6. OTHER CHARRED PLANT MACRO-REMAINS (SEEDS, FRUITS, ETC.)

6.1 INTRODUCTION

Plants are fundamental for humans as a source of food, fuel, raw material to produce tools, clothes, medicines and so on (Cotton 1996). However, there is a marked paucity of macro-botanical evidences in Later Stone Age (LSA) sites of north-western Africa, resulting in a limited and biased knowledge about plant use at that time. Plant remains such as wood charcoals, seeds and fruits are more fragile and less prone to be preserved in pre-farming sites than other botanical finds, such as starch, pollen or phytoliths (Piperno 2006; Henry / Brooks / Piperno 2011). Nevertheless, the absence of remains is also due to the lack of systematic methods for plant collection in archaeological excavations of pre-farming sites. A large proportion of LSA sites were excavated in the early part of the 20th century and no systematic sampling and analysis of plant evidence were practiced at that time. Only large pieces of wood charcoals picked up on site were analysed (Santa 1958-1959; see **Chapter 5**). The only available evidence of seeds and fruits in North Africa comes from recent excavations at Early Holocene sites in Morocco (Morales et al. 2013; 2016), Tunisia (Morales et al. 2015) and Libya (Barker et al. 2010), where systematic sampling and flotation of sediments have been carried out. In those sites, charred remains of nuts, fruits and seeds are abundantly recorded. Data on Late Pleistocene sites are scarcer and, to our knowledge, there is little published information recording archaeological seeds and fruits (but see Carrión Marco et al. 2018; Morales 2018).

In the present chapter, we examine the macro-botanical remains from the LSA levels at Taforalt. Excellent conditions here have allowed the preservation of a rich set of charred plants that were recorded in levels dated between approximately 21,000 and 12,600 cal BP. Taforalt is thus a key site to the understanding of the use of plants during the Late Pleistocene of north-western Africa. A first record of this evidence has been published in Humphrey et al. (2014). The aim of the present study is to provide a full report of the macro-botanical evidence and to discuss the role of plants in the economy and general human behavior of this period. Seeds and fruits are gathered from the environment and thus they can provide some valuable information about the palaeoflora and palaeoclimatic conditions. However, these plant remains do not represent the entire environment and they only provide information about the plants that were more commonly used (Van der Veen 2007). In many cases, the plant remains correspond to the residues of cooking activities and they provide unique information about the role of plants in the diet of the inhabitants of Taforalt. In addition, some of the plant material recorded could correspond to residues of basketry. Here the evidence is presented and its significance discussed.

Considerable overgrazing and human disturbance have transformed the modern landscape around the cave and towards the bottom of the valley and the side ravines. Here, most of the vegetation comprises pine trees (*Pinus halepensis*) from re-afforestation, tree crops such as figs and carob trees, and also other exotic or invasive plants such as Eucalyptus and the "tree of heaven" (*Ailanthus altissima*) – indeed, there is a specimen of this last species currently growing upon the Grey Series at the entrance of the cave. However, in the highland in front of the cave (to the north), the vegetation and the landscape are less transformed. No evidence of old fields is apparent, only of animal grazing. Here, the vegetation is dominated by araar / thuja

(*Tetraclinis articulata*) in the sunniest and rockiest areas, whilst, on north-facing slopes and on the higher ground, Holm oak (*Quercus ilex*) is more common. Wild olive (*Olea europaea*), dwarf palm (*Chamaerops humilis*) and pine (*Pinus halepensis*) are also common, the last again mostly due to re-afforestation. Esparto/alfa (*Stipa tenacissima*) is also quite common in the highlands, especially across the summits, as is diss grass (*Ampelodesmos mauritanicus*), another large perennial grass.

6.2 METHODOLOGY

The macro-botanical remains analysed in the current work come from the systematic sampling of sediment in Sector 8 (S8). The macro-plant remains from the burial area in Sector 10 are currently under analysis and will not be included here. Samples from S8 comprise both the Yellow Series (YS) and Grey Series (GS). They were collected from the G-sample column during the fieldwork between 2003 and 2005 (see **tab. 6.1**), and from the MMC-sample column during the fieldwork in 2009 and 2010 (see **tab. 6.2**) (see also **Chapter 2** for locations and stratigraphic sequences). One hundred samples of sediment were analysed in total, with a volume of 350 litres. The coarse stone fraction had already been removed from the sediment samples on site and is excluded from volume measurements.

Macro-botanical remains were retrieved from the sediment by floating each sample and then sieving the flot (light fraction) using a stack of sieves (2, 1 and 0.5 mm). All plant remains are carbonised and very well preserved. The identification has been done with a binocular microscope of 8x and 80x magnifications and by comparing the archaeological remains with modern seeds of the reference collections at the Department of Historical Sciences, in the University of Las Palmas de Gran Canaria, Spain, and at the McDonald Institute for Archaeological Research, University of Cambridge, UK. For botanical nomenclature, we follow Fennane et al. (1999), Fennane/Ibn-Tattou/Ouyahya/El-Oualidi (2007) and Fennane/Ibn-Tattou/Ouyahya/El-Oualidi (2014). A summary of the results is shown in **table 6.1** and **table 6.2**, while a complete table with full results is provided in the appendix (**A6**). Formal taxonomic nomenclature is given in **table 6.1** and **table 6.2**. **Figure 6.1** illustrates the most important plant species discussed in the text.

6.3 EVIDENCE OF NON-WOOD MACRO-PLANT REMAINS

The systematic sampling and flotation of the sediments have provided a rich assemblage of charred macro-plant remains from S8. A total number of 1,206 items were collected here. 98 % of the remains were recorded in the GS (n = 1,182), while in the YS the number of seeds is greatly inferior (n = 24). Density of remains is important, averaging about 3.55 items per litre of sediment, being much higher in the GS (4.37 items per litre of sediment) than in samples from the YS (0.34 items per litre of sediment).

A total number of twenty-two taxa have been identified in S8. Samples from the YS have only produced 8 taxa, mostly annuals such as cleaver (*Galium* sp.; n = 10) and wild legume (*Vicia*/*Lathyrus* sp.; n = 1), and shrubs such as ephedra (*Ephedra* sp.; n = 6) and rockrose (Cistaceae; n = 1). The great majority of the YS seeds were recorded in Units Y4 (n = 11) and Y1 (n = 11). On the other hand, samples from the GS are characterised by the abundance of arboreal or large shrub species. Holm oak (*Quercus ilex*) is the most abundant taxon in the samples (n = 495; 39.6 % of total plant remains in the GS) but other tree species, such as Maritime pine (*Pinus pinaster*), juniper (*Juniperus phoenicea*) or Terebinth pistachio (*Pistacia terebinthus*), are also

	Yellow Series			Grey Series													Total
Y/G units	Y4	Y2	Y1	G1OO	G99	G98	G97	G96	G95	G94	G93	G92	G91	G90	G89	G88	
Number of samples analyzed	4	2	3	1	4	10	1	5	4	2	2	3	1	7	2	2	**53**
Volume of sediment (in litre)	38.6	20.5	8	12.5	12.5	30	1.5	19.3	26	13.5	21	23	7	35.7	10	17.5	**296.6**
Avena sp. (wild oat), seed	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	**2**
cf. *Bromus* sp. (large seeded grass), seed	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	**2**
Cistaceae, seed	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Ephedra sp., cone bract	1	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	**6**
Fabaceae (wild pulse), seed	-	-	-	-	-	1	-	1	-	-	3	-	-	-	-	-	**5**
Fumaria sp. (fumitory), seed	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	**1**
Galium sp. (bedstraw), seed	7	-	2	-	3	5	-	-	-	1	1	1	4	9	4	5	**42**
Juniperus phoenicea L. (juniper), seed	-	-	-	-	-	4	-	-	1	1	10	17	6	26	1	2	**68**
Lens cf. *nigricans* (M. Bieb.) Godr. (wild lentil), seed	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**
Pinus pinaster Ait. (Maritime pine), seed	-	-	-	-	-	2	-	1	2	1	-	3	-	2	-	-	**11**
Pinus pinaster Ait. (Maritime pine), seed scale	-	-	-	1	2	12	1	21	30	12	14	11	8	56	3	4	**175**
Pistacia terebinthus L. (Terebinth pistachio), seed	-	-	-	-	-	-	-	-	-	-	-	3	2	15	8	1	**29**
Poaceae, seed	-	-	-	-	-	4	-	-	-	-	-	-	-	1	-	-	**5**
Quercus ilex L. (Holm oak), cupule	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	3	**5**
Quercus sp (acorn), cotyledon	-	-	-	-	-	-	-	-	-	-	-	2	1	1	2	-	**6**
Quercus sp. (acorn), cupule	-	-	-	-	8	44	2	58	43	14	36	33	3	30	8	3	**282**
Quercus sp. (acorn), abscission scar	-	1	-	-	-	2	-	1	2	-	2	1	7	18	3	2	**39**
Quercus sp. (acorn), pericarp	-	-	-	-	-	-	-	-	-	-	-	2	2	3	1	1	**9**
Rosaceae, seed	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Rubiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	**1**
Small seeded legume, seed	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	**2**
Stipa tenacissima L. (alfa/esparto), rhizome	-	-	-	-	-	8	-	3	4	2	6	18	2	5	6	4	**58**
Tetraclinis articulata (Vahl) Masters (araar), leaf	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	**2**
Vicia/*Lathyrus* sp. (wild pulse), seed	1	-	-	-	-	2	-	3	2	1	-	2	-	3	-	2	**16**
Woody legume, seed	-	-	-	-	-	-	-	-	2	2	-	1	7	5	-	3	**20**
Indeterminated type Rosaceae, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	**1**
Indeterminated type Rosaceae, fruit	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	**3**
Indeterminated seed	1	-	-	-	-	5	3	-	1	-	2	4	-	-	-	-	**16**
Indeterminated fruit	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	**2**
Total seeds	11	2	8	1	14	93	6	88	87	34	74	101	42	180	36	34	**811**
seed density per litre of sediment	0.28	0.09	0.8	0.08	1.12	3.1	4	4.55	3.34	2.51	3.52	4.39	5.85	5.04	3.6	1.94	**2.73**

Tab. 6.1 Macro-botanical remains from occupational levels in Sector 8 (Y and G units), with numbers of seeds unless otherwise stated.

	Yellow Series		Grey Series													Total
MMC units	108	107	106 to 97	96 to 92	91 to 88	87 to 80	45 to 32	31 & 28	30 to 29 & 27 to 26	25	24 to 20	19 to 15 & 13	14	12 to 5	4 to 1	
Number of samples	1	1	3	1	1	4	7	1	4		5	7	1	4	3	
Volume of sediment (in litre)	1	1	3	1	1	3.5	7	1	4	1	5	7	1	4	3	**42.5**
Avena sp. (wild oat), seed	-	-	-	-	-	-	3	-	1	-	3	3	-	-	1	**11**
cf. *Bromus* sp. (large seeded grass), seed	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	**2**
Cariophyllaceae, seed	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	**1**
Chenopodiaceae, seed	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	**1**
Fabaceae (wild pulse), seed	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	**1**
Fumaria sp. (fumitory), seed	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	**2**
Galium sp. (bedstraw), seed	1	-	-	-	-	1	2	-	-	-	2	5	4	2	1	**18**
Juniperus phoenicea L., seed	-	-	-	-	-	-	7	-	7	3	13	8	2	2	3	**45**
Lens cf. *nigricans* (M. Bieb.) Godr. , seed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	**2**
Pinus pinaster Ait., seed	-	-	-	-	-	1	1	-	1	-	5	5	-	-	-	**13**
Pinus pinaster Ait., seed scale	-	-	2	1	3	7	18	1	11	5	18	27	6	4	3	**106**
Pistacia terebinthus L., seed	-	-	-	-	-	-	7	-	8	1	3	6	1	2	7	**35**
Poaceae, seed	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	**1**
Quercus sp (acorn), cotyledon	-	-	-	-	-	-	2	-	-	-	-	1	-	5	-	**8**
Quercus sp. (acorn), cupule	-	-	4	7	-	12	4	-	4	2	17	4	-	1	1	**56**
Quercus sp. (acorn), abscission scar	-	-	1	-	1	2	8	-	6	2	9	5	-	2	4	**40**
Quercus sp. (acorn), pericarp	-	-	-	-	-	-	1	-	2	-	1	-	1	1	1	**7**
Sambucus nigra/ebulus L., seed	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	**1**
Small seeded legume, seed	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	**1**
Stipa tenacissima L., rhizome	-	-	-	-	-	-	1	-	6	1	4	-	-	1	1	**14**
Tetraclinis articulata (Vahl) Masters, leaf	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	**2**
Vicia / Lathyrus sp. (wild pulse), seed	-	-	-	1	-	-	4	-	1	-	-	-	-	-	-	**6**
Woody legume, seed	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	**1**
Indeterminated seed	-	2	-	-	-	-	1	-	1	-	1	2	3	1	1	**12**
Indeterminated fruit	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	**1**
Indeterminated nut	-	-	-	-	-	-	-	-	1	-	3	1	-	-	3	**8**
Total	1	2	7	9	4	24	61	1	49	14	82	71	19	23	28	**395**
seed density per litre of sediment	1	2	2.3	9	4	6.85	8.71	1	12.25	14	16.4	10.14	19	5.75	9.33	**9.29**

Tab. 6.2 Macro-botanical remains from occupational levels in Sector 8 (MMC units), with numbers of seeds unless otherwise stated.

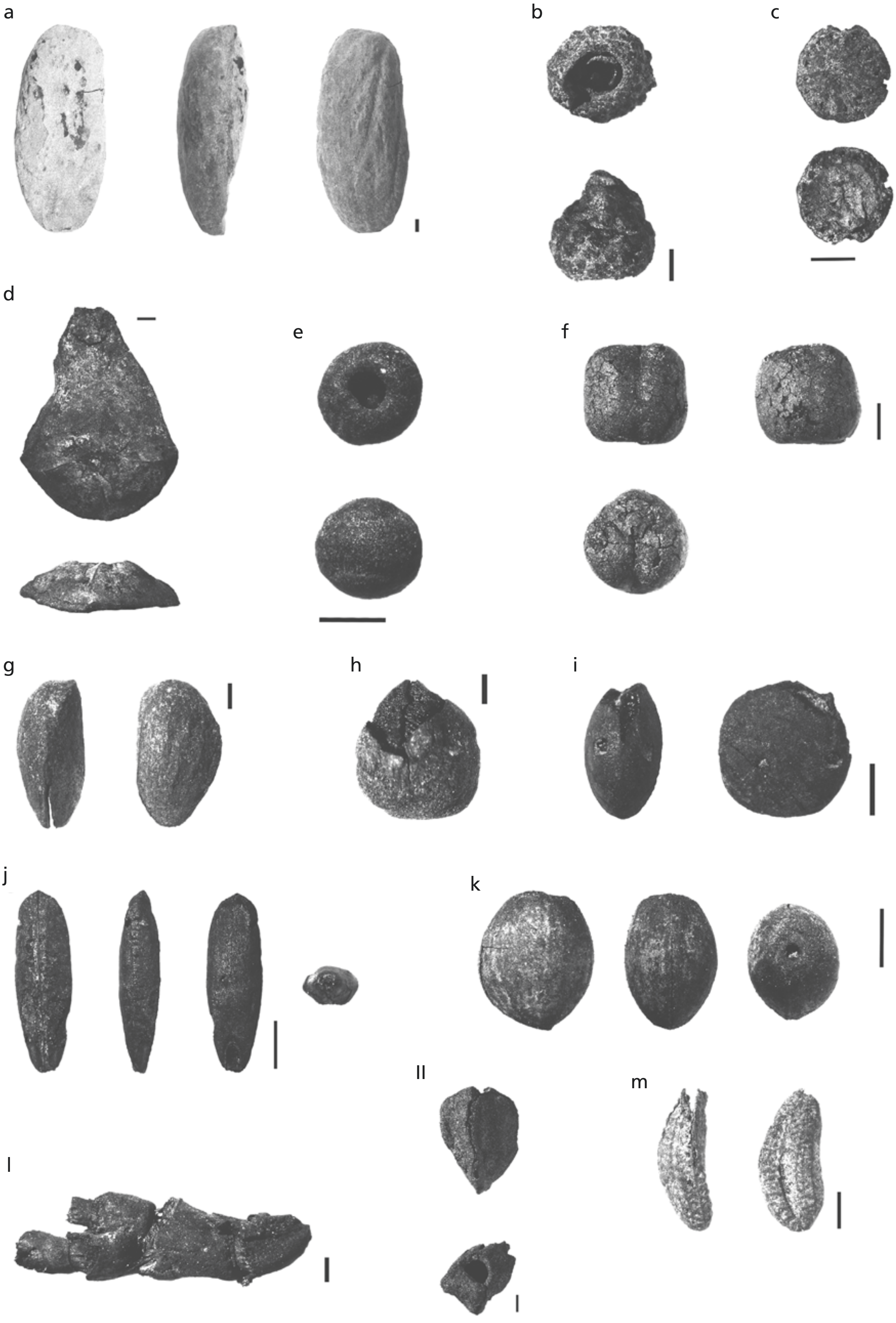

Fig. 6.1 Macro-botanical remains from Sector 8: **a** *Quercus* sp., cotyledon; **b** *Quercus ilex*, immature cupule; **c** *Quercus* sp. abscission scar; **d** *Pinus pinaster*, cone scale; **e** *Galium* sp., seed; **f** *Vicia/Lathyrus* sp., seed; **g** *Pinus pinaster*, seed; **h** *Ephedra* sp., cone bracts; **i** *Lens* cf. *nigricans*, seed; **j** *Avena* sp., seed; **k** *Pistacia terebinthus*, seed; **l** *Stipa tenacissima*, rhizome fragment; **ll** *Juniperus phoeniceae*, seed; **m** *Sambucus nigra*, seed. – (Photos J. Morales). – Scale bar 1 mm.

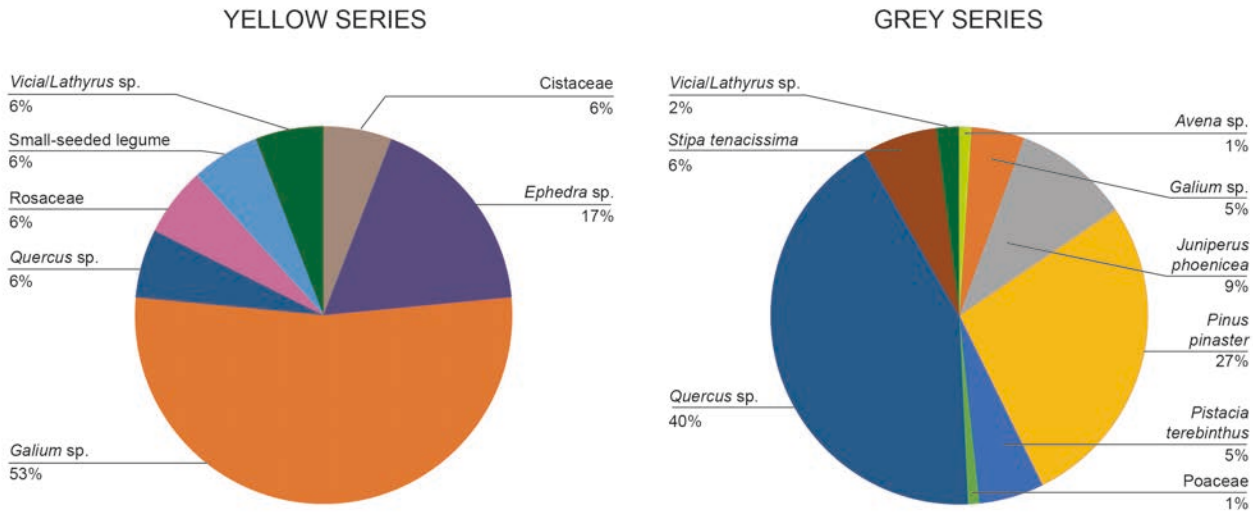

Fig. 6.2 Percentage of macro-botanical remains in the Yellow Series and Grey Series, Sector 8.

Fig. 6.3 Acorn cupule fragments found in a single sample from the Grey Series (Unit S8-G96-3). – (Photo J. Morales).

Fig. 6.4 Pine seed scales fragments recorded at a single sample from the Grey Series (Unit S8-G90-2). – (Photo J. Morales).

common here (**fig. 6.2**). The richest units in number of remains are G90, G92, and G98 (**tab. 6.1**); as well as MMC units 21, 15, and 14 (cf. **A6**). For seed density per litre of sediment the richest layers are G90 and G91, as well as MMC layers 21 and 4. The presence of taxa through the different GS units is homogeneous, with acorns and pine nuts being the most frequent species in all units, except Unit G100 that only presents two items (**figs 6.5** and **6.6**). Two taxa, juniper and Terebinth pistachio, are mostly recorded in units from the upper part of the sequence, from G92 to G88. In fact, Units G90 and G88 are the richest for plant diversity, although samples from the lower Unit G98 also present a high diversity of plant taxa (**figs 6.5** and **6.6**).

Descriptions of the taxa recorded from S8 are provided below. These include ethnographic data recorded in the Mediterranean area about the exploitation of each taxon. Ethnobotanical data are utilised here to provide models of plant processing and consumption that will be used to interpret the archaeological plant remains.

Holm oak (*Quercus ilex*) remains were mostly recorded in the GS; only one fragment of acorn was recorded in the YS (Unit Y2). They comprise abscission scar, pericarp (shell), cupule (cup) and cotyledon (seed) fragments (**fig. 6.1**). Cupules are the most frequent item and they have been recorded in all units from the G-sample column excepting G100 (**fig. 6.3**); fragments of cotyledon and pericarp are less common, being identified only in Units G92 to G88. In the MMC column sample, the pattern in the frequency of remains

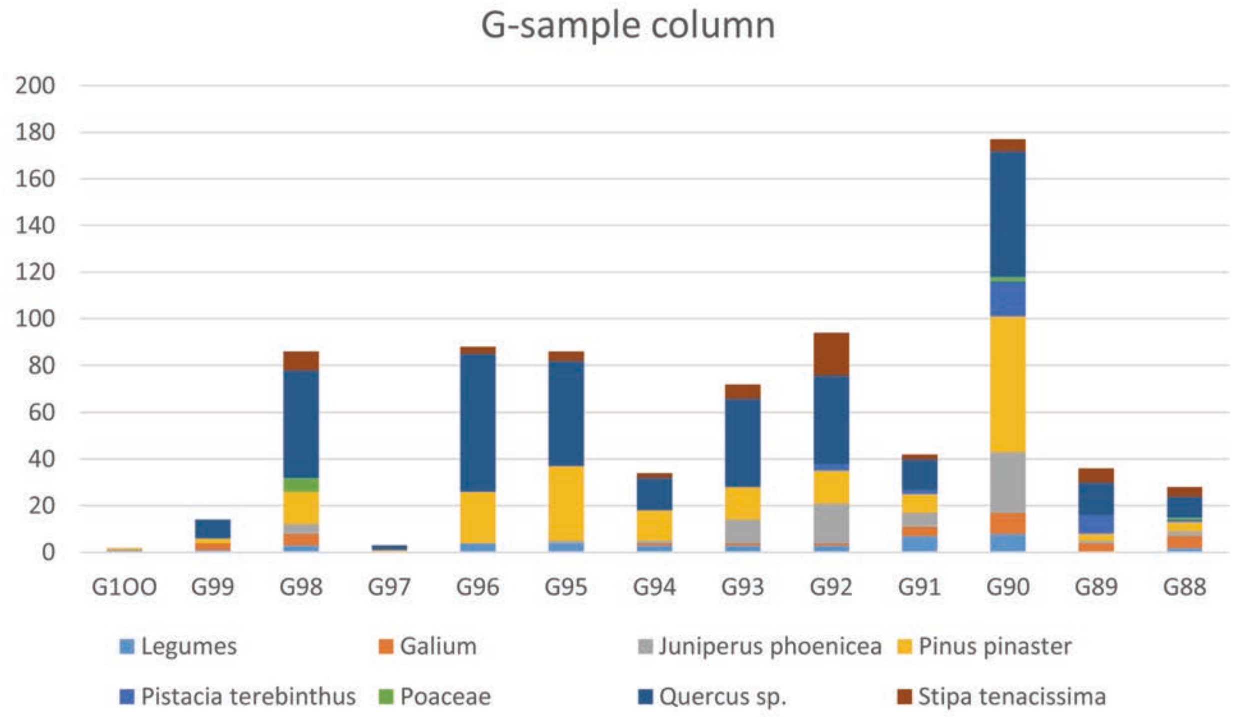

Fig. 6.5 Numbers of macro-botanical remains of the most frequent taxa in units from the G-sample column in Sector 8.

of acorns is similar (**tab. 6.2**). The cupule is a wood-like structure that partially encloses the seed and it is made of successive layers of sclerified and suberised bracts (Fey/Endress 1983; Kaul 1985). Cupules are species-characteristic and they are a diagnostic key in the identification of oaks (Kaul 1985). Identification of Holm oak (*Quercus ilex*) was only possible for 5 cupule fragments keeping the scales (**fig. 6.1**), so it is possible that other oak species currently growing in the region are also present in the samples.

Acorns are a very common food around the northern hemisphere, both for hunter-gatherer and farmer populations (Mason 1996). They are currently consumed in Morocco, where they can be found in local markets (author's personal observation). Acorns have also been consumed in other Mediterranean countries until relatively recently (Bainbridge 1985; Rivera/Obón 1991; Pereira-Sieso 2010; Rivera/Matilla/Obón/Alcaraz 2011). They are rich in carbohydrates and also contain proteins and lipids (**tab. 6.2**). Due to their low tannin content, acorns from the Holm oak can be eaten raw after the cupules and the shells are removed (Pereira-Sieso 2010; Prado-Nóvoa et al. 2017). Acorns from other Mediterranean oaks have a higher content in tannins and need processing to make them edible (Ayerdi et al. 2016). There are several ways of reducing the tannin content, such as parching or leaching (Mason/Nessbit 2009). Once tannins are removed, acorns can be consumed after boiling or roasting, or dried for storage or further processed into a type of flour (Pereira-Sieso 2010; Ayerdi et al. 2016).

Maritime pine (*Pinus pinaster*) macro-botanical remains are only recorded in the GS, where they are abundant (**fig. 6.2**). Pine remains include both seeds and seed scales. Seeds are less common, while seed scales are present in most of the samples analysed (**fig. 6.4**). The scales, a woody part of the cone in which the seeds ripen before falling to the ground, have a prominent and pyramidal apophysis, a diagnostic feature that enables identification as *Pinus pinaster* (Fennane et al. 1999). In some cases, the apophysis was not preserved, so it is possible that other pine species could also be present in the archaeological assemblage.

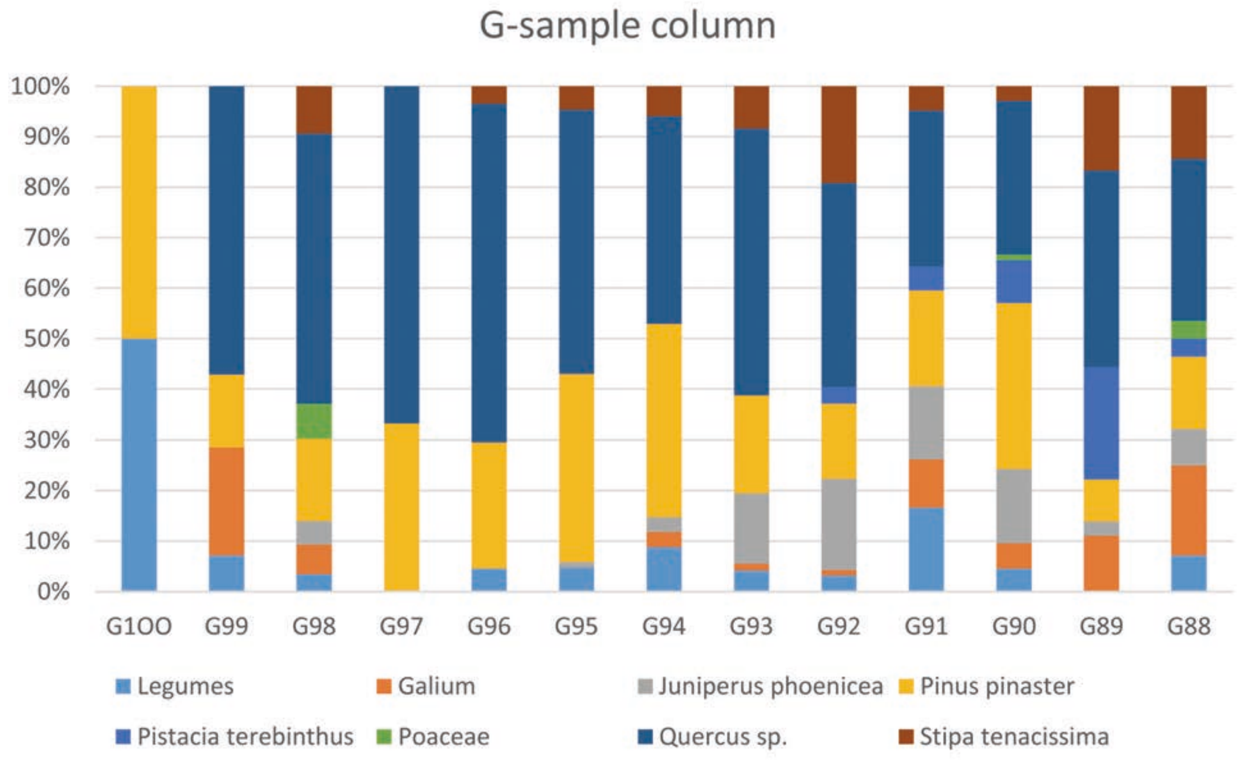

Fig. 6.6 Percentage of macro-botanical remains of the most frequent taxa in units from the G-sample column in Sector 8.

Cones of *Pinus pinaster* and other Mediterranean pines such as *P. halepensis* and *P. pinea* have traditionally been gathered to collect the pine nuts for human consumption (Rivera/Obón 1991; Rivera/Matilla/Obón/Alcaraz 2011). Usually, cones are gathered in autumn and early winter, when they are still closed and unripe. In this way seeds can be stored inside the cone with no damage for a long period. When it is time to consume the pine nuts, cones are laid out in the sun or put in the fire, as low humidity provokes the opening of the scales and release of the seeds (Morales et al. 2015). Pine nuts can be eaten raw as a snack or pounded to produce a kind of porridge (Rivera/Obón 1991; Morales et al. 2015). Pine nuts are rich in energy and contain high quantities of lipids and proteins (Lanner 1981). Once all the seeds have been extracted, the empty cones are collected and stored to be used later as fuel. This overall technique increases the preservation of seed scales and reduces the opportunities for seeds themselves to be charred (Morales et al. 2015).

Remains from juniper (*Juniperus phoenicea*) are only recorded in the GS, where they are common (9.12 % of total plant remains in the GS). Seeds and fruit fragments from this small tree were recorded in the samples (**fig. 6.1**). Berries from *J. phoenicea* have been gathered until recently in traditional communities of the Mediterranean basin (Rivera/Matilla/Obón/Alcaraz 2011). They are relatively rich in carbohydrates (Debussche/Cortez/Rimbault 1987). In both Turkey and Tunisia, the fruits are crushed and then boiled for several hours to obtain a high-energy liquid (Semiz/Isik/Unal 2007; Rivera/Matilla/Obón/Alcaraz 2011). Once boiled, the fruit fragments and seeds are discarded (Semiz/Isik/Unal 2007).

Seeds of Terebinth pistachio (*Pistacia terebinthus*) are present in the GS (5.12 % of total plant remains in the GS) and absent in the YS. Nutlets from the Terebinth pistachio are rich in lipids, and the oil extracted from them has been used for human consumption and for medicinal purposes in the Mediterranean area (Rivera/Obón 1991; Rivera/Matilla/Obón/Alcaraz 2011). According to ethnographic data from exploitation of *Pistacia* seeds in Sardinia (Loi 2013), the oil is extracted by heating the squeezed fruits in a recipient with water. The oil is deposited over the water surface and it is later collected, while the fruits are discarded or used to feed domestic animals (Loi 2013).

Other less common small trees or shrubs identified in S8 are elderberry (*Sambucus nigra/edulis*), ephedra (*Ephedra* sp.) and rose hip (Rosaceae). One seed of elderberry was recorded in the GS. Elderberries are used for human consumption in the Mediterranean area after they are processed in a kind of marmalade (Rivera/Obón 1991). One seed of rose hip was retrieved from the YS (Unit Y1). Rose fruits are rich in vitamin C and still consumed in jams (Rivera/Obón 1991; Rivera/Matilla/Obón/Alcaraz 2011). Cone bracts of *Ephedra* have only been recorded in the YS layers. This plant is a known stimulant and has been used in folk medicines in both the Old and New Worlds (Caveney et al. 2001). Fruits (seed cones) can be eaten in a fresh or dried state, and juice may be extracted from the fleshy cones, which contain higher amounts of crude protein and crude fat than other cultivated fruits (Khasbagan/Soyolt 2007).

Seeds of wild legumes are present in both the YS and GS, but they are more abundant in the GS (**tabs 6.1** and **6.2**). We have been able to distinguish three taxa, wild lentil (*Lens* cf. *nigricans*), wild vetch (*Vicia/Lathryus* sp.) and an indeterminate large-seeded legume (Fabaceae) (**fig. 6.1**). Seeds from wild legumes have been broadly consumed in the Mediterranean basin, where those plants are frequent (Rivera/Obón 1991; Butler 1998; Rivera/Matilla/Obón/Alcaraz 2011). They are very nutritious, being high in carbohydrates and relatively high in protein but, in some cases, they also contain toxic substances that may be removed by roasting or leaching (Aykroyd/Doughty 1982). Seeds can be eaten raw when they are unripe. Once they are ripe, seeds are usually consumed after boiling them or they are pounded to produce flour (Tardío et al. 2006). In order to store the seeds and eliminate potential pests, legume grains can be briefly roasted (Butler 1998).

Wild grasses are uncommon, with only 13 seeds of wild oat (*Avena* sp.) and two of brome (*Bromus* sp.) being identified. Remains of grasses are only recorded in the GS. Grains from wild oats are rich in carbohydrates and proteins (Sosulski/Sosulski 1985). Currently, only domesticated oats (*Avena sativa*) are broadly consumed but there is ethnographic evidence for the consumption of wild oats in the Mediterranean basin in the recent past (Rivera/Obón 1991; Rivera/Matilla/Obón/Alcaraz 2011).

Other annual plants recorded in the samples are fumitory (*Fumaria* sp.), cleaver (*Galium* sp.) and small-seeded legumes. Small-seeded legume is a category that includes plants of the Trifolieae tribe such as *Trifolium* L., *Trigonella* L., *Medicago* L. and *Melilotus* Miller (Butler 1995). Cleaver and small-seeded legumes have been recorded in both the YS and GS. The three taxa are nowadays common weeds in places disturbed by humans, so it is possible that they grew near the site and reached the deposits either naturally or unintentionally. We also need to consider that seeds from these taxa might have been gathered for different human uses (Rivera/Obón 1991; Butler 1995; 1998; Rivera/Matilla/Obón/Alcaraz 2011), so we cannot rule out the possibility that some of them were exploited by the inhabitants of the site.

Finally, we must highlight our recovery of a large number of rhizome fragments of alfa grass (*Stipa tenacissima*). Evidence of alfa grass is only present in the GS (5.92 % of total plant remains in the GS). Alfa is a native perennial grass in the western Mediterranean area that has been extensively used as raw material for basketry (Sánchez-Sanz 1982; Louis/Despois 1986; M'Hamdi/Anderson 2013). Leaves are the useful part of the plant, whilst rhizomes are a common by-product or residue of gathering and processing that is often used as fuel (Morales et al. 2015).

6.4 DISCUSSION

Differences in the Presence of Seeds in the YS and the GS: Environmental Change or Plant Processing Innovation?

The excellent conditions at Taforalt have allowed the preservation of a rich set of charred plants that represents one of the largest and best preserved macro-botanical assemblages of the Late Pleistocene period in North Africa. Plant remains have been recorded throughout the stratigraphic sequence analysed, covering the time span between approximately 21,000 and 12,600 cal BP. However, the seed assemblage recorded at Taforalt shows a marked difference in number of items and plant taxa between the YS and the GS. In the YS, the assemblage is characterised by the low presence of seeds, only 24 items (2 % of total macro-botanical remains), all of which belong to annual plants and shrubs. The bulk density of plant remains in the samples analysed is also reduced, with 0.34 items per litre of sediment (**tabs 6.1** and **6.2**). In contrast, in samples from the GS, the number of macro-plant remains and plant taxa is much higher, as well as the bulk density of seeds, with 4.37 items per litre of sediment (**tabs 6.1** and **6.2**). Here, seed and fruit remains of small tree species, such as Holm oak, Maritime pine, juniper and Terebinth pistachio, are the most common taxa recorded (**fig. 6.2**).

It must be noted that sedimentation rates are different for YS and GS, with sediments in the GS accumulating approximately ten times faster on average than in the YS (cf. **Chapter 2**). We have compared the rate of plant remains deposition and sedimentation within the cave through the concept of 'productivity', an index calculated from the bulk density of seeds and sedimentation rates, adjusted for stoniness (**tab. 6.3**). In the GS, 'productivity' is some 50-fold higher than in the YS. The highest values of 'productivity' in the GS are probably related to frequent human activities, while the low values for the YS may be the result of more natural (non-human origin) sedimentation episodes, coupled with lower intensity of activity when humans are indeed present. Within the GS, the highest 'productivity' is apparent in Unit G96, which is probably related to the large quantities of stones found in this interval, quickly providing structural protection for fragile remains in the stable interstices. Nevertheless, Unit G96 shows the highest percentage of acorn remains for all the units in S8 (67 % of total remains) (**fig. 6.6**), and this may also be related in another way to the extreme stoniness in this unit, suggesting that some of these rocks (most of which show heat effects) could have been used in acorn processing (**Chapter 2**), although this is a hypothesis that needs to be tested in future research at the cave.

Absolute numbers of seeds and percentage for each taxon are similar throughout units of the GS, with acorn and pine remains being the most frequent (**figs 6.5** and **6.6**). Nonetheless samples from units in the upper part of the sequence, such as Units G91 and G90, show a higher diversity of plant species, with some taxa, such as Terebinth pistachio, being recorded only in those layers. The presence of a higher diversity of plants in the upper layers may be related to some environmental change, or may be linked to economic practices, that increased the number of plant taxa being used by the inhabitants of the cave. On the other hand, overall 'productivity' appears to drop somewhat in these upper units which, given the lower sedimentation rate and reduction in stoniness, might suggest a taphonomic effect, with greater attrition in these assemblages from concentrated human activity (treadage/trampling and other forms of disturbance) (**tab. 6.3**). If this was indeed the case, the observed rise in diversity in some of these upper units may actually have been even greater than seen in the surviving remains.

This disparity in the numbers of plant remains from the YS to the GS may indicate an environmental change, with better conditions for plant growing during the GS that allowed the development of a denser arboreal vegetation. In contrast, evidence of annual plants and shrubs in the YS may indicate the presence

S8 Units	Litres	Items	Items/l	Index 'stoniness'	Sed Rate m/ky	Index 'productivity'	Y-Comparison increase in GS
Y4, 2-1	67.1	21	0.313	1	0.17	0.053	1
MMC107-108	2.0	3	1.500	1	0.17	0.255	(sample too small)
merged	69.1	24	0.347	1	0.17	0.059	1
G100-97	56.6	114	2.014	3	4.0	2.686	51-fold
MMC106-97	3.0	7	2.333	3	4.0	3.111	[59-fold]
merged	59.6	121	2.030	3	4.0	2.707	46-fold
G96	19.3	88	4.560	5	4.0	3.648	69-fold
MMC96-80	5.5	37	6.727	5	4.0	5.382	[102-fold]
merged	24.8	125	5.040	5	4.0	4.032	68-fold
G95 [no equiv MMC]	26.0	87	3.346	4	4.0	3.346	63-fold
G94-88	127.7	501	3.923	3	1.11	1.452	27-fold
MMC45-1	33.0	348	10.545	3	1.11	3.902	[74-fold]
merged	160.7	849	5.283	3	1.11	1.955	33-fold

Tab. 6.3 'Productivity' of non-tree charred plant macro-remains; 'productivity' (an essentially dimensionless number) has here been estimated using the formula: ((items/l)/stoniness) × (sedimentation rate).

of arid conditions when this part of the stratigraphy was deposited. Results obtained from the analysis of wood charcoals recorded in S8 also suggest a marked vegetation change, with arid and cold-tolerant taxa such as juniper/araar (*Juniperus/Tetraclinis*) dominating during the YS, followed by an increase of warmth- and water-demanding taxa such as pine (*Pinus* sp.) and oak (*Quercus* evergreen) and a decline of *Juniperus/Tetraclinis* during the GS (see **Chapter 5**). Other palaeoenvironmental proxies obtained in the region from marine sediments (Rodrigo-Gámiz et al. 2011; Moreno 2012; Barton et al. 2013) indicate the presence of colder and arid conditions during the YS, the most extreme coinciding with a so-called Heinrich Event just pre-dating the arrival of the LSA people. The start of the GS is dated close to the beginning of Greenland Interstadial 1e and the Series continued through most of GI1, a warmer and humid period (Barton et al. 2013). The proportions of different taxa are indeed similar throughout the Grey Series (**figs 6.5** and **6.6**), giving the impression that the plant assemblage is homogeneous and the environmental conditions were relatively stable during this period. However, archaeological assemblages of seeds do not represent the entire flora around the site, but only those plants gathered for their use; their significance as a proxy for the reconstruction of the palaeoenvironment is thus limited.

On the other hand, it must be recognised that variations in the number of plant remains must also be linked with the different activities carried out in the cave. Wood charcoals of pine (*Pinus*) and oak (*Quercus*) are recorded in sediments of the YS (see **Chapter 5**). This evidence indicates that those arboreal taxa were still growing around the site, despite the arid conditions that were prevalent at this time, with the Beni Snassen mountains probably acting as a refuge for some plants. Whilst wood from those arboreal taxa was gathered for fuel during this period, seeds were not collected or did not become carbonised, since they have not been recorded in the YS, apart from one acorn fragment. Thus, the lack or presence of seeds at the site must also be related to other taphonomic factors, such as the frequency of their use and the processing they went through (Van der Veen 2007).

Evidence from Taforalt suggests that the start of the GS is contemporaneous with a change in the processing and use of plant by the inhabitants of Taforalt. This change resulted in an increase in the number of plant species exploited and an extensive use of fire for processing them, as it is indicated by the high number of carbonised botanical remains. In contrast, in samples from the YS, only two potential food plants were recorded, legumes and ephedra.

In most cases, macro-botanical evidence from the GS is indicative primarily of food debris. The rarity of charred seeds themselves and the abundance of the unpalatable parts of the fruits, such as acorn cupules and pine seed scales, indicate that the plant assemblage recorded in the GS is mostly made of by-products of processing and cooking these plants (for acorns, see Ayerdi et al. 2016). Acorns and pine nuts were consumed and the inedible part was discarded in the fire to become preserved by carbonisation. The rarity of charred acorns and pine nuts throughout the GS implies that seeds of both plants were not directly exposed to fire during preparation. Although their numbers are low it must be highlighted that the presence of seeds (cotyledons) and shells (pericarp) of acorn is not recorded through all the GS but only in the upper parts, in Units G92 to G88 and MMC units 41 to 4 (**tab. 6.1** and **Appendix 6**). In older strata, the acorn remains only consist of cupules and abscission scars. This change in the representation of the acorn remains may be the result of introducing new processing techniques. Acorns are usually roasted when they are still covered by the shell (pericarp), whilst in contrast, when acorns are boiled, the shell is removed beforehand (Primavera/Fiorentino 2013). Thus the presence of charred shells and seeds in the upper strata may indicate an increase in the use of roasting as a technique for processing acorns. Nevertheless, the assemblage analysed is still quite small and this conclusion must remain tentative. On the other hand, huge quantities of burnt and heat-shattered rock are found throughout the GS deposits and are probably largely the result of deliberate heating of stones for cooking and processing purposes (cf. **Chapter 2**). Heated stones can be used to boil fresh or dried seeds in water-filled vessels made from basketry or animal skin (Mason/Nesbitt 2009). Alternatively, patties made from ground seeds could have been cooked directly on heated stones (Ayerdi et al. 2016).

For juniper and Terebinth pistachio, the seeds are probably the by-product, since the edible content is in the flesh of the fruits. In the case of wild legumes, seeds are usually roasted for storage and to remove toxins (Butler 1998), so it is possible that they could become accidentally charred and preserved during this processing. For wild grasses, it is also common to parch the seeds for de-husking, moments during which the seeds can come into contact with fire and be preserved (Weiss/Kislev/Simchoni/Nadel 2005). It cannot be ruled out that some of the seeds and fruits recorded in S8 were accidentally introduced into the site as part of the wood used for fuel. However, differences in the proportions of seeds and wood charcoal (cf. **Chapter 5**) for each taxon in the YS and GS indicate that each had different uses and taphonomic pathways, with the seeds probably being used as food.

Role of Plants in Human Diet at Taforalt

Most of the plants identified in S8 are recorded in ethnobotanical studies as edible items, and they have been consumed in the Mediterranean basin by traditional peasant communities until recently, so it is quite plausible that they represent food remains of the past inhabitants of Taforalt. These plants provide a broad range of nutrients, being rich in carbohydrates (wild legumes, wild grasses and acorns), and fats (Terebinth pistachio, and pine nut), and relatively rich in proteins (pine nuts, and wild legumes) (**tab. 6.4**; cf. also **tab. 18.1** and accompanying text).

The assemblage of taxa recorded in Taforalt reveals a preference for plant foods rich in carbohydrates and fats, which are the most common at the site, especially in the GS. Dietary studies on modern hunters-gatherers emphasises the preference of those populations for wild plants rich in carbohydrates and fats (Jenike 2001; Kelly 2013), particularly in highly seasonal environments with a pronounced dry season (Speth 1987). In addition, it is possible that an extensive use of fire to process plants during the GS resulted in a rise in the net energy value of this food source. The benefits of thermal food processing include: increased digestibility

Species	Common name	Nutritional value (g/100g)			Ripening season
		Carbohydrates	Lipids	Protein	
Avena sp.	wild oat	55.0	8.0	20.0	late spring-summer
Juniperus phoenicea	juniper	18.0	4.0	5.0	autumn
Lens cf. *nigricans*, *Lathyrus* sp., *Vicia* sp.	wild legume	58.0	2.0	26.0	late spring-summer
Pinus pinaster	pine nut	5.0	51.1	33.2	autumn
Pistacia terebinthus	terebinth pistachio	5.0	61.0	4.0	autumn
Quercus ilex	acorn	53.0	10.5	3.0	autumn
Sambucus nigra/ebulus	elderberry	55.0	1.0	7.0	autumn

Tab. 6.4 Nutritional value and ripening season of the most common plants identified in Sector 8. – (Data assembled from published sources: Debussche et al. 1987; Fennane et al. 1999; 2007; 2014; Sosulski/Sosulski 1985).

of carbohydrates, fats and protein; reduced costs of digestion; and reduced energetic costs of detoxification and defense against pathogens (Carmody/Wrangham 2009; Groopman/Carmody/Wrangham 2015). Reliance on plants providing carbohydrates and lipids as a staple food could account for the high caries prevalence recorded among the individuals buried at Taforalt, since frequent consumption of fermentable carbohydrates is a key factor in the initiation and progression of this disease (Humphrey et al. 2014; see **Chapter 16**). Processing and cooking of starchy foods to improve digestibility causes increased food stickiness and reduced food clearance rates within the oral cavity, providing an ideal environment for acid-tolerant bacteria (Tayles/Domett/Halcrow 2009). In this context, several grinding stones have been recovered in Sector 10 at Taforalt (and, previously, throughout the GS, cf. **Chapter 14.2**), suggesting that some foods could have been pounded; systematic use-wear analyses of these tools remains to be carried out (**fig. 6.7**). Archaeobotanical analyses from contemporaneous sites in the Mediterranean basin, which share a similar flora, further suggest a preference of Upper Palaeolithic hunters-gatherers for energy-rich plants. Charred acorns have been recorded in sites of the Near East and Mediterranean Europe (Mason/Nessbit 2009). In North Africa, charred acorns are present in Epipalaeolithic and Neolithic layers of Ifri Oudadane (Morales et al. 2013; 2016) and in Neolithic-Capsian levels of Cappeleti Cave, Algeria (Roubet 1979). For pine nuts, there is evidence of seed scales and seeds of *Pinus pinea* at the Upper Palaeolithic site of Nerja Cave, Spain (Badal 1998). In North Africa, new research carried out in Haua Fteah, Libya, has provided abundant records of *Pinus halepensis* in Libyco-Capsian (Early Holocene) levels (Barker et al. 2010). Evidence of juniper berries has also been attested in some Upper Palaeolithic-Epipalaeolithic sites from the Mediterranean basin, such as in the caves of Santa Maira, Spain (Aura/Carrión/Estrelles/Pérez-Jordà 2005), and in Abeurador (Vaquer/Ruas 2009) and Agnels (Bouby 2004), both in France, in Ifri Oudadane, Morocco (Morales et al. 2013; 2016) and in Haua Fteah, Libya (Barker et al. 2010).

For wild legumes, there is a very wide record in Upper Paleolithic and Epipalaeolithic sites from the Mediterranean basin (Butler 1998). Legumes are especially abundant at Franchthi Cave, Greece (Hansen/Renfrew 1978), in Abeurador, France (Vaquer/Ruas 2009) and in Santa Maira, Spain (Aura/Carrión/Estrelles/Pérez-Jordà 2005). In North Africa, legumes have also been identified in Ifri Oudadane (Morales et al. 2013; 2016) and Haua Fteah (Barker et al. 2010), suggesting that seeds from these plants were a common food for pre-farming populations of the Mediterranean basin.

Other less common taxa at Taforalt, such as Rosaceae fruits, *Pistacia terebinthus* and wild grasses, have also been documented at some Upper Palaeolithic sites from the Mediterranean region. Rosaceae fruits have been recorded in sites in France and the Iberian Peninsula (Aura/Carrión/Estrelles/Pérez-Jordà 2005; Vaquer/Ruas 2009), and also in Epipalaeolithic and Neolithic layers at Ifri Oudadane, Morocco (Morales et al. 2013; 2016). For *Pistacia terebinthus*, the records are limited to the Epipalaeolithic layers of Abu Hureyra, Syria (Hillman 2000); however, finds of other *Pistacia* species, such as *P. lentiscus* and *P. atlantica*,

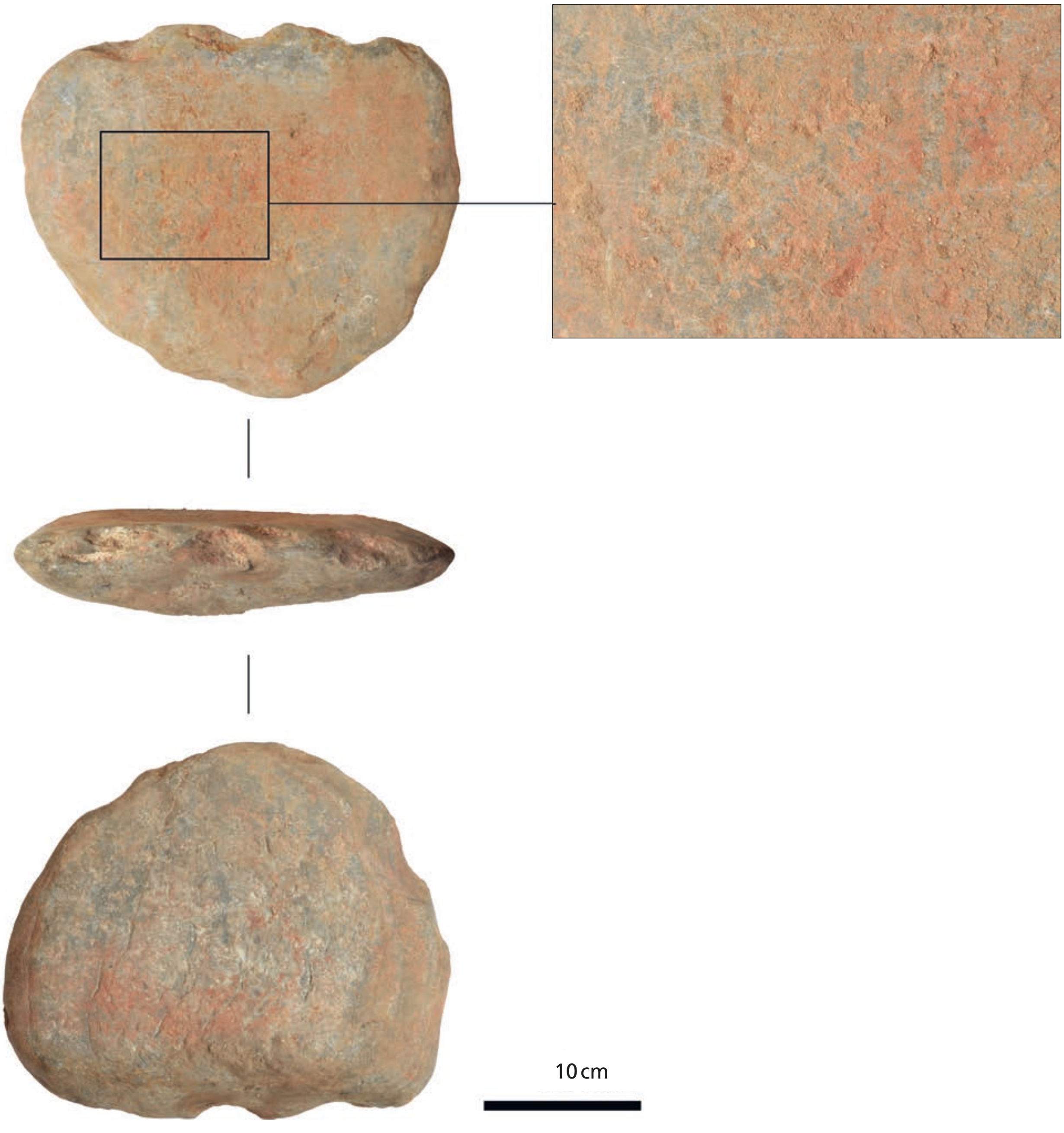

Fig. 6.7 Grinding stone recovered from Sector 10 during the 2010 season <11456>. – (Photo J. Morales).

are common in Upper Palaeolithic and Epipalaeolithic sites of the Mediterranean basin (Arranz-Otaegui / Ibañez / Zapata 2016; Hansen / Renfrew 1978; Aura / Carrión / Estrelles / Pérez-Jordà 2005; Morales et al. 2013). Archaeobotanical evidence of *Avena* and *Bromus* grains in Upper Palaeolithic sites is scarcer. There are a few records of *Avena* and *Bromus* at the 23,000 cal BP site of Ohalo II (Weiss / Kislev / Simchoni / Nadel 2005). *Avena* grains are also present at Franchthi Cave, Greece (Hansen / Renfrew 1978) and Santa Maira, Spain (Aura / Carrión / Estrelles / Pérez-Jordà 2005), as well as in Haua Fteah, Libya (Baker et al. 2010).

Ripening time of plants identified at Taforalt may provide an idea of when they were harvested and consumed. While seeds from annual plants such as wild grasses and wild legumes ripen in late spring and early summer, most taxa from arboreal species ripen in autumn (see **tab. 6.4**). Those data imply a human presence at the site during late spring/early summer and in the autumn. Nevertheless, Taforalt is in a mountainous region, in which altitudinal gradient results in different ripening times for plants, with plants ripening earlier at lower altitudes and later at higher altitudes. Other geographical factors, such as orientation (facing north) and availability of water in the ground, may also modify the ripening time. Considering those facts, it is possible that harvesting of plants could be conducted all year round if people were moving around the Beni Snassen mountains for their gathering activities.

In addition, we need to consider that people at Taforalt could be harvesting the seeds and fruits still unripe to avoid competition from animals and other human groups, as well as to extend the time available for harvest. In the case of acorns, the high number of cupules points to systematic gathering of unripe acorns, as cupules detach naturally once the acorn is ripe (Primavera/Fiorentino 2013). Ethnographic records describe the beating of trees to enable collection of green acorns, because ripe acorns are more prone to be eaten by ground-feeding competitors or infested by insects or fungi (Pereira-Sieso 2010). Evidence of pine seed scales at Taforalt, as well as ethnographic data (Rivera/Obón 1991; Rivera/Matilla/Obón/Alcaraz 2011), also point to the collection of the cones when they are still unripe and closed, keeping all the unreleased seeds.

Storage was also an activity that could allow a year-round consumption of plants, permitting a better adaptation to high seasonal variability in the environment (Speth 1987; Morgan 2012). There are no direct data about storage at Taforalt but ethnographic records and indirect evidence suggest that storage could have been practiced during the GS. Ethnographic data on acorn and pine nut consumption indicate that both plants have been stored in traditional communities of the Mediterranean (Pereira-Sieso 2010), but also by hunters-gatherers in other regions of the northern hemisphere (Mason 1996; M. K. Anderson 2005; Morgan 2012). For acorns, ethnographic data record the seeds as being stored unripe and unprocessed, but also as a prepared food (Mason 1996; M. K. Anderson 2005; Pereira-Sieso 2010). In the case of pine, seeds are stored inside the cones until needed (Lanner 1981; Morales et al. 2015). At Taforalt, the abundance of charred cone scales and the scarcity of the seeds suggest that pine nuts were stored in the cones and later processed to release and consume the seeds, re-using the cones as fuel once they were empty. If cones were only used as fuel and the pine nuts not released and thus not consumed, we should expect the presence of more carbonised seeds in the archaeological assemblage. Charred seeds of wild legumes may be indicative of storage as well; on occasion, seeds are briefly roasted to eliminate potential pests and to allow better preservation (Butler 1998). During this processing, legume seeds can become carbonised accidentally and, being discarded as waste, increase the possibilities of being preserved in the archaeological record. It is thus possible that some of the charred legume seeds identified at Taforalt are the result of processing for storage. In broad terms, thermal processing is a way to store food, since the cooking stops the action of bacteria and other pathogens that make the foods decay (Carmody/Wrangham 2009). So, any plants processed by fire at Taforalt for later consumption would have needed a method of storage.

Indirect Evidence of Basketry

Direct evidence of baskets, mats or other products from basketry has not been recorded at Taforalt for the time being (see **Chapter 2**). Well preserved desiccated examples of baskets and ropes are common in early-middle Holocene sites from the interior mountain massifs in the Libyan and Algerian deserts (di Lernia/Massamba N'siala/Mercuri 2012); however, this type of preservation has not been recorded (is effectively impossible) at Taforalt, where all the plant remains were preserved by charring. Nonetheless, carbonised rhizomes fragments of alfa grass (*Stipa tenacissima*) are common throughout the GS samples. Alfa is a native perennial grass in the western Mediterranean area that has been extensively used as raw material for basketry and other craft items in North Africa (Louis/Despois 1986; M'Hamdi/Anderson 2013) and the Iberian Peninsula (Sánchez-Sanz 1982). Leaves from alfa grass are the material used for basketry and rhizome fragments are a common by-product of this process. Carbonised rhizome fragments have been recorded at other prehistoric sites from the Iberian Peninsula (Buxó 2010) and North Africa (Morales et al. 2013; 2015; 2018), being interpreted as waste from basketry production. Their presence implies that whole alfa plants were uprooted and carried to the site, where the leaves could be collected to produce basketry and the rhizome fragments were discarded and later re-used as fuel.

6.5 CONCLUSIONS

The data presented in this chapter validate the systematic sampling of sediments during excavation, together with processing by flotation, as an efficient method of obtaining plant evidence at archaeological sites, even (perhaps especially) in the case of pre-farming sites. At Taforalt, the analyses carried out in Sector 8 have provided the largest dataset of macro-botanical remains from a Late Pleistocene site in North-Western Africa. Nevertheless, the information provided here is still preliminary, since the evidence comes from only one sector of the cave. Future studies should focus on other sectors at Taforalt, and in other Iberomaurusian sites from the Maghreb, where data on the use of plants are still rare.

Our analyses show two different patterns in the plant assemblage that are clearly linked to the formation of the YS and GS. During the YS, macro-botanical evidence is scarce, corresponding in most cases to annual plants and small shrubs. In contrast, sediments from the GS are rich in carbonised plant remains from trees, shrubs and annuals. This change in the assemblage of botanical evidences is possibly linked to environmental shifts, from colder and arid conditions during the formation of the YS, to warmer and more humid conditions throughout the GS. Nevertheless, the change in the set of plants recorded in both periods is also the result of modifications in the processing of foods and the intensity in the use of those resources. Data recorded at Taforalt indicate that during the GS there is a concerted gathering and thermal processing of acorns, pine nuts, juniper berries, Terebinth pistachio nutlets, wild legumes, wild grasses, and so on. Those resources were available during the YS, as is proven by the presence of wood charcoals from those taxa in the YS, but they were not commonly gathered for food or, most probably, they were not processed with fire. All of them are edible and rich in basic nutrients, such as carbohydrates, lipids and proteins. Indirect evidence suggests that some of them could be stored. Processed and stored plants are more nutritious and last longer, thus making a more important contribution to the diet. Evidence of this change in the diet during the GS is also visible in the oral health of the individuals buried in the cemetery (Sector 10), showing high rates of caries that are the probably result of a daily consumption of processed plants rich in carbohydrates (Humphrey et al. 2014; Chapter 16).

Our data indicate that the shift in the nature and composition of the YS and GS was possibly affected by environmental changes but was also due to technological and economic innovation (at least, within the Taforalt frame of reference), that necessarily reflected different ways of life during each period.

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