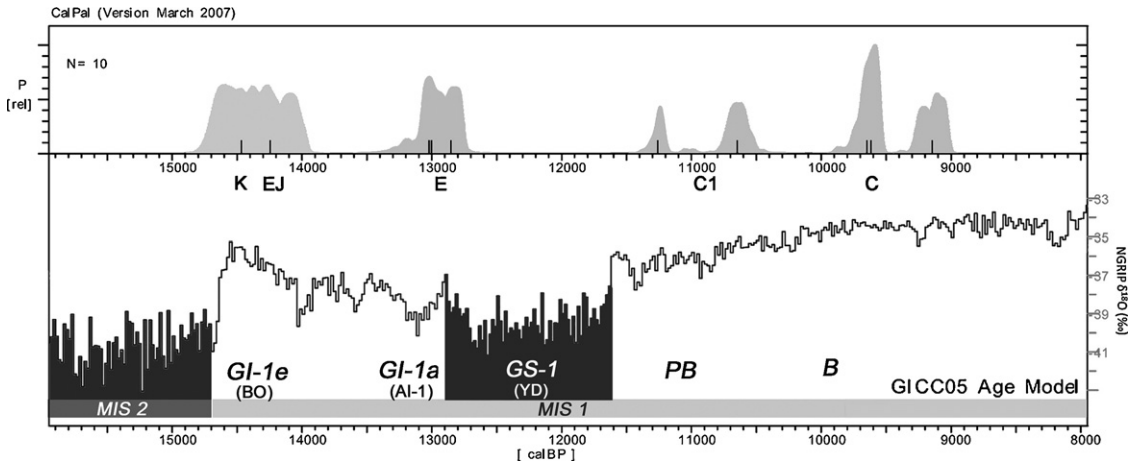

Fig. 4. Chronometric model of Guilanyà and correlation to archaeological levels in the chrono-climatic zones established in the GICC05 model.

Fig. 4. Modèle chronométrique de Guilanyà en rapport aux niveaux archéologiques des zones de chrono-climatiques établies dans le modèle GICC05.

Table 1
Radiometric series from Balma Guilanyà and calibrated dating to 2 δ p (95%) given by the *Hulu* model (Weninger et al., 2007) and its assignation to the established chronozones in the model GIC05 (Lowe et al., and INTIMATE group, 2008).
Tableau 1
Série radiométrique de Balma Guilanyà et datations calibrées à 2 δ p (95 %) donnée par le modèle Hulu (Weninger et al., 2007) et son assignation a les chrono zones établies dans le modèle GIC05 (Lowe et al., et le groupe INTIMATE, 2008). Les datations sont exclues de la proposition chronométrique établie pour Guilanyà (Fig. 4) en raison de leur incertitude radiométrique.

Level	# Laboratory	BP	σ	^{14}C	Sample type	δ ^{13}C	cal BP $_{(HULU)}$p (95%)	Chronozone
K	Beta-247708	12310	40	AMS	Charcoal	–23.9	14 850–14 090	BO
EJ	Beta-185066	12180	50	AMS	Charcoal	–24.5	14 650–13 850	BO
E[a]	UBAR-367	11460	230	CON	Charcoal	–25.7	13 810–12 890	BO/AL/YD
E	Beta-247706	11110	40	AMS	Charcoal	–23.6	13 110–12 910	AL-1
E-HB	Ua-34297	11095	195	AMS	Collagen (*Homo* tooth)	–19.6	13 380–12 660	AL-1/YD
E	Beta-210729	10940	50	AMS	*Corylus*	–26.4	12 990–12 710	AL-1/YD
E-HB[a]	Ua-34298	10195	255	AMS	Collagen (*Homo* skull bone)	–19.9	12 830–10 990	AL/YD/PB
C1	Beta-210728	9840	50	AMS	*Corylus*	–25.5	11 360–11 160	PB
C1	Beta-186168	9410	60	AMS	Charcoal	–21.4	10 810–10 490	PB
C[a]	UBAR-368	8970	430	CON	Charcoal	–24.8	11 250–9050	PB/B
C	Beta-185064	8680	50	AMS	Charcoal	–26.2	9790–9510	B
C	Beta-210730	8640	50	AMS	*Corylus*	–24.3	9740–9500	B
C	Beta-252288	8180	50	AMS	Collagen (*C. pyrenaica* tooth)	–20.0	9330–8970	B
C[a]	Beta-257402	7320	40	AMS	Collagen (*E. ferus* phalanx)	–20.5	8240–8000	B

[a] The datings point out to the ones excluded from the chronometric proposal established for Guilanyà (Fig. 4) due to their radiometric uncertainty.

2006). For the recovery of seed remains, no systematic flotation of the sediment was carried out, so a possible bias in the size of the recovered remains cannot be discarded.

4. Results

A total of 1981 charcoal fragments were identified, corresponding to 12 taxa, whose distributions and frequencies are given in Table 2.

The lower levels K, EJ and E are characterized by a dominant presence of *Pinus* type *sylvestris* and sparse appearances of *Betula*, *Prunus*, *Buxus sempervirens* and *Juniperus*. This is in contrast with levels C1 and C, where, although *Pinus* type *sylvestris* represents more than 50% of the association, a strong increase in diversity is observed with 11 identified taxa. Some of them, such as *Acer*, *Prunus*, *B. sempervirens*, *Juniperus* and Maloideae oscillate between 5 to 15%, while *Ulmus, Rhamnus cathartica/saxatilis, Fraxinus* and *Viburnum* are scarce. Likewise, in level C *Quercus ilex/coccifera* is present and the percentage of *B. sempervirens* is significantly higher. The taxonomic category *Pinus* type *sylvestris* includes three different mountain pines – *Pinus sylvestris*, *Pinus nigra* spp. *salzmanni* and *Pinus uncinata* – that grow in the same area and cannot be distinguished with the available materials, although some authors consider the presence in the past of the three different species according to their biogeographic distribution (Heinz, 1990; Vernet, 2006).

Taxonomic variability curves show that in levels C1 and C, most taxa are represented in the first 100 studied fragments, and from this number on, only one new species is identified, in level C. In the lower levels, the variability is lower, and the total diversity is achieved between 100 and 200 fragments. These results suggest that the sample is representative of the diversity of the charcoal assemblage (Fig. 5).

In Guilanyà seeds, residues and fruit remains have been recovered from a relatively small number of samples (eight from level E and 44 from level C), in which 59 remains of fruits and seeds and two remains of *Cenococcum* were determined. In total, six taxa corresponding to fruits were identified, although small seeds from the Rubiaceae family

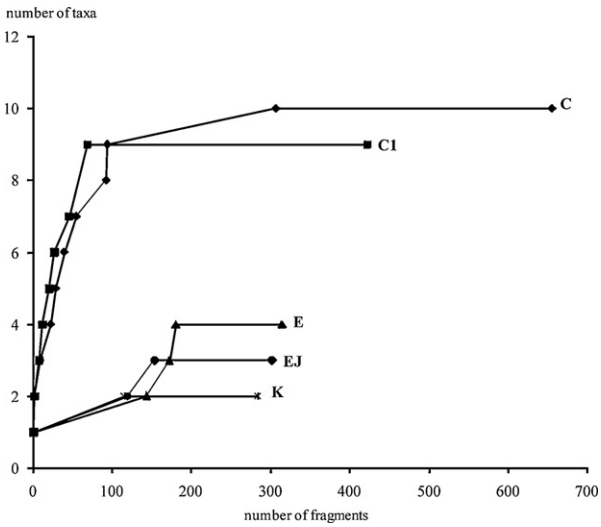

Fig. 5. Taxonomic diversity of archaeological layers of Guilanyà.
Fig. 5. Diversité taxonomique des couches archéologiques de Guilanyà.

Table 2
Anthracological record from Balma Guilanyà.
Tableau 2
Registre anthracologique de Balma Guilanyà.

Taxons	C		C1		E		EJ		K	
	Boreal		Pre-Boreal		Allerød		Bølling		Bølling	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Acer	25	3.9	25	6.2						
Betula									1	0.4
Buxus sempervirens	102	15.8	9	2.2	1	0.3				
Fraxinus	1	0.2								
Juniperus	16	2.5	12	3.0	1	0.3				
Pinus type *sylvestris*	395	61.1	293	72.9	312	99.0	290	99.7	280	99.6
Pinus type *uncinata*			1	0.2						
Maloideae	47	7.3	21	5.2						
Prunus	55	8.5	37	9.2	1	0.3	1	0.3		
Quercus ilex/coccifera	1	0. 2								
Rhamnus cathartica/saxatilis	4	0.6	4	1.0						
Ulmus			1	0.2						
Viburnum	1	0.2								
Number of taxa	10		8		5		2		2	
Total	647		403		315		291		281	
cf. *Buxus*							1	0.3		
Undetermined conifer	1	0.2	10	2.4	3	0.9	4	1.3	3	1.1
Undetermined angiosperm	4	0.6	7	1.7						
Undetermined	3	0.5	2	0.5			6	2.0		
Total	655		422		318		302		284	

were also found, which could have grown in the surroundings of the site (Table 3).

In level E, we have identified a fruit, endocarp remains, possibly from blackthorn (*Prunus* cf. *spinosa*), a poorly preserved acorn (cf. *Quercus* sp.), a Rubiaceae seed and remains of unidentified parenchymatous tissue. The most interesting example is a fragment of a stone fruit with remains of a fleshy mesocarp. Although its wrinkled surface is not entire, it can be assigned to *Prunus* (possibly *Prunus* cf. *spinosa*), just like other small-sized fragments recovered from this level (Fig. 6).

In level C, fragments of *Corylus avellana* pericarp abound, although fragments of *Sorbus*, crab or wild *Malus*, remains of parenchymatous tissue and various undetermined remains were also identified (Table 3). Hazelnut is common in archaeological sites because the woody pericarp preserves well, even though the remains are generally very fragmentary. The differentiation of Maloideae fruits is more difficult. Based on the criteria used by Zapata (2002), seeds of *Sorbus* sp. and cf. *Malus* sp. were determined.

The rest of the seeds and fruits also show taphonomic features, and the majority shows recent fractures produced during recuperation. The recognized taxa are of large size, generally fruit trees. Because our systematic sampling did not focus on recovery of these indicators, it is not possible to evaluate whether the preponderance of this segment size signifies a bias in the sample collection, since in some samples small seeds attributed to Rubiaceae were recovered.

Table 3
Seed and fruit remains identified at Balma Guilanyà.
Tableau 3
Restes de graines et fruits identifiés a Balma Guilanyà.

	C	E
Taxons	Boreal	Allerød
Corylus avellana	23	
Sorbus/Malus	14	
Sorbus sp.	2	
cf. *Malus* sp.	1	
Prunus cf. *spinosa*		2
cf. *Quercus* sp.		1
Maloideae		1
Rubiaceae		1
Parenchimatic tissue	8	1
Undetermined	4	2
Cenococcum	1	1

5. Discussion

Global-scale climatic change alters the local vegetation composition and converts the anthracological record into an expression of these climatic phenomena. Doubtless a significant change was induced by the expansion of taxa restricted to refuge areas during the Pleniglacial, a process detected through pollen analysis from natural and archaeological deposits (Carrión et al., 2010). This process is reflected in the charcoal assemblages through an increase in diversity that can be recognized in different sequences from the Mediterranean area (Allué, 2009; Carrión-Marco, 2005; Delhon and Thiébault, 2009; Ntinou, 2002; Piqué and Barceló, 2002; Thiébault and Vernet, 1992).

At Guilanyà, the analysis of the remains of trees and shrubs shows a significant change in the local plant composition. The differences in presence/absence and the values of principal taxa define two phases (Fig. 7):

Fig. 6. Vegetal macroremains identified as fruits or seeds: 1) *Sorbus/Malus* fruit: 2) *Sorbus* sp. fruit (longitudinal section); 3) *Sorbus* fruit (transverse section); 4) cf. *Malus* sp. fruit (longitudinal section); 5) *Corylus avellana* pericarp; 6) *Prunus* cf. *spinosa* fruit; 7) *Prunus* cf. *spinosa* seed fragments [Photos: Servei d'Imatges, UdL]. These remains are from level C (Boreal) except number 7 which is from level E (Allerød).

Fig. 6. Macrorestes végétaux identifiés comme des fruits ou des graines : 1) fruit de *Sorbus/Malus* 2) fruits de *Sorbus* sp. (section longitudinale) ; 3) fruit de *Sorbus* (section transversale) ; 4) fruits de cf. *Malus* sp. (section longitudinale) ; 5) péricarpe de *Corylus avellana* ; 6) fruits de *Prunus* cf. *spinosa* ; 7) fragments de graines de *Prunus* cf. *spinosa* [Photos : Servei d'Imatges, UdL]. Ces restes sont du niveau C (Boréal), sauf le numéro 7 qui est du niveau E (Allerød).

- phase 1: levels K, EJ and E reflect a dominance of pine which denotes a forest almost exclusively made up of this conifer. In the more open woodland zones, in zones with a higher humidity or that form part of the scarce understory of *Pinus*, Rosaceae (*Prunus*) and *Juniperus* might be present, though of little significance;
- phase 2: consisting of levels C and C1 *P. sylvestris* type dominates, although various mesophilic taxa in the understory indicate variation in the tree and shrub complex.

This change in the vegetation composition is coincidental and confirms the stratigraphic hiatus inferred from the radiometric series at Guilanyà. Likewise, the proposed seriation of climatic chronozones as based on the radiometry does not contradict the recorded anthracological phases.

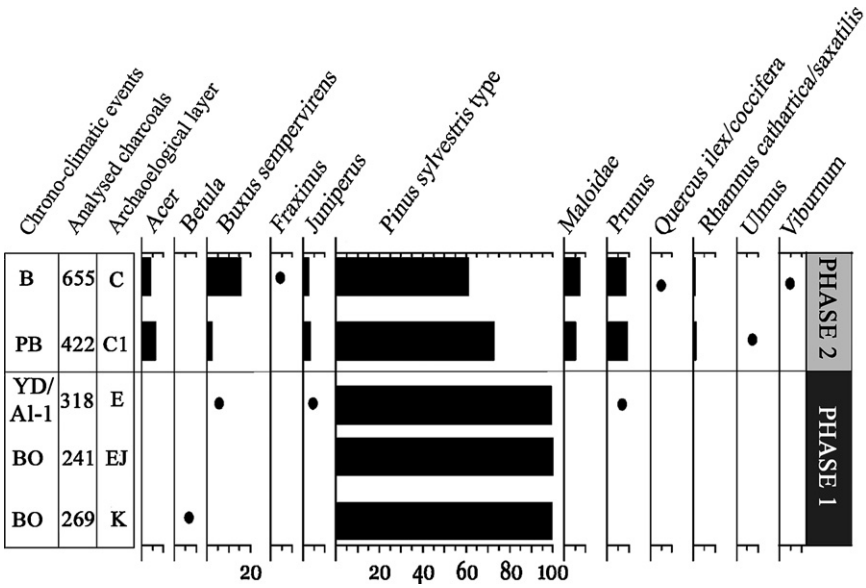

Fig. 7. Anthracological diagram from Guilanyà.

Fig. 7. Diagramme anthracologique de Guilanyà.

Thus, phase 1, which comprises levels K, EJ and E, belongs to interstadial GI-1; levels K and EJ are chronometrically placed at the Bølling event, while level E matches with the limit of the substage Allerød-1 and the beginning of the YD. Similarly, phase 2 corresponds to the radiometric attributions of C1 to the Pre-Boreal and C to the Boreal (Fig. 4).

The increase of the values of mesothermophillous taxa due to environmental changes is detected in other charcoal deposits (Allué et al., 2007, 2010; Delhon and Thiébault, 2009; Piqué and Barceló, 2002; Thiébault and Vernet, 1992). In charcoal assemblages from the northeastern Peninsula, the main taxa representing these changes are *Acer*, *Prunus*, *Rhamnus cathartica/saxatilis* and Maloideae (Allué et al., 2007, 2010; Piqué and Barceló, 2002). Meanwhile, in the palynological records, an increase of *Quercus*, *Betula* and *Corylus* is noted (Burjachs, 2009; Carrión et al., 2010; González-Sampériz et al., 2005;). In mountain areas, *Pinus* type *sylvestris* is still significantly present in some sequences from the Pre-Boreal/Boreal, especially those from sites located at higher altitudes such as Guilanyà, Margineda and Guineu (730 m) (Fig. 1) (Allué, 2009; Heinz and Vernet, 2007). Moreover, at Guilanyà, the appearance of new taxa is noteworthy, especially the presence of *B. sempervirens* since this is considered a pioneer species associated with the expansion of deciduous oak forest. *B. sempervirens* is more or less rare at other sites, especially in numerous later sequences in which deciduous *Quercus-Buxus* forest presents its maximum expansion (Piqué, 2005); this indicates that its expansion could be related to the post-Younger Dryas pioneer vegetation. The spread of *Quercus* is detected earlier in various pollen sequences suggesting a general presence during the Late Glacial (e.g. Burjachs, 2009; Carrión et al., 2010; González-Sampériz et al., 2005). According to Brewer et al. (2002), on the basis of pollen records, *Quercus* survived during the colder periods at the southern Mediterranean peninsulas. The spread to northern areas took place ca 13 kyrs BP, suffering retreats during colder phases and not expanding again until the beginning of the Holocene (Brewer et al., 2002). However, in the anthracological assemblages, *Quercus* does not record important values until ca 7 kyrs BP, as in the upper levels of Bauma del Serrat del Pont (Alcalde and Saña, 2008).

This palaeo-ecological discussion points out the difficulties of synchronizing processes of environmental change based on archaeological proxies or natural records due to differences in resolution of paleoenvironmental disciplines. At the same time, it demonstrates the highly diverse and mosaic character of the expansion of mesothermophile forest ecosystems, a process that possibly originated during the Late Pleniglacial but was not consolidated, at least in the northeast of the Iberian Peninsula, until the onset of the Holocene.

Concerning the exploitation of vegetal resources, Guilanyà permits the recognition of various aspects of the subsistence of groups of hunter-gatherers who visited this site for 6000 years. Two main issues are examined: the use of wood as fuel and the presence of indicators related to fruit gathering. Wood was the fuel used most since it was a readily available resource in the environment, though the use of other combustibles for specific uses cannot be ruled out (Théry-Parisot, 2002). For hunter-gatherers, the selection of firewood is normally the result of a random collection of (usually dry) wood, especially fallen branches (Asouti, 2003). In the oldest phases of the anthracological sequences of the NE Iberian Peninsula, a strong preference for pine is detected, due to its abundance, quality, and the easiness of being collected as dead wood. However, based on the development of other pioneer species (*Juniperus*) and/or mesophilic species (*Acer*, *Prunus* and *Rhamnus cathartica/saxatilis*), a change in the collection of fuel is identified, indicating a more diverse vegetation.

In Guilanyà, the exploitation of *Pinus* continued in all the following phases, suggesting that in this area, the *P. sylvestris* forest was stable during the total period the site was visited. However, due to the broadening of the arboreal spectrum, new species were recognized whose primary use was not as fuel but probably subsidiary as compared to other alternative resources; on the one hand the collection of branches with fruits for immediate consumption like *Prunus* or Maloideae, and on the other hand the exclusive collection of fruits and other products. In the first case, the presence of fruit trees in the vicinity of the site could provide fruits for immediate consumption and a subsequent use of the wood as fuel. It could also be suggested that the presence of fruits and seeds of Rosaceae is unintentional and their presence in the assemblage is due to the use of these species as firewood. This, however, is not always the case: taxa such as hazel, for example, are recorded exclusively through its fruits and not its wood. This could imply that either the fruits were not collected in the direct surroundings or that the wood was not considered suitable as fuel. Similarly, *Betula* is scarcely present, though its wood could be a primary material for other uses.

Betula and *Corylus* are anemophilic taxa (i.e. pollination by wind) l. Their presence is common in numerous palynological sequences from the Iberian Peninsula though even more in the Atlantic coastal region, and general in the Eurosiberian region (Burjachs, 2009; Carrión-Marco, 2005; Iriarte, 2009; Jalut and Turu-Michels, 2009). Pollen records from the Mediterranean side indicate that the bioclimatic phases with maximum *Betula* expansion occurred during the Late Glacial, while for *Corylus* this was during the Boreal (Burjachs, 2009; Carrión et al., 2010; Jalut and Turu-Michels, 2009). However, their visibility in charcoal records is low.

At the NE Iberian Peninsula, *Betula* is identified in charcoal sequences from Margineda (Heinz and Vernet, 2007), Molí del Salt, Filador or Gai (Allué, 2009; Allué et al., 2007, 2010), though always with very low values, which contrasts with its abundance in sequences from the Atlantic and Cantabric regions (Carrión-Marco, 2005; Iriarte, 2009; Uzquiano, 2000; Zapata, 2002). This shows that when it was available, it was used as firewood, so its scarcity at Guilanyà and other northeastern sites suggests that it was not common. Today this taxon occurs mixed in an oak, beech, and Pyrenean oak forest, or forms birch stands at valley bottoms or riverbanks (Blanco et al., 1998). Its scanty presence in the anthracological records could indicate that it was not a very abundant taxon at the NE Iberian Peninsula, concentrated in areas suitable for its growth.

Corylus nowadays occurs as the dominant species of communities or as a part of humid forests (Blanco et al., 1998). It is found in several sites, Sota Palou, Font del Ros, Margineda and Molí del Salt, especially in the form of exocarp remains, while charcoal from branches is not so common (Allué, 2009; Buxó and Piqué, 2008). This difference suggests that it is not an abundant taxon and the fact that the fruit is collected does not necessarily mean that it is present near the site. In fact it is often used as fuel in Cantabrian sites, which suggests that when it is abundantly present its wood is used as fuel. It is likely that the increased humidity of the Cantabrian region is more favourable to *Corylus* and *Betula*, so a significant and continuous presence of these taxa in the archaeological assemblages of this zone is not surprising (Carrión-Marco, 2005; Uzquiano, 2000; Zapata, 2002). It can also not be ruled out that these taxa, though less suitable as fuel, were appreciated for other qualities such as tool making or for providing fruits.

Nevertheless, in some cases when specific ecological conditions that promote the concentrations of certain species such as *Corylus*, are an influential factor in the selection of sites, these resources may be intensively exploited (Holst, 2010). Also human choice of some species over others cannot be dismissed (Mithen et al., 2001). These scenarios might explain the repeated occupation of some sites at the northeastern Iberian Peninsula, such as Font del Ros. Here the abundance of hazelnut shells suggests that the collection and consumption of this fruit could have been strategic for the mobility patterns of Boreal hunter-gatherers, even though this activity was of low frequency (Martínez-Moreno and Mora, in press). The presence of *Corylus* exocarps in various archaeological assemblages of the northeastern Peninsula is considered an indicator that permits research on the role of wild fruit gathering, a subsistence activity difficult to visualize (Pallarés et al., 1997; Pallarés and Mora, 1999).

The absence of *Corylus* in the anthracological record is remarkable since fragments of hazelnut pericarps were recovered in Guilanyà levels E, C1 and C. Various radiocarbon datings of this sample type are available (Table 1). Alternatively, for Rosaceae and Maloideae, both the wood and fruits of *Sorbus* and *Malus* are represented. Seeds and fruits of *Sorbus* sp. are described in Serrat del Pont (Alcalde and Saña, 2008), Aizpea (Zapata et al., 2002) and Santa Maira (Aura et al., 2005), whereas the fruits of *Malus* sp. and *Pyrus* sp., though less common, are found in Font del Ros (Pallarés et al., 1997) and Aizpea (Zapata et al., 2002). The fact that some of the fruits identified in Guilanyà were recovered with the fleshy parts preserved, i.e. unconsumed, could indicate that these fruits accompanied the wood and were burned together, although their consumption is hereby not excluded.

This does not seem to be the case with fruits of Maloideae, whose wood was used as fuel. Though it cannot be ruled out that the fruits could have accompanied the wood without necessarily being consumed, it is considered likely that the burning of the wood might related to some kind of processing. Likewise, though the fruits of *Sorbus domestica* can be eaten raw, it is known that in historical times, *Sorbus* species *S. aucuparia* and *S. aria* were dried and ground to produce flour (Zapata, 2002). A similar processing could apply to *Malus*, and in numerous prehistoric sites in Europe, there is a frequent mention of apples cut intentionally for drying (Zohary and Hopf, 2000). Drying with the aid of fire would be a technique for improving the taste of the fruit or for storage purposes related to a deferred consumption; so carbonization of these fruits could denote accidents produced during their processing.

The remains of blackthorn and acorn in the carpological record from level E are interesting since these taxa were not identified within the anthracological record (where *P. sylvestris* type is dominant), while at the same time, it suggests that the recollection of fruits could have initiated during the GI-1a or Allerød. At Balma del Gai, located more to the south and at lower altitudes, in a level with a similar chronology charcoal of *Prunus* and *Quercus* are actually identified (Allué et al., 2007). This variety of records might indicate that during the Bølling/Allerød, a varied exploitation of vegetation resources developed, as a function of whether these resources were used as fuel or collected as nutrients.

Evaluation of the importance of collection concerning the nourishment of these human groups is not easy, and indicators such as the stable isotope content ($^{13}C/^{12}C$ and $^{15}N/^{14}N$) obtained from various human remains in level E, denote a strictly carnivorous diet (García-Guixé et al., 2009). For the Holocene levels, no such information is available from the sites discussed in this article.

These arguments seem to indicate that based on archaeological proxies the collection of wild fruits is difficult to identify, and/or appears to play a marginal role. It must be noted though that the scarceness of the record obtained from Guilanyà, and generally, from sites at the northeastern Iberian Peninsula, may be related to taphonomy processes or the absence of specific sampling for recovery of seeds and fruits.

The activity of fruit collection appears to spread through the northern Iberian Peninsula during the Holocene (Aura et al., 2005; Marinval, 1995, 2007; Zapata, 2002). An indicator that supports the growing importance of collection is the presence of tools related to processing nuts and fruits for immediate consumption or storage. In fact, it is proposed that some artifacts found at Font del Ros, especially cobbles with deep central depression and intense perimetral abrasion, could have been used as nutcracking stones or to mash soft plants or vegetables (Martínez-Moreno et al., 2007; Martínez-Moreno and Mora, in press; Roda et al., 2012). Similar tools that might have been used for *Corylus* processing have been identified in some northern European sites (Holst, 2010). Future studies will have to determine whether cobbles with analogue attributes, recovered in Guilanyà levels C and E and common in other sites mentioned in this study (Margineda or Serrat del Pont), are related to vegetal preparation and/or consumption.

Other kinds of resources likely to have been exploited are the fruits and nuts that appear in these forest environments. Although it is not easy to evaluate the importance of the collection and processing of the wild fruits, the record recovered from Guilanyà provides some indications. The presence of remains of sloes, acorns and other seeds in level E indicates that fruit and nut collection could have begun during the Allerød. In level C, remains of fruits such

as rowan, wild apple and hazelnut are identified, though hazel wood was not found in the anthracological assemblage. This is concordant with data derived from similar sites in the southern Pre-Pyrenees (Zapata et al., 2002). These indicators also confirm the occupation of the site at the end of summer or the beginning of autumn, the period in which these fruits can be collected and/or consumed.

6. Conclusion

The archaeobotanical record of Guilanyà allows various inferences about the climatic changes that occurred during the onset of MIS 1 and affected the northeastern Iberian Peninsula. This process forced an important remodelling of the plant communities and undoubtedly had an influence on the resources that these ecosystems offered to the human groups who recurrently though discontinuously installed themselves in this cave between the Bølling and Boreal chronozones.

The anthracologic study identified a forest community characterized by the dominance of Scots pine. Two phases were differentiated: in the first phase, Scots pine is practically the only recognized taxon. The second phase develops after the Younger Dryas climate crisis. Though Scots pine continues to be important, an increase of tree-shrub diversity is detected, with thermophilic species that form the understory. This vegetal sequence is coherent with the chronology obtained for this site, with a first phase included in the Bølling/Allerød cycle and a second phase that develops from the Pre-Boreal and extends until the Boreal. The radiometric series displays a hiatus throughout the Younger Dryas event. Similarly, between the mentioned anthracological phases an important gap is detected, provoking an image of an explosive expansion of mesophilic taxa, which are only scarcely represented in the lower part of the Guilanyà sequence.

The exploitation of plant resources from these forest environments is not restricted exclusively to obtaining fuel; and though no hearths were detected in the excavated area, their presence could be inferred from the thermoalterations that affected fauna and tools. The preserved archaeobotanic assemblage suggests that wood was used from those species that were most appropriate and abundant in the surroundings. Firewood collection was beyond doubt a central labour among the organization of activities carried out at the site, and fire was key for the processing and intake of prey or for providing the inhabitants of the site with light and warmth. Thus, the acquisition of firewood was an essential task for these groups.

In summary, the archaeobotanical record recovered in Balma Guilanyà provides information on how hunter-gatherers exploited local resources, which were conditioned by global-scale climatic change during the beginning of Marine Isotope Stage 1. Forest ecosystem elements were identified that characterize the management of vegetal resources.

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