The Use of Wild Plants in the Palaeolithic and Neolithic of Northwestern Africa: Preliminary Results from the PALEOPLANT Project

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Abstract. This contribution presents preliminary results from PALEOPLANT, a European Research Council (ERC) multidisciplinary research project that focuses on the analyses of plant remains from Palaeolithic and Neolithic sites in North Africa. The project aims are to: (1) characterize wild plant exploitation among human communities; (2) refine current knowledge on past landscapes; and (3) improve archaeological methodology and fieldwork when studying plants. We discuss preliminary results from charred plant macroremains (wood, seeds and fruits) and plant microfossils (phytoliths and calcitic ash pseudomorphs), as well as dung spherulites recorded in several northwestern African sites spanning the Late Pleistocene to the Early-Middle Holocene (c. 33 to 2 ka BC). Charcoal assemblages indicate the presence of mixed oak/juniper woodlands during the Late Pleistocene while conifers become the dominant element of the vegetation during the transition from Late Glacial to Early Holocene. In these contexts, some of the main species of thermo- and meso-Mediterranean Holocene landscapes (*Olea europaea*, *Pistacia*, etc.) were already present but their spread occurred during the Middle Holocene, concurrently with Neolithic occupations. The combination of wood charcoal, other plant macroremains (seeds and fruits) and plant microfossils, including both plant and dung indicators, provide new insights not only into the presence of a wide range of plant resources (wild pulses, *Ziziphus*

lotus, *Pinus halepensis*, *Quercus* sp., *Stipa tenacissima* and *Chamaerops humilis*) but also on the variability of their potential uses (including fuel, food, fiber, bedding, fodder). Archaeobotanical results suggest continuity in the use of wild plants during the Neolithic. In addition, wood charcoal assemblages reflect significant changes that occurred in plant composition including the expansion of thermo-Mediterranean species.

Keywords: Northwestern Africa · Palaeolithic · Neolithic · Charcoal Seeds · Calcitic microfossils · Phytoliths · Spherulites · Food plants Basketry

Introduction

Plants have been fundamental for human societies across the planet and many communities still depend upon gathering wild plants for their subsistence (Kelly 2013). Nevertheless, most archaeobotanical research has focused on domesticated plants from later chronological periods (Hather and Mason 2002). Consequently, there is a lack of information when it comes to archaeological evidence of plant foraging and collecting during the Palaeolithic of northern Africa. Such studies, however, are emerging in other regions (Sievers 2006; Wadley et al. 2011; Baines et al. 2015; Riehl et al. 2015; Badal García and Martínez Varea 2018, among others). Moreover, taphonomic processes generally favor the preservation of hard remains such as bone and shell while more fragile plant parts such as leaves, do not preserve as well. As a result, interpretations and syntheses of the Palaeolithic and Epipalaeolithic have most certainly overestimated the role of hunting and fishing, and underestimated the role of plants in ancient human diets. Because of these bias efforts to collect plant remains during excavations have been very limited (Kornfeld 1996; Hather and Mason 2002). The resulting outcome has been a limited picture of pre-agrarian subsistence where plants are often neglected or play a secondary role (Richards and Trinkaus 2009; Hardy 2010; Colonese et al. 2011; Mannino et al. 2012).

In this paper, we present the first results of PALEOPLANT, a multidisciplinary research project, focusing on the study of plants during the Palaeolithic and Epipalaeolithic periods. The project aims at exploring the interaction of humans with their environment, searching for new empirical discoveries which can lead to a novel understanding of plant exploitation. In order to address this urgent research question, the project and the current paper pursue the following objectives: (1) to assess wild plant exploitation among Palaeolithic groups; (2) to refine current knowledge of Palaeolithic landscapes; and (3) to improve archaeobotanical methodologies by evaluating sampling strategies and analytical procedures during fieldwork and other stages of the research. Here we present a summary of preliminary results, focusing on plant exploitation during the Middle and Later Stone Age in northwestern Africa. Some Neolithic contexts recorded in the upper layers of studied sites have been also included because during this period changes and continuities in the landscape and/or in the use of plants are detected.

Study Area

Northwestern Africa, including Morocco, Algeria and Tunisia, is the area under examination in this contribution (Fig. 1). This is a mountainous region with a Mediterranean climate that is home to a rich and varied flora (Charco 2001; Fennane et al. 2007; Le Floc'h et al. 2010). Climate conditions exert a strong influence on vegetation in North Africa: this region is isolated by barriers including Mediterranean Sea, the Atlantic Ocean and the Sahara. Mean annual temperatures range from 13 °C to 19 °C (although there are important differences within the region) and the mean minimum temperature ranges from 1 °C to 10 °C. Rainfall is restricted to the autumn to spring months, and summer is hot and dry, ranging from 20 mm in the south near the Sahara, to 2000 mm in northern Morocco (Rejdali 2004).

In terms of vegetation, the Maghreb has a rich flora, with a high level of endemism, which approaches 27% in some regions. The flora includes Mediterranean, Macaronesian, Saharo-Sindian and tropical species. The diverse climate and geology result in different forest types. The following principal forest types are found: pine (*Pinus pinaster* Aiton var. *maghrebiana* Vill., *Pinus nigra* var. *mauretanica* Maire & Peyerimh), Berber thuya (*Tetraclinis articulata* Valh.), oak (*Quercus suber* L., *Q. rotundifolia* L., *Q. faginea* Lam., *Q. coccifera* L.), wild olive (*Olea europaea* L.) and carob (*Ceratonia siliqua* L.) woodlands and maquis. Scrublands are diverse in size and coverage, ranging from shrubby formations dominated by Lamiaceae, Cistaceae, *Phillyrea* and others, to closed canopies. Steppes of *Stipa tenacissima* L. and *Artemisia* are frequent as well (Fennane 1989; Rejdali 2004).

The region is also well known for its interesting archaeological record and well-dated Middle (MSA) and Later Stone Age (LSA) sequences (Lindstädter et al. 2012). The MSA in northwest Africa is associated with anatomically modern humans and it dates as far back as c. 300,000 years ago (Barton et al. 2009; Nami and Moser 2010; Jacobs et al. 2012; Richter et al. 2017), extending to c. 27,000 years ago (Barton et al. 2016). For the LSA, chronology spans from c. 20,000 BC (22,000 cal yr BP) to 5500 BC (7500 cal yr BP; Lubell 2001; Lindstädter et al. 2012; Barton et al. 2013). The LSA is characterized by the occurrence of microlithic bladelet industries that characterize the Iberomaurusian (c. 20,000–10,000 BC; 22,000–12,000 cal yr BP) and the Capsian/Epipalaeolithic (c. 8000–5500 BC; 10,000–7500 cal yr BP). These are well known cultures distinguished by the development of rich cultural deposits and rather elaborate human burials (Camps 2000; Lubell 2001; Barton et al. 2013; Humphrey et al. 2014).

Materials and Methods

PALEOPLANT focuses on pre-agrarian plant exploitation through an interdisciplinary approach which includes the analysis of plant macroremains (seeds, fruits and non-woody plant remains), wood charcoal, and plant microfossils (phytoliths and calcitic ash pseudomorphs), as well as dung spherulites.

Given that landscapes result from the dynamic interaction between human communities and their environments, palaeoenvironmental reconstructions of these spaces require a multidisciplinary approach. Both macro- and micro-remains have been studied allowing

investigations of taphonomic processes. This approach has led to an improvement in identifications which has allowed a more detailed knowledge of past plant species use.

In collaboration with various local and international institutions (Institut National des Sciences de l'Archéologie et du Patrimoine of Morocco, Centre National de Recherches Préhistorique of Algeria, Institut National du Patrimoine of Tunisia, University of Oxford, University of Cologne, University of Aix-Marseille), recovery techniques have been applied systematically to a selection of sites in northwestern Africa. Systematic sampling at the sites has led to the collection of a substantial dataset of micro and macro-botanical remains (seeds, fruits, wood charcoal, phytoliths and calcitic microfossils) spanning a long chronological sequence, with some hiatuses, across large areas of the region (Fig. 1, Table 1).
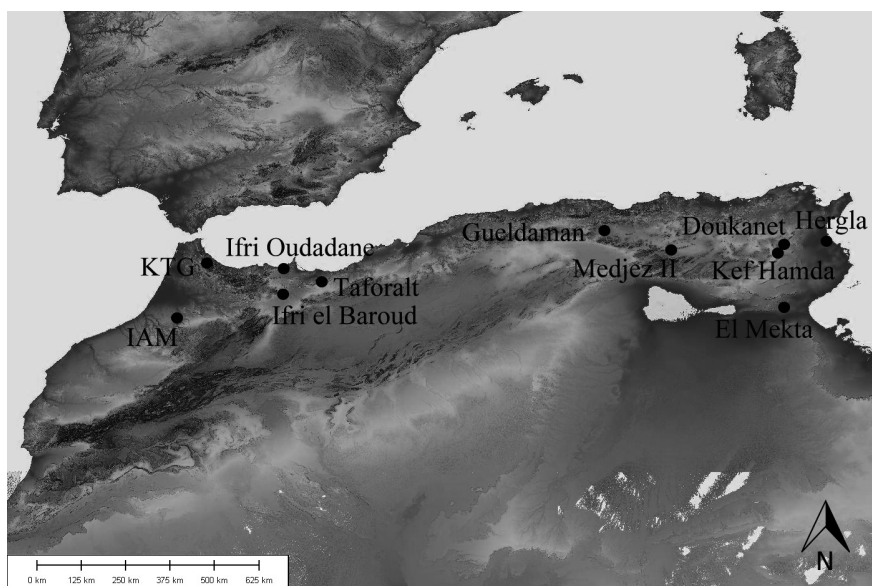

Fig. 1. Map with location of sites.

Table 1. Site location, description and volume of sediment processed.

Site	Cultures	Country	Type of site	Altitude	Volume of sediment (l.)
Taforalt	MSA, LSA	Morocco	Cave	720	561
Gueldaman	LSA, Neolithic	Algeria	Cave	500	no data
Ifri el Baroud	LSA	Morocco	Cave	535	no data
Ifri N'Amr ou Moussa	LSA, Neolithic	Morocco	Cave	200	3257
Kaf That el Ghar	LSA, Neolithic	Morocco	Cave	410	554
Medjez II	LSA	Algeria	Open-air	1000	no data
El Mekta	LSA	Tunisia	Open-air	430	133
Kef Hamda	LSA	Tunisia	Rock shelter	705	833
Ifri Oudadane	LSA, Neolithic	Morocco	Cave	50	6383
Hergla SHM-1	LSA, Neolithic	Tunisia	Open-air	70	no data
Doukanet el-Khoutifa	Neolithic	Tunisia	Open-air	672	50

Although for each site different types of plant material have been studied, depending on the availability of adequate samples (Fig. 2), the information obtained has allowed the exploration of plant resources along the sequences examined both at the local and regional scale. Data on the various materials analyzed and the methods applied are detailed below.
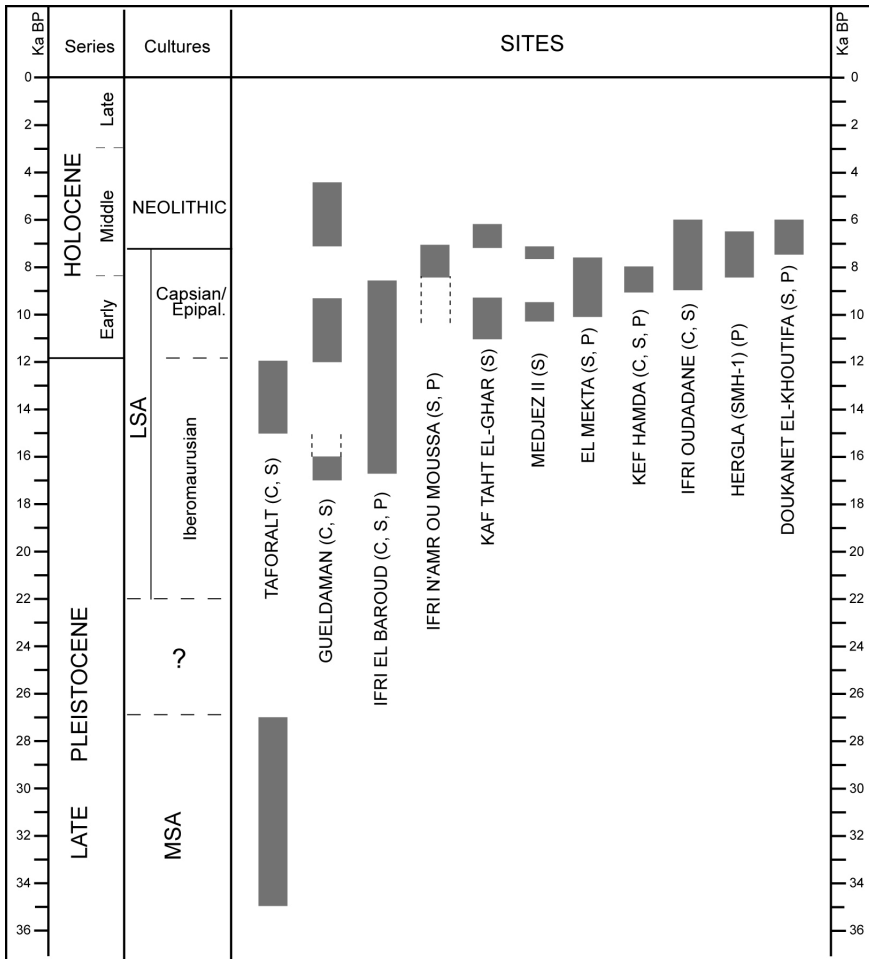

Fig. 2. Chronological assignment of each site with information of the type of remains examined. C=Charcoal; S=Seeds and fruits; P= Phytoliths and calcitic microfossils.

Seeds and Fruits

The limited application of efficient techniques for collecting plant remains in pre-agrarian contexts in comparison to later chronological periods where plant recovery methods are standardized, explains to large extent the scarcity of plant assemblages

Table 2. Presence (√)/absence (-) of seeds and fruit remains of most common taxa recorded in the sites studied.

Sites	Taforalt	Taforalt	El Mekta	Ifri Oudadane	KTG	IAM	Gueldaman	Kef Hamda	Doukanet
Period	MSA	LSA	LSA	LSA-Neolithic	LSA-Neolithic	LSA-Neolithic	LSA-Neolithic	LSA-Neolithic	Neolithic
Chamaerops humilis	-	-	-	√	√	-	-	-	-
Galium sp.	√	√	-	-	-	-	-	√	-
Juniperus sp.	-	√	-	√	-	-	√	-	-
Malva sp.	√	-	-	-	-	-	-	-	-
Olea europaea	-	-	-	√	-	√	√	-	-
Pinus spp.	-	√	√	-	-	-	-	√	√
Pistacia spp.	√	√	-	√	√	√	√	-	-
Poaceae	-	√	-	√	√	-	-	-	-
Quercus sp.	-	√	√	√	-	√	√	√	√
Stipa tenacissima	√	√	√	√	-	-	-	√	√
Taxus baccata	-	-	-	√	-	-	√	-	-
Vicia/Lathyrus	√	√	-	√	√	√	√	√	√
Vitis vinifera	-	-	-	-	-	-	√	-	-
Ziziphus lotus	√	-	-	-	-	-	-	-	-

from earlier periods. In addition, the assumption that taphonomic processes in pre-farming sites constrain plant preservation has also hampered the development of hunter-gatherer archaeobotany. Thus, one of the main goals of the project seeks to test the presence of plant macroremains in Palaeolithic sites through systematic soil sampling and sediment processing by flotation. This methodology has not been previously applied to Palaeolithic sites in this region.

Systematic sampling and recovery of plant macroremains (seeds and fruits) have been carried out at ten sites, including five sites in Morocco- Taforalt, Ifri Oudadane, Kaf Taht el-Ghar, Ifri el-Baroud and Ifri N'Amr ou Moussa (from now on IAM)-, two sites in Algeria (Gueldaman and Medjez II); and three sites in Tunisia (El Mekta, Kef Hamda, and Doukanet el Khoutifa) (Fig. 1). Their chronology spans begins in the MSA and extends to the LSA, comprising a sequence that includes the Middle-Late Pleistocene and the Early-Middle Holocene. Neolithic levels have been also sampled where available. A chronological description of the sites is summarized in Fig. 2.

Macro-plant remains were retrieved from archaeological deposits using both machine assisted and manual flotation. The number of samples and the volume of soil analyzed for each site is presented in Table 2. Flots were processed using a column of sieves with mesh sizes of 2 mm, 1 mm, 0.5 mm, and 0.25 mm. Plant remains were preserved by charring and have been identified using a binocular microscope (8–80× magnification). Identification of macroremains has been carried out by comparison to modern specimens using seed reference collections of the Archaeobiology Laboratory of the Spanish National Research Council in Madrid and the Department of Historical Sciences of the University of Las Palmas de Gran Canaria (Spain). Additionally, specialized literature on plant anatomy was also consulted (Cappers et al. 2009). Botanical nomenclature follows Charco (2001), Fennane et al. (2007) and Le Floc'h et al. (2010). Images of the most significant plant taxa are found in Fig. 3.

Wood Charcoal

Charcoal analyses have been carried out at four sites: Taforalt and Ifri el Baroud (Morocco), Gueldaman (Algeria) and Kef Hamda (Tunisia) (Figs. 1 and 2). Charcoal was recovered by flotation and analyses were completed at the Laboratory of the Department of Prehistory and Archaeology at the University of Valencia.

Charcoal analysis is based on the botanical identification of charred wood fragments based on anatomical features that sometimes enable species identification. Each charcoal fragment is observed under reflected light optical microscopy with bright and dark fields without chemical treatment. This permits the same samples to be used later for radiocarbon dating (Vernet et al. 1979). Identifications are made by comparison to a modern reference collection, specialized literature on plant anatomy (Greguss 1955, 1959; Jacquiot 1955; Jacquiot et al. 1973; Schweingruber 1990; Neumann et al. 2001) and a collection of charred woods held at the University of Valencia.

Charcoal was found to be abundant in all sites, therefore sub-sampling was undertaken. Charcoal fragments of different sizes (>4 mm and 4–2 mm) were selected
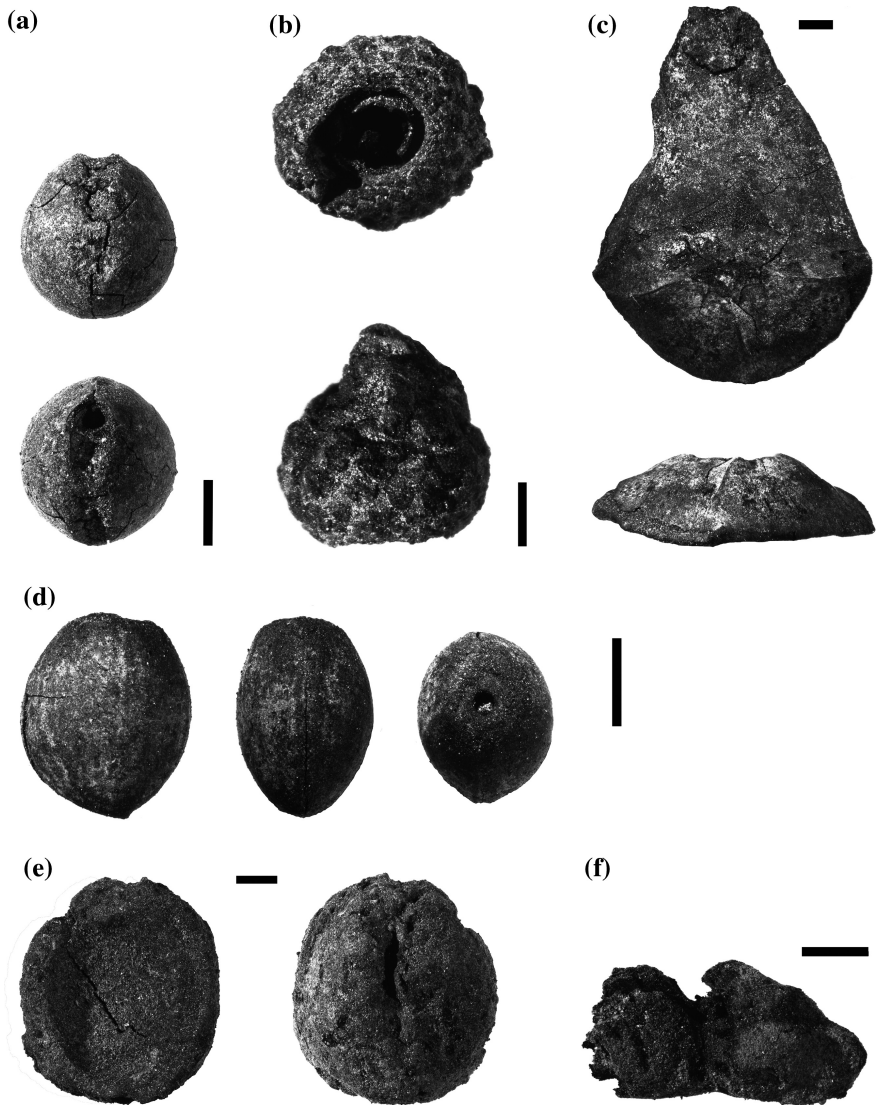
Fig. 3. Seed and fruit remains from MSA and LSA sites: (a) *Vicia/Lathyrus* sp. (MSA, Taforalt), (b) *Quercus* sp., immature cupule (LSA, Taforalt), (c) *Pinus pinaster*, seed scale (LSA, Taforalt), (d) *Pistacia lentiscus* (LSA, Ifri Oudadane), (e) *Ziziphus lotus* (MSA, Taforalt), (f) *Stipa tenacissima,* rhizome fragment (MSA, Taforalt). Scale bar = 1 mm.

for analysis but demonstrate no significant differences in species diversity between the two sieve sizes and as such, results have been combined. The identification of some taxa required the use of a scanning electron microscope (SEM) (Fig. 4). A Hitachi S-4100 MEB held at the Central Service for Experimental Research Support (SCSIE) at the University of Valencia was used for this purpose.

1. *Acer* sp., cross section x 90, Taforalt

2. *Cedrus* sp., cross section x 180, Taforalt

3. *Ephedra* sp., (TV3) cross section x 2000, Gueldaman

4. *Juniperus/Tetraclinis*, cross section x 130, Taforalt

5. *Juniperus/Tetraclinis*, radial section x 900, Taforalt

6. *Olea europaea*, (TV2) cross section x 2000, Gueldaman

7. *Pinus pinaster*, radial section x 900, Taforalt

8. *Pinus* sp., scale, cross section x 70, Taforalt

9. *Pistacia* tp. *lentiscus*, (TV8) cross section x 2000, Gueldaman

10. *Quercus* sp., cross section x 80, Taforalt

11. *Rhamnus-Phillyrea*, cross section x 110, Taforalt

12. *Salix* sp. (TV3), cross section x 200, Gueldaman

Fig. 4. SEM photographs of wood taxa identified in the charcoal assemblages.

The frequency of identified taxa is measured as a percentage of total fragment counts. This statistic is generally thought to reflect the range of woody species present in the local flora which were used for different purposes (Chabal 1988, 1997; Asouti and Austin 2005). Although the identified taxa represent only a portion of the existing vegetation, there are various species which might not be represented in the anthracological spectrum. This might be the case with herbaceous plants (which are not preserved) or woody species that were not collected by prehistoric groups for cultural reasons.

Some of the identifications, particularly those of species or groups of species that are anatomically very similar, were challenging. This was the case for the genus *Juniperus* which is anatomically very close to *Tetraclinis articulata* (Vahl.) Masters (both are present in the area today and are frequent in the charcoal assemblages). The basic difference between them is the presence of wedge-shaped cell walls around the bordered pits in *Tetraclinis* (Schweingruber 1990) while this feature is absent in juniper. Their presence/absence is generally confirmed by observation under SEM. Since in most cases differences between both were not significant, as observed by Zapata et al. (2013) in samples from the region, the taxon has been identified as *Juniperus/Tetraclinis*.

Phytoliths and Calcitic Microfossils

The microfossil studies reported here focused on plant exploitation using opal phytoliths (microscopic bodies composed of pure silica present in the tissues of many vegetal species, see Piperno 2006, and references therein) and calcitic ash pseudomorphs (calcite pseudomorphs remaining after heating calcium oxalate crystals to at least 450 °C), primarily originating from wood and dicotyledonous leaves (Wattez and Courty 1987; Brochier and Thinon 2003). Additionally, dung spherulites (calcitic microscopic particles that form in animal gut and found in dung (see Brochier et al. 1992; Canti 1999) were also examined dating to the transition from Epipalaeolithic hunter-gatherers to early Neolithic food producers.

In the framework of the PALEOPLANT project we have conducted phytolith and calcitic microfossil studies at six sites: Ifri el Baroud and IAM (Morocco), and El Mekta, Kef Hamda, Doukanet el Khoutifa and Hergla (SHM-1), in Tunisia (Figs. 1 and 2). Systematic sampling strategies at most sites included micromorphological analyses, which are currently in progress, and may provide detailed contextual information critical for accurately interpreting the microfossil assemblages. A full record of microfossil datasets will be published when all analyses are completed. As a case study, we present here initial results from Early Holocene IAM. Samples were taken across several contexts described in the field as fireplaces and ashy layers composed of charcoal and various artefacts and remains (i.e. lithic industries, animal bones, land snail shells, Table 3). Microfossil analyses were undertaken at the Palaeobotany Laboratory "Lydia Zapata" (Faculty of Arts) and the Department of Analytic Chemistry (Faculty of Pharmacy) of the University of the Basque Country.

Phytoliths were extracted following methods outlined by Katz et al. (2010). A weighed aliquot of ∼40 mg of dried sediment was treated with 50 µl of a solution of 6 N HCl. The mineral components were then separated according to their densities in order to concentrate the phytoliths using a 450 µl 2.4 g/ml sodium polytungstate solution [$Na_6(H_2W_{12}O_{40})\cdot H_2O$]. Microscope slides were mounted with 50 µl of processed sample. A minimum of 200 phytoliths with recognizable morphologies were counted at 200X using a Nikon Eclipse 50i optical microscope. The estimated phytolith numbers per gram of sediment are related to the initial sample weight. Phytoliths that were unidentifiable because of dissolution were listed as weathered morphotypes (WM, Table 3). Multicellular structures (multi-celled or interconnected phytoliths, MC) were also recorded. These latter data may provide information regarding preservation

Table 3. Description of samples and main phytolith, ash pseudomorph and dung spherulite results obtained from Epipalaeolithic (E) and early Neolithic (EN) Ifri n'Amr ou Moussa, Morocco (2013 field season). Stratigraphical unit descriptions as recorded by the excavators in the field (J.C. Vera and R.M. Martínez Sánchez, pers. comm).

US	Phase	N. Phytoliths 1 g of sediment	% Monocotyledonous	% Dicotyledonous leaves	% Dicotyledonous wood/bark	% WM phytoliths	% MC phytoliths	Ash pseudomorphs 1 g of sediment	Spherulites1 g of sediment	Description
2004	EN	1,060,000	68	4.6	16.1	11.3	7.4	2,560,000	150	White-gray sediment composed of ashes and charcoal fragments, hearth
2006	EN	950,000	69.1	4.5	16.5	9.9	6.7	1,990,000	52	White-gray sediment with ashes, charcoal bits, burnt clay material and faunal remains, hearth
2012	E	840,000	67.9	6.1	21	5	1.7	900,000	0	White layer with ashes, charcoal, animal bones, land snail shells and lithic artifacts

(continued)

Table 3. (*continued*)

US	Phase	N. Phytoliths 1 g of sediment	% Monocotyledonous	% Dicotyledonous leaves	% Dicotyledonous wood/bark	% WM phytoliths	% MC phytoliths	Ash pseudomorphs 1 g of sediment	Spherulites1 g of sediment	Description
2014	E	790,000	60.6	8.6	19.6	11.2	2.7	1,220,000	0	White-gray sediment with ashes, charcoal, faunal bones, land snail shells and lithic artifacts
2029	E	770,000	57.9	4,2	23,5	14.4	4	1,400,000	0	Dark-gray and white-ashy layered filling with charcoal, faunal remains, burnt clay material and lithicindustry, stony hearth/oven

conditions. Morphological identification was based on modern plant reference collections from the Mediterranean region (Albert and Weiner 2001; Tsartsidou et al. 2007; Albert et al. 2008, 2011; Portillo et al. 2014) and standard literature (Twiss et al. 1969; Brown 1984; Rosen 1992; Twiss 1992; Mulholland and Rapp 1992; Madella et al. 2005; Piperno 2006).

Calcitic microfossil samples were prepared following methods developed by Canti (1999). Approximately 1 mg of dried sediment was mounted on a microscope slide with Entellan New from Merck. Slides were examined at 400X magnification under an optical microscope with crossed polarized light (XPL) for spherulites, whereas pseudomorphs where examined in plane polarized light (PPL). Similar to phytoliths, both calcitic microfossil numbers were related to the initial sediment weight. Samples were compared to a pilot modern plant reference collection, which includes selected woody species, as well as modern dung materials from the Mediterranean Maghreb (Portillo et al. 2012, 2016).

Results

Seeds and Fruits

Preliminary results indicate the presence of plant macroremains at all sites sampled. Analyses have been carried out in eight out of the ten selected sites (data from Ifri el-Baroud and Medjez II are not yet available) (Table 2). Here we present data on presence/absence of the most common taxa recorded at each site, considering the frequency and number of remains. A complete report with absolute numbers of seeds and radiocarbon dates for each site will be published when analyses are completed.

For the MSA, the only existing data come from the recent excavations at Taforalt where layers dating to c. 33,000–25,000 BC (35,000–27,000 cal yr BP; Barton et al. 2016) have yielded charred seeds of wild pulses (*Vicia/Lathyrus* sp.). Wild pulses are present throughout the sequence analyzed. Plant remains from other taxa such as alfa grass (*Stipa tenacissima*), mallow (*Malva* sp.), lotus jujube (*Ziziphus lotus* L.), and cleavers (*Galium* sp.) have been also identified. Plant remains are more abundant in LSA sites (c. 20,000–5500 BC; 22,000–7500 cal yr BP), especially in levels dated after c. 13,000 BC where a larger assemblage of seeds is available and many more species have been identified.

In Taforalt, layers belonging to the Iberomaurusian horizon and dated to c. 13,000–10,000 BC (15,000–12,000 cal yr BP) have provided abundant charred plant remains totaling 1270 (Humphrey et al. 2014). Acorns from the holm oak (*Quercus ilex* L.) and pine nuts from maritime pine (*P. pinaster*) were the most abundant taxa. Other diaspores include juniper (*Juniperus phoenicea* L.), terebinth pistachio (*Pistacia terebinthus* L.), wild pulses (*Lens* sp., *Vicia/Lathyrus* sp.) and wild oat (*Avena* sp.).

The macro-botanical assemblage from the Epipalaeolithic and Early Neolithic levels of Ifri Oudadane (c. 7000–4000 BC) is extremely rich, with more than 14,000 botanical remains recorded (Morales et al. 2013; 2016, Zapata et al. 2013). The most common taxa are *Pistacia lentiscus* L., wild pulses (*Vicia/Lathyrus* sp.), and dwarf palm (*Chamaerops humilis* L.), but other potential food plants such as acorns

(*Quercus* sp.) or wild olives (*Olea europaea*) have been also recorded. Epipalaeolithic layers (c. 9000–7000 BC) of Kaf Taht el-Ghar have yielded a few remains of *Avena* sp. and wild pulses. Seeds of wild plants are more abundant in Neolithic layers (c. 5300–4200 BC) where they appear along with emmer (*Triticum dicoccum* L.), free-threshing wheats (*Triticum aestivum/durum*) and naked barley (*Hordeum vulgare* var. *nudum* L.) (Morales et al. 2016). Wild pulses (*Vicia/Lathyrus* sp.) are the most common wild species, but other taxa such as *P. lentiscus* and dwarf palm (*C. humilis*) have been documented in this study.

At IAM, a total of 49 remains of wild plants have been identified. For the Epipalaeolithic layers, wild pulses (*Lens* sp., *Vicia/Lathyrus* sp.) and pistachio (*P. terebinthus)* are the most significant taxa, while in the Neolithic, dated to c. 5100 BC, seeds of domesticated plants such as barley (*H. vulgare*) and wheat (*Triticum* sp.) are found along with wild plants such as *O. europaea*, *Quercus* sp., and *P. terebinthus*, among others.

The plant assemblage from Iberomaurusian layers (c. 15,000–8000 BC; 17,000–10,000 cal yr BP) at Gueldaman, is composed of seeds of *Juniperus*, *P. lentiscus*, *P. terebinthus* and *Taxus baccata* L. In Neolithic layers, dated to about 4800 BC (6800 cal yr BP), wild plants such as *Vicia/Lathyrus*, *O. europaea*, *P. lentiscus*, *Vitis vinifera* L. and *Quercus* are common. No cereal crops have been recorded.

El Mekta (c. 8000–5500 BC; 10,000–7500 cal yr BP) has produced a limited number of plants and information on their use is scarce. Only 34 fragments were retrieved of which 30 were accurately identified. Three taxa including *Pinus halepensis* Mill., *Quercus* sp., and *S. tenacissima* are present (Morales et al. 2015).

At Kef Hamda (c. 7000–6000 BC; 9000–8000 cal yr BP), the most common remains are pine (*P. halepensis*), acorns (*Quercus* sp.) and a wild legume (*Lathyrus/Vicia* sp.) (Mulazzani et al. 2015). Despite the presence of pottery fragments in the upper layers no domesticated plants have been identified so far, and the only evidence comes from wild taxa.

First results from Doukanet el-Khoutifa (c. 5500–4000 BC; 7500–6000 cal yr BP) point to the presence of wild plants while domesticated species are so far absent (Mulazzani et al. 2015). In total, 22 seeds belonging to 4 taxa have been identified. The most common species are acorns (*Quercus* sp.) and wild pulses (*Lathyrus/Vicia* sp.), while pine (*P. halepensis*) is rare. Rhizome fragments of alfa grass (*S. tenacissima*) are also abundant.

Wood Charcoal

Some of the pioneering research on wood charcoal was developed in North Africa (e.g. Balout 1952; Momot 1955; Santa 1961; Couvert 1969). Among the early work, there were also attempts at interpreting wood charcoal from prehistoric sites in climatic terms (Couvert 1976). A significant contribution to the study of wood charcoal in the region is represented by the remarkable work of Wengler and Vernet (1992) on deposits from eastern Morocco. However, systematic studies with proper sampling strategies and the application of effective recovery techniques did not take place until the 21st century when several studies of seeds, fruits and wood charcoal from Moroccan Neolithic sites were undertaken by the AGRIWESTMED project (Morales et al. 2013; Zapata et al. 2013). Charcoal analyses presented here have been carried out within the

PALEOPLANT project with the aim of providing information on the mosaic of existing landscapes in northern Africa and gaining insight into their exploitation over a wide temporal sequence.

Four of the sites, Taforalt, Ifri el Baroud, Kef Hamda and Gueldaman, have provided abundant charcoal assemblages in all phases (Fig. 2). Table 4 shows the presence of identified taxa during the various chronological periods. With at least 27 different species identified, the data show significant plant diversity which includes trees (including *Acer* sp., *Cedrus*, pine, oak, and *Fraxinus*), large shrubs (such as juniper, wild olive and pistachio) and scrubs (including Cistaceae, Lamiaceae). Some charcoal pieces are of a very small size such as the 1–1.5 mm diameter monocotyledon twigs documented at several sites. Conifers (Cupressaceae and/or pines) appear systematically throughout the region with particular intensity in pre-Neolithic levels. However, the most ubiquitous taxa are *Juniperus*/*Tetraclinis* and legumes, the latter being represented in lower percentages. In fact, only a few taxa show significant percentages while the remaining are scarcely represented with percentages in many cases below 1%. This is the case, for instance, of carob and tamarisk at Gueldaman where only a few fragments have been recovered.

Despite the presence of common taxa at all sites, each reveals unique vegetation complexes reflecting the peculiarities of each territory. For instance, pines seem to be an important element of the Late Glacial vegetation in Taforalt and Kef Hamda, while they are almost absent at Ifri el Baroud and Gueldaman. As such the presence/absence of pines in charcoal assemblages might be a marker of regional particularities. In addition, pine wood charcoal can be identified to the species level, offering the possibility of obtaining more accurate environmental information. In Taforalt, *P. pinaster* is widely represented while the percentages of *P. halepensis* are rather low. Both species are typical of warm and temperate conditions, although in North Africa, pines can also be found up to 2000 m asl where climatic conditions are more severe. The maritime pine is associated with siliceous areas and sub-coastal sandy soils which explains its dominating presence at Taforalt. The location of the cave coincides with the area of current distribution of this species, which is restricted to the Rif, Middle Atlas and Tell Atlas. Its presence in Taforalt not only provides information on the relationship between areas of current and potential distribution of this species (Charco 1999) but it also demonstrates its presence in the region since pre-Holocene times. Likewise, Aleppo pine is dominant in Kef Hamda and is presently the most naturally widespread pine species in North Africa. Another distinctive species of the area is cedar which is only present in the Iberomaurusian layers of Taforalt. This is a water demanding taxon that can requires an annual precipitation above 500 mm. It generally prefers humid or sub-humid environments above 1000 mm. Its presence in Taforalt was probably favored by the presence of northern-exposed slopes that trapped maritime moisture where this species could thrive.

A preliminary assessment of the flora present along the long temporal sequence that characterized the sites is provided in Table 4. Taforalt presents the only available archaeobotanical example from MSA contexts. The wood charcoal identified suggests that *Quercus* sp., both evergreen and deciduous, together with *Juniperus*/*Tetraclinis* were the most important taxa. Other taxa, *Acer* sp., Rosaceae Maloideae, *Salix* sp. and some shrubby plants (Cistaceae, Fabaceae, Monocotyledon) were also present, forming mixed open forests.

Table 4. Presence/absence of the woody taxa identified. Shading indicates taxa with percentages over 10% (Identifications in the range of Conifer or Angiosperm group are not included).

TAXA / SITES	Taforalt MSA	Taforalt Iberomaurusian	Ifri el Baroud Iberomaurusian	Kef Hamda Epipalaeolithic	Gueldaman Epipalaeolithic	Gueldaman Neolithic
Acer sp. (maple)	*	*				
Arbutus unedo (strawberry tree)	*			*		*
Cedrus sp. (cedar)			*			
Ceratonia siliqua (carob tree)					*	
Amaranthaceae (goosefoots family)	*					
Cistaceae (rock-rose family)	*			*		*
Asteraceae (aster family)	*	*	*		*	*
Ephedra sp. (ephedra)					*	
Erica sp. (heather)					*	*
Ficus carica (fig tree)					*	*
Fraxinus sp. (ash)					*	*
Juniperus/Tetraclinis (juniper/thuja)	*	*	*	*	*	*
Lamiaceae (mint family)		*			*	*
Fabaceae (legumes)	*	*	*	*	*	*
Monocotyledon	*	*	*		*	
Olea europaea (wild olive tree)					*	*
Pinus halepensis (Aleppo pine)		*		*		
Pinus pinaster (maritime pine)	*	*				
Pinus sp.	*	*		*		
Pistacia tp. *lentiscus* (mastic)				*	*	*
Pistacia terebinthus (terebinth)					*	*
Pistacia sp.		*		*	*	*
Quercus deciduous (oak)	*	*			*	*
Quercus evergreen (holm oak/ kermes oak)	*	*	*		*	*
Quercus sp.	*	*			*	*
Rhamnus/Phillyrea (buckthorn/green olive tree)	*	*		*	*	*
Rosaceae (rose family)					*	*
Rosaceae Maloideae (juneberry subfamily)	*	*			*	*
Rosmarinus officinalis (rosemary)		*		*		
Salix/Populus (willow/poplar)	*	*		*	*	*
Tamarix sp. (tamarisk)					*	*
Minimum N. of species	13	16	5	9	19	18
Charcoal fragments analysed	661	2130	540	450	1083	2360

Charcoal assemblages dating to the Iberomaurusian and Epipalaeolithic provide environmental information for the Pleistocene/Holocene transition. *Juniperus/Tetraclinis* is the most common taxon in these contexts. In Taforalt, this species is accompanied by pine (*P. pinaster*), which increases along the sequence while Cupressaceae declines (c. 13,000-10,000 BC). Conifers appear together with *Cedrus*, *Quercus* (both evergreen and deciduous), *Acer*, and low percentages of thermo-Mediterranean scrub species which gradually begin to spread (including Lamiaceae, Fabaceae, pistachio, and *Rhamnus-Phillyrea*). The Ifri el Baroud assemblage is taxonomically rather poor but it shows the predominance of *Juniperus/Tetraclinis* together with legumes. On the contrary, Epipalaeolithic levels of Kef Hamda are rich in pine (*P. halepensis*) while junipers are barely represented. Here, the charcoal assemblage shows the initial spread of scrubland Mediterranean species represented by a high percentage of Cistaceae, *Pistacia*, *Rhamnus-Phillyrea* and legumes. Some of these have been also identified in low percentages in Epipalaeolithic levels at Gueldaman where pre-Neolithic assemblages are dominated by *Juniperus/Tetraclinis* and *Pistacia* together with Lamiaceae, Asteraceae and *Ephedra*. Riparian vegetation consists of *Salix-Populus* and ash.

In Gueldaman, a radical change in the vegetation is observed in Neolithic levels. At this site, *O. europaea* becomes the dominant species reaching percentages up to 90% of the charcoal record. *Arbutus unedo* L., *Quercus* and *Pistacia*, also have been identified while the presence of conifers is minimal. Other taxa such as carob, Ericaceae (heather), legumes, *Ficus* or Rosaceae are occasionally present. This spectrum of plant species dominated by *O. europaea* may be explained by the intensive use of the cave as an animal pen during Neolithic times (Kherbouche et al. 2014), which will be further discussed below.

Phytoliths and Calcitic Microfossils

First results from transitional Epipalaeolithic- early Neolithic food producers at IAM provide both plant microfossil (phytoliths and calcitic ash pseudomorphs) as well as dung spherulite indicators. The integration of these lines of evidence both complements and supplements other sources of archaeobotanical data at the cave (i.e. charred plant macroremains, pollen) since each is influenced by different taphonomic processes. Table 3 shows the location and field descriptions of the five samples analyzed, together with the main quantitative results. Phytoliths and calcitic microfossils were noted in different amounts in the sediments, with the exception of all three Epipalaeolithic samples, where dung spherulites were absent.

Phytoliths were abundantly noted in all samples. The richest sediments were Early Neolithic hearth samples (samples 2004 and 2006, around 1 million phytoliths per gram of sediment, Table 3). The dissolution index of phytoliths does not correlate with their concentration in the samples, and the assemblages do not seem to be highly affected by post-depositional processes. The ashy-layered fill deposit from the firing installation belonging to the Epipalaeolithic, where macroscopic remains from compacted burnt clay material were observed, showed the highest dissolution rate (sample 2029, around 14%). The morphological results indicated that monocotyledonous plants and particularly grasses dominated all samples at approximately 60–70% of all counted

morphotypes, whereas wood, bark and dicotyledonous leaf indicators (i.e. tracheids, globulars, and irregular morphologies) constituted about 20–30% of the assemblages. This is especially noteworthy given that woody plants are not great phytolith producers. It is also worthy of note that monocotyledonous leaves produce up to 20 times more phytoliths than wood and bark and 16 times more than dicotyledonous leaves, and they are also present as exterior contamination on woody material used as fuel (Albert and Weiner, 2001; Albert et al. 2003; Tsartsidou et al. 2007). This is consistent with abundant macro-botanical charred remains which were common in these contexts, as well as large concentrations of ash pseudomorphs (ranging between 0, 9 to 2.5 million/1 g of sediment, Table 3), indicative of wood-dominated ashes. Early Neolithic firing installations were by far the richest contexts sampled. Pseudomorphs included mostly prisms and rhomboidal morphologies, which are common in modern reference datasets, such as *Pistacia* sp. and *O. europaea* (Portillo et al. 2016, Fig. 5a). Both wild and domesticated plants were noted in the botanical record (Table 2).
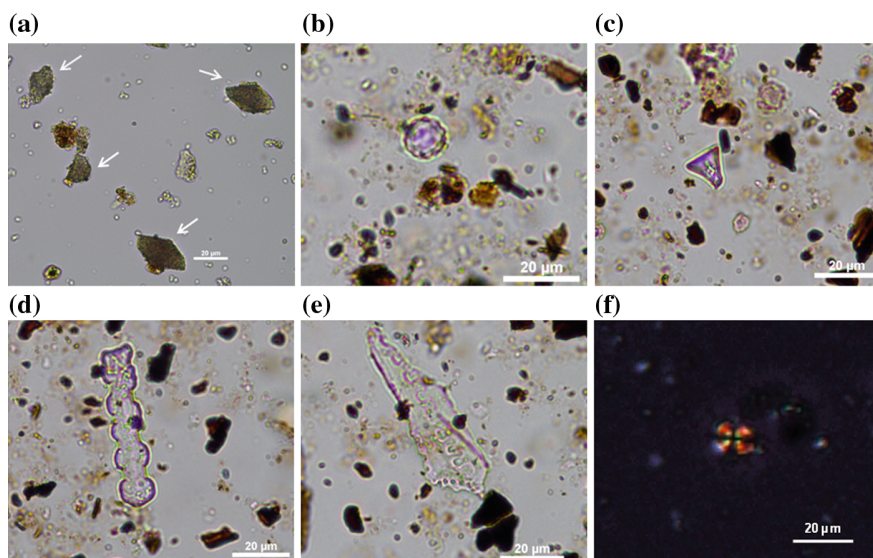
Fig. 5. Photomicrographs of phytoliths and calcitic microfossils identified in archaeological samples (at 400×) (a–e PPL; f XPL, photo A. Polo-Díaz, UPV-EHU). (a) ash pseudomorps, (b) spheroid echinate, (c) short cell rondel, (d) long cell polylobate, (e) multicellular phytoliths of dendritic long cells, (f) dung spherulite.

In addition, diagnostic morphotypes produced by the leaves of the Arecaceae family (palms) were also identified in all samples although to a lesser extent (Fig. 5b). Grass phytoliths belonged mostly to the Pooid subfamily (Fig. 5c). Grasses were in general represented by leaf/culm phytoliths (i.e. long cell polylobates, prickles, bulliforms and multi-celled phytoliths, Fig. 5d), whereas inflorescence morphotypes (i.e. papillae and decorated long cells, such as echinate and dendritics) were scarce in most assemblages, with the exception of one Neolithic sample (2004). Multi-celled

phytoliths from the floral parts or husks of Pooid seeds were also noted in early Neolithic firing installations (Fig. 5e). This is consistent with findings of charred caryopses of barley (*H. vulgare*) and wheat (*Triticum* sp.) which were common in Early Neolithic deposits of the cave, as well as in other Western Maghreb sites, in addition to faunal remains from domestic animals (Ballouche and Marinval 2003; Morales et al. 2013, 2016).

Lastly, dung spherulites were noted only in Neolithic hearth samples, although in relatively lower quantities (52,000–150,000 spherulites/g, Table 3, Fig. 5f). Interestingly, spherulite abundances correlate with large numbers of grass phytoliths in both samples, possibly derived from cereal crops according to macrobotanical datasets. This suggests that these sediments were at least partly composed of livestock dung.

Discussion

Exploring Vegetation Dynamics

Archaeobotanical remains identified at the various site are spread over a rather long chronological sequence which includes some hiatuses. Such a long span of time offers the possibility of assessing not only plant diversity, and thus, landscape evolution over time, but also exploring plant uses. Indeed, most species identified in both the macro and micro remains were selected by ancient communities for a wide variety of uses. Fuel was almost certainly one of the main sources of wood charcoal at the sites. In fact, firewood collection was most certainly a non-specialized task carried out on a daily basis. Wood was probably collected from the nearby area, and it is likely that species represented in the archaeological assemblages correspond to at least part of the present-day vegetation. In addition, human groups probably collected other categories of plants (roots, rhizomes, etc.), relating to a diverse range of activities (food, drinks, crafts, bedding, fodder, etc.).
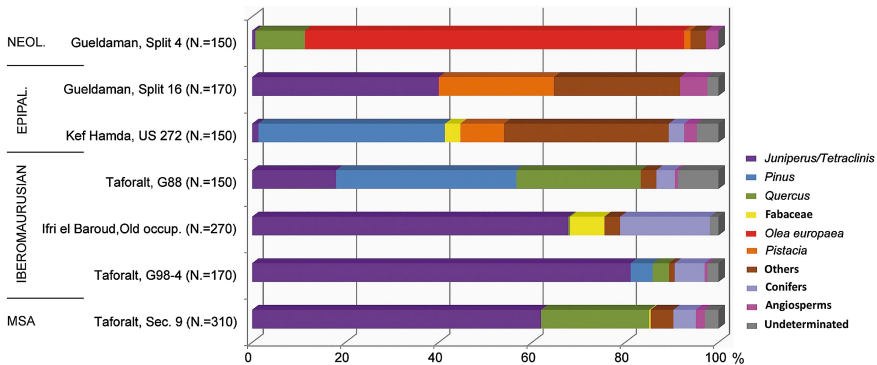

Fig. 6. Summary wood charcoal main species for the various sites analyzed.

Figure 6 presents a synthesis of the woody vegetation used for fuel at the various sites which allows the comparison of wood assemblages over time. Taforalt is the only MSA site that has offered a plant assemblage dated to c. 33,000–25,000 BC (35,000–27,000 cal yr BP; Barton et al. 2016). The samples suggest the presence of a mixed open forest dominated by junipers together with oaks (deciduous and evergreen), maple and shrubs of Cistaceae, Amaranthaceae, Asteraceae, Fabaceae, and monocotyledons. Water demanding plants such as *Salix* sp. are also present.

The Late Glacial period, and in particular the Pleistocene-Holocene transition, is well documented in all sequences (Taforalt, Ifri el Baroud, Gueldaman, Kef Hamda). Iberomaurusian and Epipalaeolithic layers (c. 13,000–5500 BC) are characterized by the ubiquity of coniferous woodlands across the whole region and the spread of juniper forests (perhaps together with *T. articulata*). *Juniperus/Tetraclinis*, species that are well-adapted to impoverished soils (Wengler and Vernet 1992), may have been pioneer species which colonized postglacial soils. These taxa are very abundant in Taforalt, Ifri el Baroud and at the base of the Gueldaman sequence dating between c. 13,000 and 8000 BC.

Wood charcoal analyses also indicate that pines were present in Late Glacial coniferous forests. Their presence is, however, more irregular as shown by the percentage values of *P. pinaster* in Taforalt and *P. halepensis* in Kef Hamda. In Taforalt, pines replace *Juniperus/Tetraclinis* forests that were dominant at the beginning of the Iberomaurusian (Fig. 6), which might indicate increasing humidity. Pines are absent from Ifri el Baroud and Gueldaman, although pollen records from marine sequences suggest this species was widespread during the Late Glacial period (Desprat et al. 2013).

The common presence, although in low percentages, of other dry-resistant taxa, such as *Ephedra* or Amaranthaceae in juniper-pine forests, points perhaps to some level of aridity. On the contrary, at Taforalt before Holocene, as mentioned above, there is a trend towards a more humid phase characterized by an increase of the proportion of pine and cedar compared to *Juniperus/Tetraclinis*.

At Gueldaman, the retreat of Cupressaceae during the Preboreal-Boreal transition occurred in parallel with a rapid development of a sclerophyllous vegetation dominated by several *Pistacia* species which is well documented both in the charcoal and seed records. Interestingly, during the Neolithic, the taxa composition of wood charcoal assemblages evidences a profound change when compared to previous phases. In fact, *O. europaea* dominates the spectrum with percentages up to 90% while *Arbutus* and evergreen *Quercus* are also present. *Pistacia* and *Juniperus* are represented in lower proportions.

From the Middle Holocene, wild olive appears to have been a key forest component of *Olea-Ceratonion* components of thermo-Mediterranean vegetation, suggesting the occurrence of warm, semi-arid conditions (Wengler and Vernet 1992). Other species such as *Pistacia*, *Juniperus*, *Tetraclinis*, *C. siliqua*, and Fabaceae were probably equally significant in these habitats as suggested by data from other Neolithic sites in the region (Wengler and Vernet 1992, Zapata et al. 2013). At Gueldaman, *O. europaea* may be overrepresented. This species is commonly used for animal fodder because of the palatability of its leaves (Badal 1999). Its dominant presence in the cave as a result of its use as animal pen may have distorted the picture and it is likely that many other

species were actually present. The presence of ovicaprine coprolites in the Neolithic sediments strongly supports the use of the Gueldaman cave as livestock pen.

A similar use is proposed for the early Neolithic IAM cave where there is evidence of dung spherulites in addition to one ovicaprine charred dung pellet obtained by flotation. Phytolith results also suggest that leaves and culms of grasses, such as barley and wheat, whose seeds were common in the plant macroremain record, could have been used as bedding or matting material, and fodder. It is well known that since the Neolithic caves and rock-shelters have long been used as pens in the Mediterranean region (Brochier et al. 1992; Macphail et al. 1997; Badal 1999; Vergès et al. 2002; Karkanas 2006; Angelucci et al. 2009), and southern in the Central Sahara (Mercuri 2008; Mercuri et al. 2018; Amrani 2018).

Evidence of Food Plants

Preliminary results from Taforalt, the only site that has provided botanical evidence of wild plants from MSA layers, indicate that wild pulses (*Vicia/Lathyrus* sp.) and other species such as lotus jujube (*Z. lotus*) could have been part of the human diet during that time. Seeds from *Lathyrus* and *Vicia* species are very nutritious; they are relatively high in proteins and contain carbohydrates and also contain some toxic substances that may be removed by roasting or leaching (Aykroyd and Doughty 1982:108). However accidental burning during roasting also could account for the charred state of these remains. Charred seeds of *Lathyrus* sp. and *Vicia* sp. have been recorded in Middle Palaeolithic layers of sites in the Near East (Lev et al. 2005; Baines et al. 2015) suggesting that wild pulses were common food plants at that period.

Lotus jujube (*Z. lotus*) fruits are rich in carbohydrates and vitamins and nowadays it is a common food in North Africa and the Near East (Boulos 1983; Rivera et al. 2011). *Ziziphus* fruits are also have medicinal uses in North Africa (Boulos 1983), as such it cannot be ruled out that it was used as both food and medicine. There is no other Middle Palaeolithic evidence of *Ziziphus*, and the earliest remains of *Ziziphus* seeds have been recorded in Ohalo II, Israel (c. 21,000 BC) (Weiss 2009). Although the size of the dataset is still limited, seeds from Taforalt are one of the oldest charred plant assemblages recorded from archaeological sites in North Africa and have provided interesting new data about the use of plants during the MSA (Barton et al. 2016).

The data available for LSA layers are more extensive and have produced a richer assemblage of plant taxa. Wild pulses (*Vicia/Lathyrus* sp. and *Lens* sp.) were present, but the most abundant macrofossils were acorns (*Quercus* sp.), pine (*P. halepensis* and *P. pinaster*) and wild pistachio (*P. lentiscus* and *P. terebinthus*), recovered at most of the sites (Table 2). Although the data available from MSA contexts are still limited and the results obtained are preliminary, we propose that the increase of seeds and taxa during the LSA may be related to a higher consumption of food plants during this period. This seems to be confirmed by data from Iberomaurusian burials at Taforalt, where frequent dental caries in human remains suggest significant consumption of plants rich in starch (Humphrey et al. 2014). Charred remains of acorns, pine nuts, wild pulses and wild pistachios are also frequent in other Epipalaeolithic sites of the Mediterranean basin, confirming the widespread use of these plants (Hansen 1991;

Butler 1998; Aura et al. 2005; Vaquer and Ruas 2009). Data suggest that acorns and pine nuts may have played an important role in human subsistence. They were abundant, highly nutritious and easy to collect, process and store (Lanner 1981; Mason, 1995; Mason and Nesbitt 2009). Ethnographic data indicate that both acorns and pine nuts have been used as staple foods by hunter-gatherer populations (Barrett and Gifford 1933; Kroeber 1976; Lanner 1981; Anderson 2005). Further evidence of the importance of gathered plants in the human diet is provided by their persistent exploitation through the Middle Holocene. For instance, continuity in the use of acorns, pine nuts and wild pulses has been recorded in some Neolithic contexts studied. Crops and domestic animals have been also identified in the same contexts, especially at sites in northern Morocco (Ballouche and Marinval 2003; Morales et al. 2013, 2016; Zapata et al. 2013), suggesting a mixing foraging-farming economy where wild plants continued to play an important role. These interpretations are further supported by microfossil evidence from phytoliths.

Indirect Evidence of Basketry

Archaeological evidence of prehistoric basketry is limited due to poor preservation of organic material and deficient recovery techniques. The earliest evidence comes from the site of Dzudzuana cave in the Caucasus dated to 30,000 years ago (Kvavadze 2009). Fibers identified as wild flax or simple bast fibers as suggested by Bergfjord et al. (2010) were discovered during microscopical analyses. In addition, the sites of Dolní Věstonice and Pavlov in the Czech Republic (Adovasio et al. 1996; Soffer et al. 2000a) have provided basketry impressions in fired and unfired clay. The finds were dated to the Upper Palaeolithic, between c. 27,000 and 22,000 BC. Further evidence comes from Ohalo II (Israel) where fibers belonging to a mat were identified and dated to c. 17,000 BC (Nadel et al. 1994). Soffer et al. (2000b) collect additional data from the Upper Palaeolithic showing the presence of this technology in France, Germany, and Russia. Neolithic examples of cordage and fiber impressions appear occasionally at various sites in Europe, revealing that basketry was a technology known in the period. For the Mediterranean area, examples of basketry are found in the Neolithic Cueva de Los Murciélagos (Albuñol, Granada, Spain) (Cacho Quesada et al. 1996) where several complete baskets were exceptionally preserved due to arid conditions inside the cave. Two fragments of plant material from a sandal and a piece of plaited material using alfa grass (*S. tenacissima*) have been dated to c. 3800 BC. More recently, a textile from China dating to c. 4700–4600 BC (6775–6645 cal yr BP) and made from reeds has been identified (Zhang et al. 2016).

In Mediterranean North Africa, there is no direct evidence of baskets, mats or other products from basketry; well preserved desiccated remains of these items have only been recorded at sites from the Tadrart Acacus massifs in Central Sahara, with remains dated to the Early and Middle Holocene 'Green Sahara' (di Lernia et al. 2012). We propose that some of the carbonized rhizome fragments of alfa grass which have been recorded at most of the sites in both MSA and LSA layers, could have played role of basketry plants, although preservation conditions and inappropriate recovery techniques have not allowed the recognition of basketry items for the time being. Alfa is a

native perennial grass in the western Mediterranean area which has been extensively used as raw material for basketry and other craft items in North Africa (Louis and Despois 1986; M'Handi and Anderson 2013) and the Iberian Peninsula (Kuoni 1981). The preservation of charred rhizomes suggests that alfa grass could have been collected for basketry. Leaves are the useful part of the plant, while rhizomes are a common by-product or residue of gathering and processing the fibers, which are usually discarded and re-used as fuel. Since remains of baskets or cordage have not been recorded in our analyzed sites, we cannot rule out that alfa grass was also introduced to the site as part of bedding or other subsistence activities.

In addition, seeds of the dwarf palm (*Chamaerops humilis*) has already been recorded at several Epipalaeolithic and Early Neolithic sites across the Western Maghreb (Morales et al. 2013, 2016; Zapata et al. 2013). Interestingly, phytoliths from palm leaves have been identified in fireplaces from both periods, suggesting that this plant could have been used also as fuel or discarded deliberately or accidentally into the fire. Although both seeds and leaves are potential plant foods, ethnographic research in the Rif and other Mediterranean areas (Peña-Chocarro et al. 2015, and references therein) demonstrates the extensive use of palms for basketry.

Conclusions

This project has produced important new data that fills a major gap in prehistoric knowledge, namely how plant foods and vegetal resources were used by pre-agrarian and first farming groups. Initial results of PALEOPLANT demonstrate that when properly sampled, Palaeolithic and Epipalaeolithic sites can produce direct evidence of plant use. In fact, although the analyses have not yet been completed, the available data contradicts the general assumption that plant remains do not preserve well in pre-farming sites. Moreover, the combination of multiple lines of evidence, e.g. plant macroremains, phytoliths, and other plant microfossils, has significantly improve our understanding of plant exploitation by taking into account the various pathways to archaeological record formation, each influenced by different taphonomic processes.

Our preliminary results point to the exploitation of an impressive range of plant resources, including wild pulses, acorns, pine nuts, grasses, and palms, characterized by different potential uses, such as food, fuel, basketry, bedding and animal fodder. Plant macro and micro remains have been recovered from eleven archaeological sites in our study area (Fig. 2), providing most interesting data on the range of wild plants used during the Palaeolithic and Neolithic in northwestern Africa, including wild pulses, acorns, pine nuts, alfa grass and dwarf palm. Different types of evidence (archaeological and ethnographic) suggest that wild pulses, pine nuts and acorns could have played a role as food in human subsistence while alfa grass and dwarf palm may have been used as a source of fiber for basketry or fuel.

Outstanding results have been obtained from the Middle Stone Age deposits of Taforalt (Morocco) where charred seeds of wild pulses, lotus jujube, and rhizome fragments of alfa grass in addition to other species have been identified. Continuity in the use of wild plant species is observed in Neolithic layers indicating the significant

role of gathered sources in the subsistence of the first farmer communities in north-western Africa.

The large charcoal assemblages examined highlight the importance of wood gathering activities and offer a vivid picture of the existing vegetation and of its evolution throughout the sequence. Particularly interesting is the observation of the spread of thermo- and meso-Mediterranean landscapes during the Pleistocene/Holocene transition. In these transitional phases, some regional traits are distinguished in the various sites which require further work. The challenge for the future is, therefore, deepening our knowledge on regional differences observed and filling in the crucial remaining hiatuses along the chronological sequence.

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