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NEOLITHIC WOODLAND IN THE NORTH MEDITERRANEAN BASIN: A REVIEW ON *OLEA EUROPAEA* L

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Abstract: *The aim of this paper is to specify the natural distribution of* Olea europaea *L. during the Early Holocene in the Northern Mediterranean by means of the identification of wood charcoal remains of this species at prehistoric sites. For this purpose, we have reviewed the relevant literature and extracted the data in which* Olea *charcoal has been identified. We have taken into consideration the biogeographical and chrono-cultural contexts in which the species is present, its frequency of occurrence at different locations and the associated plant taxa with the aim of tracking the Holocene history of the oleaster. Based on this information we suggest that the species started expanding during the Preboreal from Pleistocene thermophilous tree* refugia *located in the Levant, Cyprus, Sicily and the southern parts of the Iberian Peninsula. Its presence was confined to the thermomediterraenan bioclimatic level. The expansion dynamics of* Olea *after the Boreal are better understood in the western Mediterranean. There the species becomes very abundant or dominant in the thermophilous plant formations of the Atlantic period and expands to favorable enclaves outside the limits of the thermomediterraenan bioclimatic level.*

Key words: Olea *wood charcoal, Pleistocene refugia, Holocene, thermomediterranean level*

INTRODUCTION

At present, *Olea europaea* L. var. *sylvestris* is an important element of the vegetation in the circummediterranean area. The species is considered an accurate thermal bioindicator for the definition of the thermomediterranean bioclimatic level while its cultivated variety is an emblematic and genuine plant of the Mediterranean cultures from protohistoric times. In the archaeological record the presence of *Olea* remains, is recorded since prehistoric times in context associated to the Epipalaeolithic, the Neolithic and the Bronze Age periods while great part of the discussion concerning this plant has been dedicated to its domestication and cultivation (Besnard *et al.* 2002; Breton *et al.* 2006; Contento *et al.* 2002; Liphschitz *et al.* 1991; Rodríguez-Ariza and Montes 2005; Zohary and Hopf 2000).

In this paper our aim is to discuss the presence of *Olea europaea* in the thermophilous vegetation since early post-glacial times in order to define the early Holocene distribution and consolidation of this species in the Mediterranean basin. For this purpose we use the information that originates from charcoal analyses carried out at various prehistoric sites of the northern Mediterranean basin. We believe that wood charcoal is probably the most adequate category of archaeobotanical remains for approaching the above-mentioned issues; if *Olea* had existed in a given area, its wood would have been used as fuel in domestic fires much before the management of the tree for its edible fruits and/or its cultivation. *Olea* wood charcoals at a site most probably reflect its presence in a certain area while by way of charcoal analysis the species becomes an integral part of the charcoal assemblages that reflect the characteristics of the local vegetation. Therefore, by using charcoal sequences from prehistoric sites we may document the vegetation types in which *Olea* was established in early Holocene times, its frequencies in formations of the Atlantic *optimum* (c. 8800-5600 cal. BP) and its behaviour in relation to human activity.

The chronological framework in this paper is delimited by the beginning of the Preboreal and the end of the Atlantic (c. 11500-5600 cal. BP), approximately coinciding with the Mesolithic and Neolithic period. The origins of olive domestication and the expansion of techniques and/or cultivars during the Bronze Age in the eastern Mediterranean (Terral *et al.* 2004) and during the Iron Age in the western Mediterranean are important topics that lay beyond the scope of this article.

SETTING

In the present-day, the olive is a prominent feature of the whole Mediterranean basin and constitutes a complex of wild forms, cultivated varieties and secondary feral

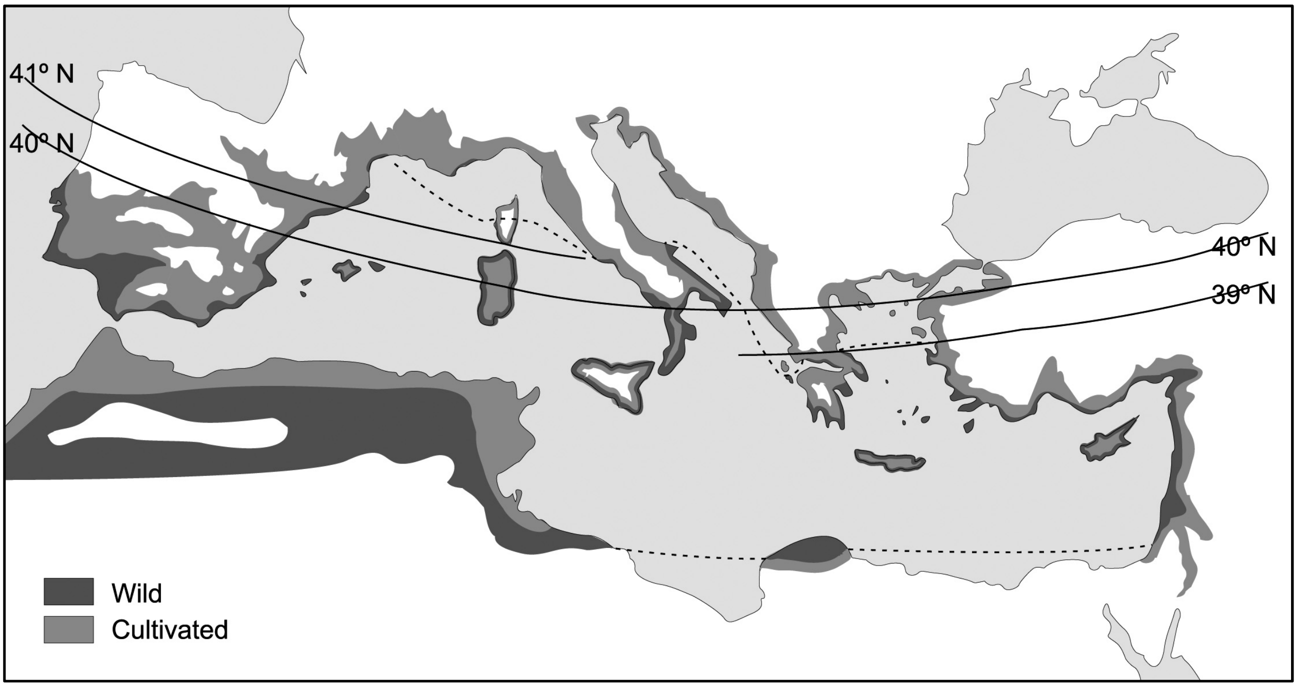

Figure 1. Current distribution of wild and cultivated olive tree (*Olea euroapaea* L.) in the Mediterranean basin

forms. The oleaster occupies the warmest areas of the Mediterranean, approximately coinciding with the thermomediterranean bioclimatic level or with the lower mesomediterranean (Ozenda 1975; Rivas-Martínez 1987) (Figure 1). In the western Mediterranean, it extends over low, warm lands with a mean annual temperature of between 17-19ºC. A limiting factor for its development is the mean temperature of the coldest month that should not be below 6ºC (Rubio *et al.* 2002, 343, figure 1). In terms of altitude, its limit in the Iberian Peninsula is around 500 m. In the eastern Mediterranean, the oleaster thrives in the *Ceratonion-Pistacion lentisci* plant association (Browics 1983; Zohary and Orshan 1959). In the plant associations of both the western and the eastern Mediterranean, thermophilous elements like *Pistacia lentiscus* L., *Quercus* sp. evergreen, *Myrtus communis* L.; *Rhamnus lycioides* L., *Rosmarinus officinalis* L., etc., accompany *Olea*. In areas that have suffered little human activity, these species may form well-structured woodlands with trees up to 15 metres high, as the case of Serra d'Arrabida in Portugal shows (Costa *et al.* 2001).

Since late Prehistory, the olive has been grown for its oil-rich fruit. The cultivated variety, *Olea europaea* L. var. *europaea*, has become more flexible to climatic and environmental conditions and therefore extends beyond the previously described area (Figure 1). It penetrates towards higher, colder and more continental lands, mainly on calcareous soils, *terra rossa,* and sandy marls.

MATERIAL AND METHOD

The paper focuses on *Olea* macroremains, particularly on wood charcoal. In the last 30 years, charcoal analyses have been carried out at archaeological sites across the Mediterranean basin and have provided ample information on the plant taxa used as fuel by human groups. Wood charcoal is particularly interesting as it concerns the local flora of each region, which responds to certain thermoclimatic parameters. Moreover, wood charcoal remains of selected taxa can be directly AMS dated, therefore offering the possibility of documenting their first appearance in a region, tracing their expansion and/or detecting taphonomic problems.

The paper is based on a thorough bibliographic review of charcoal analyses data in which *Olea* occurred (Figure 3). It is evident that not all regions and chronological periods rely on a sample of sufficient and comparable data. Despite the limitations, we use the information concerning the presence and frequency of *Olea europaea*, the accompanying flora, the associated chrono-cultural sequence, the biogeographical contexts, and the AMS dates provided by *Olea* charcoal or endocarps as tools for tracing the Holocene history of the species. For this task, we have elaborated maps for the distribution of the oleaster at present (Figure 1) and during the early Holocene (Figure 2), in order to delimit its biogeographical affinities now and in the past. These maps combined with an evaluation of the accompanying flora -in those cases that charcoal sequences were available- and with a list of AMS dates on *Olea* macroremains, constitute the bases for reassessing the issues of the postglacial presence and expansion of oleaster populations in the sclerophyllous vegetation of the Mediterranean basin. The radiocarbon dates cited in this paper are presented in calendar years BP. Dates in other formats from the cited references have been calibrated to 2 sigma using the CalPal-2007 program (Weninger *et al.* 2009) and the CalPal-2007-Hulu calibration data set (Weninger and Jöris, 2008).

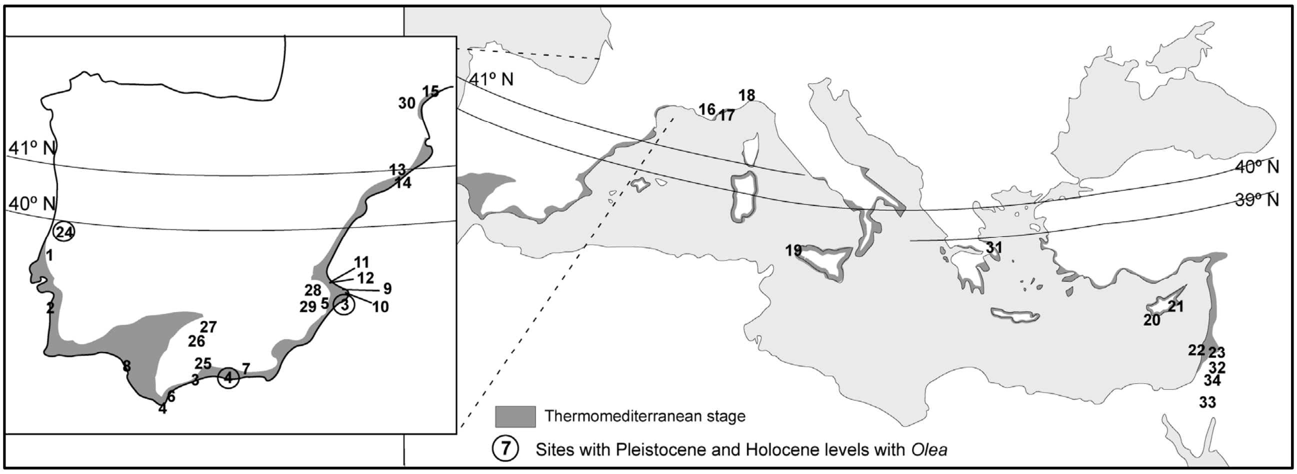

Figure 2. Holocene distribution of *Olea europaea* L. wood charcoal finds in the north Mediterranean (see information of sites in Figure 3)

Concerning the accompanying flora, we consider as thermophilous formations the association of species that usually accompanies the oleaster nowadays, which includes i.e. *Pistacia lentiscus, Rosmarinus officinalis, Rhamnus-Phillyrea, Pinus halepensis, Pinus pinea-pinaster, Quercus* sp. evergreen.

RESULTS

Olea remains have been identified in 34 archaeological sites (Figure 2, Figure 3). The majority concentrates in the western Mediterranean, although this may be due to the unequal number of charcoal analyses carried out in different regions. Concerning the chronology, *Olea* is present in only 6 sequences of the Preboreal, 11 sequences of the Boreal and 31 sequences of the Atlantic. The scarce presence of *Olea* during the Preboreal might be related to the hiatuses observed in archaeological sites coinciding with the Pleistocene-Holocene transition.

The early presence of *Olea* in southern Iberia, Sicily, Cyprus and the Levant points to the existence of thermophilous *refugia* in these regions during the Pleistocene, a hypothesis that for the case of the former is supported by other lines of evidence (Carrión *et al.* 1995; Carrión *et al.* 2008; Pantaleón Cano *et al.* 1999). From the Boreal onwards, there is a progressive increase of sites in which *Olea* finds have been identified, a trend that consolidates during the Atlantic period, therefore allowing tracing the distribution of the species in more detail:

- The first expansion of *Olea* coincides with the thermomediterranean bioclimatic level.
- During the Atlantic period, *Olea* is more frequently identified and more abundant in the western Mediterranean.
- In the Iberian Peninsula, when the thermophilous woodland is established, it is then when *Olea* expands beyond the thermomediterranean level, surpassing its original distribution area.

The Eastern Mediterranean

The earliest *Olea* finds in the eastern Mediterranean come from sites located in the thermomediterraenan level, particularly in the Levant and in Cyprus (Figure 2, Figure 3). In the Levantine area the presence of *Olea* is attested as early as the 10th millennium BP in Jericho (Western 1971) and at Abu Salem (Liphschitz *et al.* 1991). During the Pre-Pottery Neolithic (hereafter PPN) B and C (10500-8250 cal. BP), the species was present at the now submerged settlement of Atlit Yam (Galili *et al.* 1993) and also at the sites of Horvat Galil (Liphschitz 1997) and Divshon (Liphschitz *et al.* 1991). The oleaster would have formed part of the Mediterranean vegetation in the coastal areas and it would have probably grown in regions that are presently characterized by Irano-Turanian and Saharo-Arabian formations.

The presence of *Olea* on the island of Cyprus is well-documented as early as the mid-11th millennium cal. BP in Early Neolithic A contexts at Shillourokambos (Thiébault 2003) and it is also present during the 9th and 8th millennium cal. BP, at the PPN site of Khirokitia (Thiébault 2003). Therefore, the evidence from Cyprus indicates a continuous and locally abundant presence of *Olea* in the vegetation from the Preboreal and until the Atlantic period.

In Greece and the Aegean area *Olea* is infrequent during the earlier part of the Holocene. One reason for the meager identification of the species is probably the fact that the majority of the available charcoal analysis results come from northern sites (Ntinou 2002) that lay outside the area of the natural oleaster distribution, which is confined to the south of parallel 39º N (Ozenda 1975). The available data, mostly from pollen sequences, indicate the late appearance of *Olea* (towards the end of the Atlantic period) even in southerly thermomediterranean locations where the species could potentially grow (Bottema and Sarpaki 2003; Turner and Greig 1975; Jahns 1993; Moody *et al.* 1996; Wright 1972). At the site of Knossos in Crete wood charcoal

Site		Climatic period			Cultural context	References
		Preboreal	Boreal	Atlantic		
***Olea* finds in the thermomediterranean stage**						
1	Abrido da Pena d'Água		■	■	Epipalaeolithic, Neolithic	Figueiral 1998
2	Vale Pincel I			■	Epipalaeolithic, Neolithic	Carrión 2005
3	Cova de les Cendres			■	Upper Palaeolithic, Neolithic	Badal *et al*. 1994
4	Cueva de Nerja	■	■	■	Epipalaeolithic, Neolithic	Badal 1990
5	Cova de Santa Maira	■	■	■	Magdalen., Epipaleo., Mesol.	Badal 1999; Carrión 2005
6	Río Palmones		■	■	Epipalaeolithic	Rodríguez-Ariza 2004
7	Murciélagos de Albuñol			■	Neolithic	Rodríguez-Ariza, Montes 2005
8	El Retamar			■	Neolithic	Arnanz and Uzquiano 2002
9	Cova Bolumini			■	Neolithic	Badal 1990
10	Cova Ampla del Montgó			■	Neolithic	Vernet *et al*. 1983
11	Cova del Llop			■	Neolithic	Vernet *et al*. 1983
12	Cova de la Recambra			■	Neolithic	Vernet *et al*. 1983
13	Can Sadurní			■	Neolithic	Ros 1992
14	Can Tintorer			■	Neolithic	Ros 1992
15	Cova de l'Espérit			■	Mesolithic, Neolithic	Solari and Vernet 1992
16	Caucade			■	Neolithic	Thiébault 2001
17	Giribaldi			■	Neolithic	Thiébault 2001
18	Arene Candide			■	Neolithic	Nisbet 1997
19	Grotta dell'Uzzo	■	■	■	Mesolithic, Neolithic	Constantini 1989
20	Shillourokambos	■	■		Neolithic	Thiébault 2003
21	Khirokitia		■	■	Neolithic	Thiébault 2003
22	Atlit Yam		■		pre-Pottery Neolithic	Galili *et al*. 1993
23	Horvat Galil		■		pre-Pottery Neolithic B	Liphschitz 1997
***Olea* finds in the mesomediterranean stage**						
24	Buraca Grande		■	■	Upper Palaeol. to Neolithic	Figueiral and Terral 2002
25	Cueva del Toro			■	Neolithic	Rodríguez-Ariza 2004
26	Murciélagos de Zuheros			■	Neolithic	Rodríguez-Ariza 1996
27	Polideportivo de Martos			■	Neolithic	Rodríguez-Ariza 1996
28	Cova de l'Or			■	Neolithic	Badal *et al*. 1994
29	La Falguera			■	Mesolithic, Neolithic	Carrión 2002; García and Aura 2006
30	Montou			■	Middle Neolithic	Heinz *et al*. 2004.
31	Cave of The Cyclops			■	Neolithic	Ntinou in press
***Olea* finds in the irano-turanian stage**						
32	Jericho	■			pre-Pottery Neolithic A	Western 1971; Wilcox 1991, 1992
***Olea* finds in the saharo-arabic stage**						
33	Abu Salem	■			pre-Pottery Neolithic A	Liphschitz *et al*. 1991
34	Nahal Divshon		■		pre-Pottery Neolithic B	Liphschitz *et al*. 1991

Figure 3. Archaeological sites with *Olea* wood charcoal finds in the north Mediterranean

analysis (Badal and Ntinou in press) failed to detect the presence of the olive in any of the layers of the Neolithic sequence, despite the fact that typically thermomediterranean formations have been identified. In the central Aegean area, the only evidence for the presence of *Olea* derives from the Cave of the Cyclops, Youra, Northern Sporades (Figure 2, Figure 3), where few charcoal fragments have been identified in the upper part of the sequence, after *ca*. 8,500 cal. BP, coinciding with the Neolithic period (Ntinou 2011) .

The Central Mediterranean

In the central Mediterranean, *Olea* wood charcoal finds are reported from Sicily and the Liguro-Provençal region, restricted to the thermomediterranean bioclimatic level (Figure 2, Figure 3).

At Grotta dell' Uzzo, the presence of the wild olive is confirmed by wood charcoal from the Mesolithic levels dating to between 12060-11220 and 9560-9080 cal. BP (Costantini 1989). In these levels, *Quercus* cf. *ilex* and *Phillyrea* sp. have also been identified and Costantini describes the vegetation as a xerophyll *macchia*.

In the Liguro-Provençal region, *Olea* is present at several sites, in levels corresponding to the Atlantic period, and later. These sites are strictly located in the thermomediterranean level. At Giribaldi (Thiébault 2001) and Arene Candide (Nisbet 1997), *Olea* reaches percentages of between 10% and 30%, and is accompanied by other thermophilous species, such as the lentisc and the Aleppo pine. However, *Olea* is completely absent from other sites located on the mesomediterranean level, even within a few kilometers distance from the aforementioned sites (Thiébault 2001). Only in Caucade, do *Olea* and other warm-loving taxa appear in this level, but later in the Atlantic (Thiébault 2001). The data indicate the existence in the Liguro-Provençal region of an area with warm influences constrained to the lowest parts of the thermomediterranean level.

The Western Mediterranean

The Holocene marks the beginning of the massive expansion of *Olea* attested in most of the charcoal sequences from the warmest areas in the western Mediterranean (Figure 2, Figure 3).

In the Iberian Peninsula, the first continuous *Olea* curve is documented at Cueva de Nerja, from the end of the Pleistocene throughout the Holocene sequence (Badal 1998). At Cova de Santa Maira, *Olea* and other thermophilous taxa are continuously present with low percentages throughout the Epipalaeolithic and Mesolithic sequence (11260-11100 cal. BP and 10690-10410 cal. BP) of the cave (Aura *et al.* 2005). However, *Olea* increases substantially during the Atlantic and becomes co-dominant with *Pinus halepensis*, a fact that depicts a vegetation change (Badal 1999). During this period, the presence of *Olea* is confirmed by AMS dates (Figure 4) and there are numerous sequences on both the Mediterranean and the Atlantic façade of the Iberian Peninsula where the species constitutes more than 10% of the charcoal remains.

The largest collection of *Olea* findings is recorded to the south of the parallel 40ºN. This is the case of Cova de les Cendres, Cova Bolumini, Cova Ampla, Cova de la Recambra and Cova del Llop along the eastern coast, (Badal *et al.* 1994; Vernet *et al.* 1983), Los Murciélagos de Albuñol (Rodríguez Ariza and Montes 2005) and Río Palmones (Rodríguez Ariza 2004) at the mouth of the Guadalquivir River, Vale Pincel I (Carrión 2005) and Abrigo da Pena d'Água (Figueiral 1998) along the western coast. On the Atlantic façade *Olea* is usually accompanied by *Pinus pinea* or *P. pinaster* and other taxa like *Arbutus unedo*, *Pistacia lentiscus*, evergreen *Quercus* sp., *Quercus suber*, *Rhamnus-Phillyrea*, etc.

One of the most northerly pieces of evidence for the presence of *Olea* is found at Cova de l'Espérit (Solari and Vernet 1992) in the east Pyrenees and at Can Sadurní and Can Tintorer in Catalonia (Ros 1992). However, despite the numerous anthracological analyses performed in this region, these are the only sites to the north of parallel 40ºN where *Olea* is present. This latitude marks the northernmost limit of a continuous thermomediterranean belt, beyond which these bioclimatic conditions are restricted to discontinuous, isolated enclaves and it is precisely in these where *Olea* is documented, i.e. the south-eastern French sites, along the Liguro-Provençal basin.

The presence of *Olea* is also reported in the mesomediterranean level, particularly in its lower part. In this case however, the distribution and abundance of the species are quite different from those described for the thermomediterranean level. *Olea* remains seem to be strongly linked to favorable orography, such as warm and sunny slopes or valley bottoms. This is the case of Cova de l'Or, located on a south-facing slope, where *Olea* is present in percentages around 10-15% (Badal *et al.* 1994). In other more interior enclaves however, i.e. La Falguera, the presence of this species is more sporadic in the same way as other thermophilous taxa (Carrión 2002; García and Aura 2006). Many valleys tend to act as channels that let the warm coastal conditions and the thermophilous vegetation reach further inland, as deduced

Site	Cultural context	*Olea* material	ASM B.P.	Date relevance
La Falguera	Epipalaeolithic	Seed	7410 ± 70	Relevant
Cova de les Cendres	Early Neolithic	Charcoal	6650 ± 50	Relevant
Vale Pincel I	Early Neolithic	Charcoal	6350 ± 50	Relevant
Cova de Santa Maira	Epipalaeolithic	Charcoal	420 ± 40	Irrelevant
Cova de les Cendres	Upper Palaeolithic	Charcoal	6660 ± 50	Irrelevant

Figure 4. AMS radiocarbon dates on *Olea* macro-remains
("Date Relevance" refers to the coherence of the date with the stratigraphic and cultural context)

from the presence of *Olea* in the Guadalquivir valley. There, this species has been documented at Cueva del Toro, Murciélagos de Zuheros and Polideportivo de Martos (Rodríguez-Ariza and Montes 2005).

The most northerly presence of *Olea* in the mesomediterranean level is reported at Buraca Grande and at Montou (Figure 2). At the former, the species is present throughout the Holocene sequence, with initial dates of 9290-8890 cal. BP (Figueiral and Terral 2002), while its presence at Montou is restricted to a single level dating back to 6180-5780 cal. BP (Heinz *et al.* 2004).

DISCUSSION

In previous sections, we have collected data concerning the presence, distribution and expansion of *Olea* in Holocene contexts. In the following paragraphs, we will consider the above-mentioned data in relation to the biogeographical situation of the sites with *Olea* remains, the accompanying flora and the available AMS dates on *Olea* wood charcoal for the purpose of specifying the establishment of the thermophilous woodland.

The area of distribution in the early Holocene

The presence of *Olea* since the beginning of the Holocene (11700 cal. BP) has been reported in several sites in the Near East and Cyprus. In contrast, the presence of the olive in the Aegean area and Greece is not well defined. *Olea* charcoal, pollen and seed macroremains data indicate a late appearance of the olive, after the 9th millennium cal. BP, for Crete, Southern and Central Greece, and much later dates for northern Greece. In the central Mediterranean, the early presence of *Olea* is confirmed by wood charcoal from Mesolithic levels at Grotta dell' Uzzo (Costantini 1989). However, the species is systematically absent from the Italian peninsula, even later in the Holocene. In the Iberian Peninsula, the presence of *Olea* in some southern sequences (Badal 1998; Carrión 2005) is documented continuously since the end of the Pleistocene and during the early Holocene (Carrión *et al.* 2008).

The early postglacial presence of *Olea* at the south of the Iberian Peninsula, in Sicily, Cyprus and the Levant allows suggesting the location of thermophilous Pleistocene *refugia* in these areas. However, AMS dates of *Olea* remains from Full and Late Glacial contexts are needed to help clarify the distribution of the oleaster in pre-Holocene chronologies.

The Preboreal and the Boreal constitute a pioneer phase that would have implied the establishment of a biogeographical configuration similar to that of the present-day in which the wild olive distribution would have coincided with the current thermomediterranean belt. The Atlantic period would have marked the consolidation of the species, as well as the differences in its distribution and the variable dynamics between the western and eastern areas of the Mediterranenan basin.

The expansion: biogeographical patterns

The Atlantic period marks the expansion of *Olea*, a pattern that is better observed in the western Mediterranean. This may be linked to the aforementioned presence of the species in early post-glacial contexts in this region. On the contrary, *Olea* is scarce in Italy while in mainland Greece and Crete the majority of sites with *Olea* remains date to the late Neolithic or the Bronze Age. Whether the species was introduced, as proposed for Crete (Bottema and Sarpaki 2003), or whether it expanded in the wild at a very slow rate and only became abundant with tree-tending and cultivation after the Neolithic, it remains an open question until more results are provided. In the western Mediterranean, in the Iberian Peninsula in particular, *Olea* appears during the Atlantic at virtually all the sites that are presently situated in the thermomediterranean bioclimatic level or in the lower mesomediterranean. There, the sites with *Olea* finds are distributed along the coast or at a distance of 50 km from it, generally not surpassing an altitude of 500 m. Beyond this setting, the presence of *Olea* is much scarcer, and it is only restricted to sporadic enclaves that present favorable orographic conditions.

The distribution of *Olea* finds indicates that temperature and continental conditions would have been the limiting factors for its expansion. During the Preboreal and Boreal, there are no records for the presence of *Olea* in the mesomediterranean level (except for Buraca Grande), thus the later presence of the species there should be linked to its large expansion during the Atlantic period and to the favorable orography of particular areas. In any case, the frequency of *Olea* and other thermophilous species at this level is sporadic, probably reflecting the prevailing bioclimatic conditions that would have been close to the minima for their growth.

The rapid expansion of *Olea* could have been favored by the higher temperatures during the Atlantic period. However, the human factor may have played a fundamental role in the expansion process, as well. The establishment of Neolithic groups and the farming economy are linked to evidences of deforestation and expansion of sclerophyllous woodland in many palaeobotanical sequences, probably because of woodland clearing practices or the slash-and-burn agriculture. The charcoal analysis record of the Iberian Peninsula shows that *Olea* was an intensively exploited species in most thermomediterranean and in some mesomediterranean contexts which has led several authors to consider it as evidence of an early manipulation of the species (Terral 1997; Badal 1999). In later periods, by means of cultivation, *Olea* became resistant to more continental conditions and reached the Atlantic façade of the Iberian Peninsula.

Olea in the sclerophyllous woodland

During the Atlantic period, *Olea* forms part of the typical sclerophyllous woodland in the Mediterranean basin. If we take into account its frequency and the accompanying taxa in the available charcoal sequences, three clearly defined behaviours of the *Olea* populations can be described:

A) *Olea* dominates: *Olea* charcoal surpasses 50% of the remains and *Pistacia lentiscus, Quercus* sp. evergreen, *Phillyrea* and/or *Rhamnus* play a key role in the plant formations. This situation may be observed in coastal sites to the south of parallel 40ºN during the Boreal and the Atlantic. On the eastern coast of the Iberian Peninsula, *Pinus halepensis* is an important element of the vegetation, while *P. pinaster* and *P. pinea* are abundant on the western coast.

B) *Olea* accompanies species with a similar ecology: in some cases, *Olea* reaches significant percentages, but it is not dominant in the charcoal assemblages. The dominant taxa are evergreen *Quercus* sp., *Pinus halepensis*, *P. pinaster* or *P. pinea*. In these formations, *Pistacia lentiscus*, *Rhamnus* and/or *Phillyrea*, *Arbutus unedo*, Leguminosae, etc. are usually present. This would have been the case of either Cova de l'Or or the Liguro-Provençal sites.

C) *Olea* shows low frequency: the species represents less than 10% of the remains. The charcoal assemblages are dominated by evergreen *Quercus* sp., *Phillyrea* and deciduous taxa. *Pistacia lentiscus* is less represented in such contexts and together with the scant presence of *Olea*, indicates the ecological upper limits for the development of thermophilous Mediterranean woodland. Such conditions can be observed i.e. at La Falaguera and the Cave of the Cyclops, located at the mesomediterranean level, probably at the limits of what would have been the optimal oleaster distribution area.

In the two former cases, *Olea* could have formed sclerophyllous woodland as most of the maquis species may had reached a considerable height of more than 10 m. *Olea,* together with *Pistacia lentiscus*, *Phillyrea latifolia*, *Arbutus unedo*, *Quercus coccifera*, etc., would have formed well-structured, impenetrable thermophilous woodland with climbers and dense undergrowth.

The available data reveal the importance of *Olea* as part of the genuine Mediterranean vegetation, particularly relevant in the western part of the Mediterranenan basin. In terms of climate, the combination of *Olea* and the above mentioned thermophilous taxa indicates thermomediterranean conditions with mean annual temperatures of between 17ºC and 19ºC, and mean minimum temperatures of more than 4ºC. In terms of the rainfall pattern, this could vary from dry to subhumid since, in the present-day, the wild olive tolerates this range of precipitation regimes. We propose that, at a time when the anthropic impact on the landscape was still weak, the sclerophyllous thermomediterranean vegetation with *Olea* would have constituted woodlands that could have reached several meters in height (up to 10-15 m), as we are able to see nowadays at Serra da Arrábida in the Portuguese Alentejo (Costa *et al.* 1994). Such woodland would have been located mainly to the south of parallel 40ºN, where *Olea* is very abundant in the charcoal records. To the north of this parallel, the presence of the species is more discrete, and its expansion would have probably been linked to human deforestation processes. We therefore consider that it is necessary to provide a phytogeographical entity to the thermomediterranean formations with *Olea,* which were present from times prior to intensive anthropic landscape management.

CONCLUSION

The available charcoal analysis data concerning *Olea* enable us to conclude the following:

A) We propose that *Olea* might have survived during the Pleniglacial in thermophilous *refugia*, located in south Iberia and Italy Peninsulas, in Cyprus and the Levant. This fact may explain the early Holocene presence of the species in these enclaves during the Preboreal and the Boreal.

B) During the Early Holocene *Olea* is more abundant in coastal sites of the Iberian Peninsula, while its presence is less conspicuous in other regions.

C) The emergence and development of the *Olea*-dominated formations took place in the Atlantic period and within the thermal, altitudinal and latitudinal limits of the thermomediterranean belt, coinciding with its present-day distribution (Figure 1). It was only during the mildest periods that this species spread further to mesomediterranean areas with a strong determining thermicity-type orography.

D) The formations in which the oleaster was an important element of the natural vegetation would have constituted the basis for the implementation of its cultivation.

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