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ORIGINAL ARTICLE

Bronze Age subsistence in Sardinia, Italy: cultivated plants and wild resources

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Abstract This paper presents new archaeobotanical data from six sites in Sardinia, Italy, dated to the Bronze Age (2000–1100 cal. BC). A total of 978 l of sediment has been sampled and 23,008 items retrieved. The study reveals the presence of cereals (*Hordeum vulgare*, *H. vulgare* var. *nudum*, *Triticum monococcum* and *T. aestivum/durum*), legumes (*Lathyrus sativus/cicera*, *Lens culinaris*, *Pisum sativum* and *Vicia faba*), and wild plants such as *Ficus carica*, *Fragaria* sp., *Rubus* sp., *Prunus spinosa*, *Vitis vinifera, Myrtus communis, Juniperus oxycedrus* and *Pistacia lentiscus*, providing substantial information on the agricultural practices of the first Nuragic communities during the Bronze Age in Sardinia.

Keywords Agriculture · Wild plants · Subsistence · Bronze Age · Sardinia

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Introduction

Sardinia is a large Mediterranean island with an area over 24,000 km^2, situated in the central part of the western Mediterranean. Most of its territory consists of hills and rocky plateaus. The island has a typical Mediterranean climate characterized by humid winters and a hot and dry season over the summer. Some areas display, however, microclimatic regimes induced by solar exposure and elevation. The earliest signs of human presence go back to the Mesolithic (9th–8th millennium cal. BC) but settled occupation is only attested since the early Neolithic (6th millennium cal. BC) (Lugliè 2009a, b). Archaeobotanical data from this period is rather scarce and it relates to casual finds described in old excavation reports. According to this data, several cereals (*Triticum aestivum/durum*, *Hordeum vulgare* var. *nudum*) and legumes (*Vicia faba*, *Lens culinaris* and *Pisum sativum*) were cultivated at least from the Middle and Late Neolithic (5th–4th millennium BC). These finds come from sites such as Filiestru, Sa Ucca de su Tintirriòlu (Sassari), Grotta del Guano (Nuoro) and Molia (Nuoro) (Trump 1990; Sadori et al. 1989).

Data from the Chalcolithic Period (late 4th and early 3rd millennium BC) comes from a recently excavated open-air site where naked wheats (*T. aestivum/durum*) and hulled and naked barley (*H. vulgare*, *H. vulgare* var. *nudum* have been identified (Ucchesu, in press). No data are available from the late Chalcolithic. Archaeobotanical studies carried out by Bakels (2002) on the Late Bronze Age (LBA, 2nd–1st millennium BC) site of Duos Nuraghes (Borore) identified cereals (*H. vulgare*, *T. dicoccum*, *T. aestivum/durum*) and a legume (*V. faba*). More recently, a waterlogged well in Cabras (Oristano) has produced substantial amounts of pips of *Vitis vinifera* (grape), seeds of *Ficus carica* (fig) and other archaeobotanical remains currently

under study. Based on ceramic typology, the material is dated to the Middle-Late BA (Usai 2011; Usai et al. 2012). The grape pips have undergone morphocolorimetric analyses which have determined their relation to wild *V. vinifera* and present-day Sardinian cultivars (Orrù et al. 2013).

In contrast to the amount of knowledge about the BA on the Italian peninsula, researching into the social and economic patterns of this period in Sardinia is an arduous task. With the exception of some sites not sufficiently studied, data related to settlement occupation in both caves and open-air sites is almost nonexistent, while funerary contexts are better known (Ugas 2006; Depalmas 2009).The Nuragic civilization has its roots in the Middle Bronze Age (MBA) when communities started to mark territorial dominance with monumental tombs (*Tombe dei giganti*) and cyclopean buildings (*Nuraghi*). These are enclosed spaces using layers of stones whose size decreases with height, with a terrace above, to which access is provided by a stone stair (*Nuraghi a corridoio*). These massive buildings were elements of territorial control but in periods of difficulties due to environmental or social stress, they could have had multiple roles such as animal shelters, food and water storage areas etc. (Ugas 2006). The diversity of the economic data does not yet allow us to reach a full understanding of the agrarian system during the BA in Sardinia, although preliminary archaeobotanical data seems to indicate a quite well-developed economic structure. The main objective of this work is, therefore, to study agrarian production by looking at the existing crop biodiversity and exploring the role of wild plants within the subsistence system of the BA communities, through the analyses of the archaeobotanical remains from six sites in Sardinia (Fig. 1).

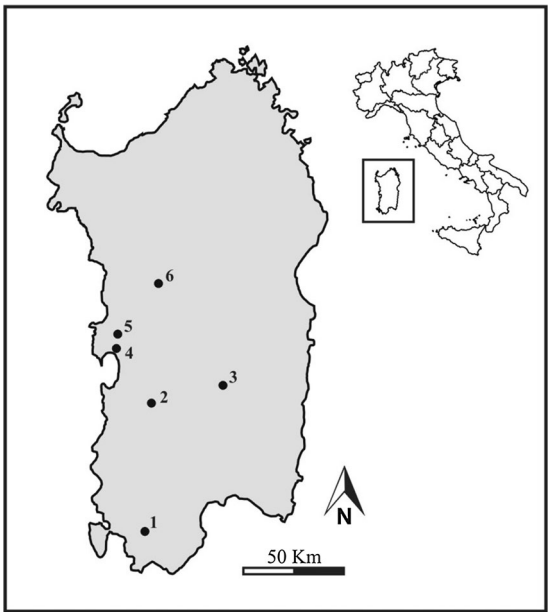

Fig. 1 Locations of the six sites investigated: *1* Monte Meana; *2* Cuccurada; *3* Adoni; *4* Sa Osa; *5* Sipoi; *6* Duos Nuraghes

The sites

Monte Meana

The cave of Monte Meana is located in the southwestern part of the island, in the region of Sulcis some 5 km from the village of Santadi (province of Carbonia-Iglesias) and 12 km from the southern coast (Fig. 1). The site belongs to a region of high density of archaeological sites, with both settlements and funerary sites, which span from the early Neolithic to the Roman period. The karst cave opens on the western side of the carbonate-dolomite massif of Monte Meana, not far from the famous caves of Is Zuddas. The cave has a constant temperature of 16 °C and almost 100 % humidity.

Below the cave on the plain, a watercourse, Rio Murrecci, is used today for irrigating wheat and barley fields as well as vineyards. Most of the land is used by farmers for keeping pigs and for sheep and goat pastures. The thermomediterranean climate favours the development of shrubby vegetation, mainly a tree layer with *Quercus ilex* and *Q. suber*, which is accompanied by an association of typically Mediterranean shrubs such as *Erica arborea*, *Arbutus unedo*, *Pistacia lentiscus*, *Juniperus turbinata*, *Myrtus communis* and *Cistus monspeliensis*. Other taxa such as *Lavandula stoechas*, *Helichrysum italicum*, *Nerium oleander*, *Rubus ulmifolius* and *V. vinifera* ssp. *sylvestris* grow along the watercourses and on the alluvial plain (Bacchetta 2006).

The cave of Monte Meana was first occupied during the Middle Neolithic with the Bonu Ighinu and San Ciriaco Cultures during the 5th millennium BC and it was in use until the Phoenician Period (8th century BC). Since 2008, the cave has been excavated each year by G. Tanda from Cagliari University. Several structures such as stone walls and stairs have been identified within the cave and dated to the Chalcolithic (Monte Claro Culture, 3th millennium BC) but kept in use during the first phase of the Early BA (EBA, 10th century BC) (Tanda et al. 2012). Two areas of excavation were opened: a 20 m^2 area characterized by the presence of hearths for domestic and metallurgical activities, and the "grottino", a small cave which produced organic material as well as pottery fragments. The use of this space is still uncertain.

The first area included a space sealed by stones from the collapse of cave blocks. Here, two different layers of occupation have been identified, the younger yielding

Table 1 AMS dates on macro-botanical remains from Monte Meana, Sa Osa and Cuccurada

Site	Context	Material	Lab.code	Age BP	Age cal. BC	Culture
Monte Meana	Hearth (SU4)	Charcoal	LTL4198A	3,547 ± 45	2017–1751	EBA
Monte Meana	Hearth (SU8)	Charcoal	LTL4199A	3,555 ± 50	2026–1743	EBA
Monte Meana	"Grottino" (SU22)	Naked barley	LTL6007A	3,463 ± 50	1914–1641	MBA
Sa Osa	Well N (SU171)	Grape	OxA-25106	2,981 ± 27	1286–1115	LBA
Sa Osa	Well N (SU171)	Grape	OxA-25107	2,968 ± 27	1276–1088	LBA
Cuccurada	Tower D (SU174)	Hulled barley	LTL12137A	3,030 ± 50	1412–1127	LBA

Calibrated with OxCal v4.2.3 (Bronk Ramsey and Lee 2013); r5; IntCal13 atmospheric curve (Reimer et al. 2013); EBA, MBA, LBA: Early, Middle and Late Bronze Age

many fragments of pottery, domestic animal bones (*Capra hircus*, *Ovis aries*, *Bos taurus*, *Sus scrofa*), terrestrial gastropods, lithic and bone instruments as well as charred plant remains; below, there is a small hearth of about 50 cm diameter containing cemented ashes (Tanda et al. 2012).

Moreover, many remains of *Prolagus sardus* were found. The Sardinian Pika is an extinct small rabbit which was used as human food, and is documented from the Mesolithic until the BA in Corsica and Sardinia. Its extinction occurred in historical times, perhaps related to the arrival of new predators such as the dog and the fox (Vigne 1998).

The radiocarbon dating of the two layers (LTL4198A: 2017-1751 2σ cal. BC; LTL4199A: 2026-1743 2σ cal. BC) (Table 1) reveals the use of this area during the EBA which corresponds to the local phase *S. Iroxi* (Depalmas 2009; Ugas 2006). Next to the hearth, a working area for copper smelting was identified.

The second area of interest is a small cavity (*grottino*), discovered during the excavation of the central part of the cave. It opened at the eastern wall of the cave at a depth of 1.50 m. Although not fully excavated due to safety reasons, the explored deposit consisted of several different layers. The upper part of the section was a carbonaceous dark brown layer, ca. 30 cm thick, rich in small ceramic fragments, burnt bones of *Prolagus sardus,* shells of *Paracentrotus lividus* (sea-urchin) as well as small copper slag fragments and large amounts of charred plant remains. The ^{14}C data (LTL6007A: 1914-1641 2σ cal. BC) (Table 1) date this occupation to the MBA (Tanda et al. 2012).

Sa Osa

The archaeological complex of Sa Osa is located in the west-central part of Sardinia on the northern border of the Gulf of Oristano, 2 km from the coast (Fig. 1). The site is situated on the alluvial plain of the river Tirso delimited by two ponds, Cabras to the north and Santa Giusta to the south. A recent geomorphological survey has established that the northern part of the archaeological context was built on an ancient alluvial terrace, while the southern sector stands on a terrace of more recent formation (Melis and Sechi 2011).

The vegetation of the area comprises two different areas, a swampy area surrounding the pond and the lagoon and an extensive formation of Mediterranean scrub from the peninsula of Capo Frasca. The marshy vegetation is mainly composed of reeds and rushes (*Phragmites australis*, *Typha angustifolia*, *Juncus subnodulosus*, *J. acutus*, *Salicornia* species) while the scrub is made up of *Euphorbia dendroides*, *P. lentiscus, Arbutus unedo* and *Q. ilex*. The rescue excavation carried out in 2008 brought to light several shallow pits, wells and archaeological structures related to settlements dated between the Chalcolithic and the Iron Age (Usai et al. 2012). Three excavation campaigns were carried out between 2008 and 2009 by the Soprintendenza per i Beni Archeologici per le province di Cagliari e Oristano and the Univeristy of Sassari during which were found several wells dug into the sandstone block, and containing large quantities of plant remains. Wells U and V also contained numerous pottery fragments dated to the MBA (Usai et al. 2012). Three wood fragments from inside well V were dated, but only the sample from *Olea europaea* L. has provided a date which is in agreement with the ceramic context of the MBA (1537–1425 2σ cal. BC) (Table 1). Both wells have been investigated to a depth of 4 m providing large amounts of animal bones, pottery fragments and plant remains which have been preserved in waterlogged conditions.

Sipoi

The Sipoi Nuragic settlement is located inside the village of Baratili San Pietro (Oristano) on the alluvial plain of Campidano between the rivers Tirso and Rio Mare Foghe (Fig. 1). The site had a sunken sub-circular domestic structure excavated into the alluvial sediment to a depth of 0.8 m. The presence of postholes and clay remains with clear impressions of branches suggested the presence of a

roof made of plant material and clay layers. Faunal remains, molluscs, obsidian tools, pestles and pottery were retrieved from the well. Based on the pottery, Sipoi has been dated to the MBA (Sebis and Pau 2012). Plant remains consisted of charcoal and seeds present in significant quantities inside the clay layers of the sunken structure.

Duos Nuraghes

The Duos Nuraghes site is located to the northeast of Borore over an area of about 4,600 m^2 (Fig. 1). The archaeological complex is composed of two "*Nuraghi a Tholos*" consisting of Nuraghe A with a stratigraphy showing occupation phases from the Early to the MBA (ca. 2300–1300 BC), and Nuraghe B which was in use between the MBA and the Iron Age (ca. 1300–500 BC) (Webster and Webster 1998). The area is nowadays deeply affected by modern agro-pastoral activity. The archaeological complex was excavated by Webster from 1987 to 1996. In Towers A and B, 41 samples were taken from contexts between the MBA and the medieval period and the plant remains were studied by Bakels (2002).

Cuccurada

The Cuccurada archaeological site is located in the territory of Mogoro (Oristano), at the end of the valley of the Rio Mogoro (Fig. 1). The area is characterized by rocky areas where the dominant vegetation is composed of *Genista moristi*, *Helichrysum italicum*, *Teucrium marum*, *Lavandula stoechas* and *Stachys glutinosa*. The arboreal component is represented by *Q. ilex, Olea europea* var. *sylvestris*, *Populus alba*, *Ulmus minor*, *Salix purpurea*, *Fraxinus angustifolia* ssp. *oxycarpa*, *Q. suber* and *Q. pubescens*. In more areas of more degraded vegetation, species such as *P. lentiscus, M. communis, Cistus monspeliensis* and *Erica arborea* dominate.

The archaeological site is composed of a complex Nuraghe (Cuccurada B) made up of various huts and an elliptical structure formed of big rocks (Cuccurada A). The site was excavated from 1994 to 2012 by the Soprintendenza of Cagliari and Oristano and University of Cagliari (Cicilloni 2007). The Nuraghe is located in an area with strong signs of human activities where a Middle Neolithic phase has been found. Plant remains were collected from the floor of Tower D dated to the LBA (1420–1120 2σ cal. BC) (Table 1) (Atzeni et al. in press).

Adoni Nuraghe

The Adoni Nuraghe is located in the municipality of Villanovatulo at about 800 m a.s.l., on a calcareous relief in the centre of the historic region of Sarcidano (Fig. 1). The landscape is characterized by ancient calcareous formations (outcrops) which together with the microclimate of the area favour the development of a rich biodiversity. An extensive woodland of *Q. ilex*, *Ostrya carpinifolia*, *Ilex aquifolium* and *Taxus baccata* grows on these outcrops. On the areas most degraded by human action there is the Mediterranean maquis consisting of *Phillyrea angustifolia*, *Pistacia terebinthus* and *P. lentiscus* in association with extensive formations of *Juniperus oxycedrus*, *Rhamnus alaternus*, *Arbutus unedo* and *Erica arborea*.

The systematic excavations carried out from 1997 to 2002 revealed a complex quatrefoil structure and several huts of the Nuragic village (Campus and Leoneli 2012). The site yielded numerous pottery remains dated to the LBA (ca. 1350–1150) (Campus and Leoneli 2012). The plant remains were found inside three pottery containers which survived thanks to the collapse of the roof of the hut.

Materials and methods

The material analyzed for this paper comes from sites where recovery techniques have been applied, although in some cases not systematically. Monte Meana is the site that has provided the largest number of samples. A total of 80 samples, from seven stratigraphic units, were taken from both the various hearths identified and the "*grottino*", producing a total of 12,716 plant remains. Almost 700 l of sediment were processed using a flotation machine. Most of the material was preserved by charring, although a small part was preserved by mineralization due to the high content of calcium carbonate in the soil. The heavy residue accumulated on a 1 mm mesh was sorted and the relevant material picked out. Once floated, the samples were sieved through a column with sieve meshes of 4, 2, 1, 0.50 and 0.25 mm to facilitate the sorting process. Plant remains were then identified using modern reference collections (CCHS - CSIC in Madrid and CCB in Cagliari) as well as several atlases (Jacomet 2006; Beijerinck 1947; Berggren 1969, 1981; Bojňanský and Fargašová 2007; Cappers et al. 2012). The botanical nomenclature follows Pignatti and Anzalone (1982) and Zohary et al. (2012).

Samples from Sipoi came from the floor of a hut. Only two samples (2 l of sediment each) were analyzed producing a total of 881 remains. All the material was preserved by charring.

Sa Osa is the only site where material was preserved in wet conditions. Due to the enormous quantity of organic material only a 25 l sample was collected from each well and the sediment was then processed by wash-over using a column of steel sieves with meshes of 4, 2, 1, 0.50 and 0.25 mm. The total number of remains recovered is 8,341

of which almost 60 % were charred while the remainder were preserved in a waterlogged state. The latter were stored in distilled water in a refrigerator at a temperature of +5 °C.

At Cuccurada Nuraghe, samples were taken from the bottom of the Tower D, from a context dated to the LBA. Seven soil samples amounting to 169 litres were floated, producing 902 charred plant remains. Finally, the Adoni Nuraghe yielded 30 samples that were recovered from the bottom of the hut. Three of them were taken from inside jars which were still leaning on a wooden beam. The material showed an excellent degree of preservation due to the collapse of the roof on top of the various vessels containing single crops which prevented the remains from being further destroyed and moved around.

Results

Most of the taxa identified at Monte Meana are cultivated plants; cereals represent 94 % of the total assemblage of which 55 % are *T. aestivum/durum* (naked wheats), 17 % are *H. vulgare* (hulled barley) and 19 % *H. vulgare* var. *nudum* (naked barley) (Fig. 2). The richest concentrations of cereals came from three different levels (S.U. 4, a hearth; S.U. 28, a metallurgical hearth; S.U. 22, "*grottino*") (Fig. 3). The only difference between the units is the absence of naked barley in S.U. 2 and 4, due perhaps to the high temperatures reached in the hearths which may have prevented the identification of this species amongst some of the indeterminate cereals retrieved from these contexts. Chaff fragments from *H. vulgare*, *T. aestivum* and *T. durum* were also present in the samples (Fig. 4). Possible 2-row and 6-row barley rachis have been identified, proving their presence at the site (Table 2). Although in small numbers (1 %), legumes are represented by *V. faba* (broad bean), *P. sativum* (pea), *L. culinaris* (lentil), *Lathyrus sativus/cicera* (grass/red pea) and cf. *Vicia sativa* (a possible vetch) (Fig. 2). Due to preservation issues, other specimens have been classified as *Vicia/Lathyrus* and *Pisum/Vicia.* Wild plants were also recovered, *F. carica*, *V. vinifera*, *Rubus* sp., *Fragaria/Potentilla*, *M. communis*, *P. lentiscus* and *Cistus* sp., which had most probably been collected around the site (Table 1). Other wild plants include arable weeds and ruderal plants such as *Brassica* sp., *Galium* sp., *Fumaria* sp., Lamiaceae, *Medicago* sp., Polygonaceae and *Rumex* sp. (Fig. 2).

At Sipoi plant remains were scarce. Only cultivated legumes, *V. faba* cotyledons and fragments as well as a single *Hordeum* grain were found (Table 3).

Plant remains from Sa Osa included hulled barley and free-threshing wheats. Chaff from hulled *Hordeum* and *T. durum* was also retrieved. Among the legumes, *V. faba*, *Pisum* and possibly *Lens* were represented. *Linum* sp. (flax) and *Papaver* sp. (poppy) were also found. Wild plants comprised a large number of edible taxa such as *F. carica* (fig) and *V. vinifera* (grape) along with *Sambucus nigra* (elderberry), as well as others typical of the maquis such as *P. lentiscus* (mastic tree) and *J. oxycedrus* (juniper). While most of the fruits and seeds were preserved in a waterlogged state, the cereals, legumes and some grape and fig remains were charred. The assemblage also includes a total of 28 taxa of ruderal and herbaceous plants, such as *Achillea* sp., *Chenopodium* sp., *Daucus carota*, *Fumaria* sp., *Heliotropium* sp., *Polygonum* sp., *Ranunculus sardous*, *Silene* sp., *Stellaria* sp., *Vicia/Lathyrus* sp. and *Medicago* sp. (Table 3).

At Cuccurada, as in most the sites, the cereals were dominated by hulled barley and free threshing wheats. The only documented legume was *V. faba*, while wild plants include *Olea europaea, V. vinifera* and several taxa typical of the maquis such as *P. lentiscus, M. communis* and *Phillyrea* sp. Herbaceous plants such as *Alkanna tinctoria*, Asteraceae, *Brassica* sp., *Lithospermum* sp., *Medicago* sp., *Polygonum* sp., and *Vicia/Lathyrus* have also been identified (Table 4).

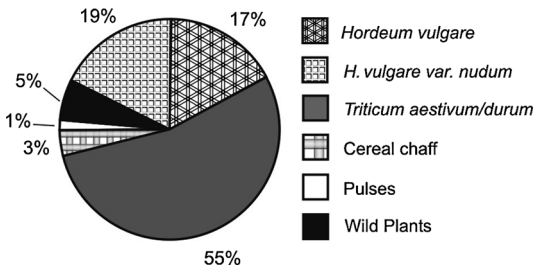

Fig. 2 Percentage representation of plant remains at Monte Meana

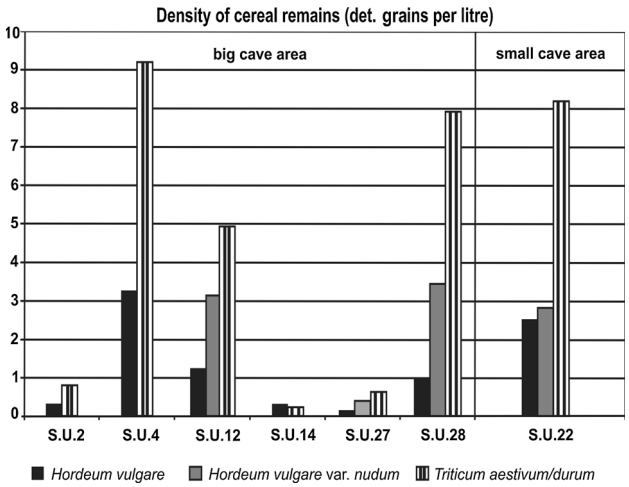

Fig. 3 Density of cereals from layers at Monte Meana

Table 2 Plant remains from Early and Middle Bronze Age site of Monte Meana

Phase	Early Bronze Age				Middle Bronze Age		
Layers	SU2	SU4	SU12	SU14	SU22	SU27	SU28
No. of samples	12	1	2	6	56	2	1
Soil volume (l)	92	7	12	52	541	12	11
Cultivated cereals							
Hordeum vulgare (fragm.)	24 (11)	5	3 (9)	15 (2)	1,369 (900)	1	11
Hordeum sp.	6	19	11		2		
H. vulgare var. *nudum* (fragm.)				38 (10)	1,528 (950)	5	38
Triticum monococcum					2		
T. aestivum/durum (fragm.)	72	65	12	59 (10)	4,438 (1,180)	7	87
Triticum sp. (fragm.)	26 (4)	11 (10)	5 (3)		2		
Hordeum/Triticum					88		
Cereal indet. (fragm.)	14 (237)	7 (10)	4 (35)	(79)	121 (350)	(18)	(118)
H. vulgare rachis two/six row (six row)					2 (2)		
H. vulgare rachis fragm.	4	2	2		1		1
Triticum/Hordeum rachis fragm.		2					
T. monococcum rachis fragm.	3				1		
T. durum rachis fragm.	1	1			3		
T. aestivum rachis fragm.	1	3	4				
Triticum sp. rachis		1					
Cereal indet. straw fragm.	65	1			64	9	
Cereal culm/internodes	22						
Legumes							
Lathyrus sativus/cicera					2		
Lens culinaris					1		
Pisum sativum			1		9		
cf. *Pisum sativum*	1	1		3	3		
Pisum/Vicia				1	11		
Pisum/Lathyrus sp. (-type)			1 (1)				
Vicia faba minor (cf., fragm.)				2 (2)	46 (5)		2
Vicia/Lathyrus (*Pisum*)	1			1 (1)	8 (5)	1	
Vicia sp.					2		
cf. *Vicia sativa*					1		
Fabaceae-type	1	5	5		11		
Gathered plants							
Ficus carica charred (mineralised)	33 (33)	7	11		10	5 (2)	
Fragaria/Potentilla					2		
Rubus sp.	1		1				
Vitis vinifera seed (petiole)	7	(24)	1 (4)				
Vitis vinifera fragm. (grape)	1	8 (2)	2				
Maquis shrublands							
Cistus sp.					17		
Myrtus communis	3				16		
Pistacia lentiscus	1		3		10		
Wild plants							1
Brassica sp.					1		
Galium sp.					1		
Fumaria sp.	1				3		
Lamiaceae	1						
Medicago sp.	6	4			2	1	
Polygonaceae	6						
Rumex sp.	1						
Parenchyma		1					
Poaceae indet. (rachis)	1				1 (1)		2
Indeterminatae	20		6		85	7	
Total	608	189	124	223	11,256	56	260

Table 3 Plant remains from Middle Bronze Age sites

Sites	Sa Osa		Sipoi	Duos Nuraghes
	Well U	Well V		
No. of samples	1	3	2	3
Volume (l)	5	20	2	3
Cultivated cereals				
Hordeum vulgare / fragm.	25 (c)	84 (c) / 3 (c)	1	
Triticum aestivum/durum	6 (c)	55 (c)		
Triticum sp.	2 (c)	7 (c)		
Cereal (frag.) / indet.	15 (c)	104 (c)		/1
H. vulgare (rachis)	18 (c)	170 (c)		
T. durum (rachis)	15 (c)	130 (c)		
T. dicoccum (spikelet base)				1
Cereal (culm/internodes)	26 (c)	19 (c)		
Legumes				
cf. *Lens culinaris*	1 (c)			
Pisum sativum	2 (c)			
Vicia faba / fragm.	44 (c)/51 (c)	12 (c)	89/791	1
Vicia/Lathyrus	5 (c)	15 (c)		
Gathered plants				
Ficus carica	3,000 (w), 25 (c)	2,485 (w), 15 (c)		
Juniperus oxycedrus / fragm.	15 (w)	19 (w) / 11 (w)		
Olea europaea				1
Rubus sp.	3 (w)			
Sambucus nigra	2 (w)			
Vitis vinifera ssp. *sylvestris*	206 (w), 21 (c)	151 (w), 18 (c)		
V. vinifera ssp. *sylvestris* fragm. / pedicels	148 (w)	100 (w) / 12 (w)		
Maquis shrublands				
Pistacia lentiscus	7 (w)	12 (w)		
Wild plants				
cf. *Achillea* sp.	34 (w)			
Anagallis sp.	7 (w)	2 (w)		
Anchusa sp.	2 (w)			
Asteraceae	2 (w)	10 (w)		
Borago sp.	1 (w)			
Carex sp.	6 (w)	3 (w)		
Chenopodium sp.	187 (w)			
Daucus sp.	201 (w)	23 (w)		
Echium sp.	1 (w)			
Eleocharis palustris				3
Euphorbia helioscopia	1 (w)			
Festuca/Lolium		7 (w)		
Fumaria sp.	60 (w)	28 (w)		
Galium sp.				1
Heliotropium sp.	97 (w)	6 (w)		
cf. *Juncus acutus*		2 (w)		
Linum sp.	1 (w)	1 (w)		
Lithospermum sp.		2 (w)		
Lotus/Trifolium				24
Malva sp.	3 (w)	7 (w)		
cf. *Medicago littoralis*		3		
Medicago sp. / caps	/ 4 (w)	3 (w) / 2 (w)		
Melilotus sp.				2
Nigella sp.		9 (w)		
Ornithopus perpusillus	1 (w)	1 (w)		
Pavaver sp.		1 (w)		
Persicaria sp.	13 (w)			
Poaceae		15		
Polygonum sp.	71 (w)	13 (w)		
cf. *Ranunculus trilobus* / cf. *R. sardous*	/ 63 (w)	1 (w) / 2 (w)		
Ranunculus sp.		1 (w)		
Rumex sp.	1 (w)			
cf. *Scirpus lacustris*				2
Silene sp.	175 (w)	31 (w)		
Stellaria sp.	59 (w)			
Verbena sp.	1 (w)			
Indeterminatae	8 (w)	7 (w)		1
Total	4,736	3,602	881	37

w = waterlogged; c = charred

Table 4 Plant remains from LBA, FBA sites in Sardinia; X ≤ 100; XXX ≥ 1,000

Phase	LBA		FBA
Sites	Cuccurada	Duos Nuraghes	Adoni
No. of samples	7	12	30
Soil volume (l)	169	12	40
Cultivated cereals			
Hordeum vulgare (fragm.)	369 (154)	2	x
Triticum aestivum/durum (fragm.)	34 (2)	7	xxx (xxx)
Triticum/Hordeum		1	
Cereal indet. (fragm.)	283	2	
H. vulgare (rachis)	3		
T. aestivum/durum (rachis)		7	
Legumes			
Pisum sativum			xxx
Vicia faba (fragm.)	1		xxx (xxx)
Vicia/Lathyrus			
Gathered plants			
Olea europaea	2		
Rubus ulmifolius		1	
Vitis vinifera ssp. *sylvestris*	2	2	
Maquis shrublands			
Myrtus communis	1		
Phillyrea sp.	2		
Pistacia lentiscus	10		
Wild plants			
Alkanna tinctoria	1		
Asteraceae	1		
Avena sp.		2	
Brassica sp.	4		
Carex sp.		1	
Daucus sp.		1	
Echium sp.		4	
Fumaria sp.		1	
Galium sp.	4		
Lithospermum sp.	1	3	
Lolium sp.		6	
Lotus/Trifolium		1	
Medicago sp.	5	29	
Persicaria sp.		3	
Phalaris sp.		5	
Poaceae	5	2	
Polygonum sp.	3		
Ranunculus sp.		1	
Raphanus raphanistrum		1	
Rumex sp.		2	
Stellaria sp.		4	
Verbena sp.		4	
Indeterminatae	15		
Total	902	93	

The results from Adoni are only preliminary, but they show the same association of hulled barley and free-threshing wheats observed at the other sites, while *V. faba* and *P. sativum* represent the legumes (Table 4).

Discussion

Archaeobotanical research in Sardinia has been little developed. Apart from a selected list of sites from which plant remains have been studied, mainly from the BA (Bakels 2002), Sardinia appears as a blank area in terms of plant remains within the central Mediterranean region. The material presented in this paper comes from different sites which cover a period of about 1,000 years. It offers valuable information on the agrarian system adopted by the human communities which inhabited Sardinia during the BA.

Monte Meana is the earliest site (Early to Middle BA). The main crops identified are free-threshing *T. aestivum/durum*, hulled and naked *Hordeum*, and *Triticum monococcum* in very small proportions (4 spikelet forks and 2 caryopses). The identification of *T. aestivum/durum* at Monte Meana represents the first evidence of its cultivation in Sardinia between the Early and the Middle BA. Both naked and hulled *Hordeum* are represented in similar percentages, showing the importance that both had in the economy of the site. According to Zohary et al. (2012), naked *Hordeum* is scarcely present in Italy and therefore its relative importance in comparison to the hulled variety at Monte Meana stresses its significant role during the EBA. In fact, the site is one of the few Italian contexts in which this species reaches a high percentage.

Several authors (Hopf 1991; Ciaraldi 1998, 2000; Buxó 1997; Bakels 2002) have already emphasized the gradual abandonment of naked *Hordeum* in favour of the hulled types and *T. aestivum/durum*, which shows the delay in events observed in some of the Mediterranean islands when compared to contemporary mainland contexts. However, further research would allow determination of the role of this species in Sardinian prehistoric agriculture.

As far as legumes are concerned, four taxa are represented, *V. faba*, *L. culinaris*, *P. sativum* and *L. sativus/cicera*.

Wild plants were also collected by the community living at the Monte Meana cave. Several taxa have been recorded, such as *Ficus*, *Vitis*, *Rubus* sp. and *Fragaria* sp. (Fig. 4), which were probably collected in the surroundings of the site from places where they nowadays grow, along the river banks. Among these, figs and grapes are major elements of the Mediterranean fruit assemblage. Wild plants represent a highly valued complement to human diet which was surely appreciated by prehistoric communities. They may have provided vitamins, proteins, minerals and sugars. In addition, during the Holocene, wild plants were abundant, predictable, easy to collect and able to be stored, representing, therefore, a critical food resource (Zapata 2000). Although it is difficult to assess the role of wild plants in farming communities, it is likely that they played an important role in prehistoric subsistence, complementing not only human diet but also contributing to many other aspects of human life, being used as medicines, dyes, fuel, animal fodder, crafts, rituals, etc. Besides, other wild plants from the Mediterranean scrub, *M. communis*, *Cistus* sp. and *P. lentiscus* were also present in almost all layers of the stratigraphy. In most cases, the examples from Monte Meana are the first archaeobotanical finds in Sardinia. Although their presence at the site might be accidental, it is likely that they were also used by the people inhabiting the site. Myrtle fruits are nowadays used for producing an aromatic liqueur in Sardinia. Ethnobotanical accounts from the island indicate their use as a digestive remedy by shepherds, while fresh branches were collected to aromatize roasted meats (Atzei 2003). Moreover, the wood of *Myrtus*, *Pistacia* and *Cistus* has been traditionally used in Sardinia for firing pottery and making crafts and it is still possible to find examples of these practices (Atzei 2003; Annis 2007). This is also the case in other Mediterranean areas where, for example, in Morocco, *P. lentiscus* wood is one of the main species used as fuel while its branches are used as green fodder; the fruits of *Myrtus* are commonly eaten by humans and animals and *Cistus ladanifer* seeds are milled into flour and its wood used for kindling bread ovens (Zapata and Peña-Chocarro 2003; Peña-Chocarro et al. 2005). Further work on the wood charcoal from Monte Meana will allow us to throw light on the taxa used for providing firewood at the cave.

The presence of cereal chaff and weeds at the site is rather meagre, suggesting that cereal processing took place somewhere else, perhaps on the flat areas in the valley. The high levels of humidity of the cave (it reaches 80 %) may not have been suitable for long term storage, indicating perhaps that the inhabitants would have only brought there the amount of cereals needed for short periods. There is no evidence of germinated grain which is a clear indicator of excessive humidity pointing to deficient environmental conditions of the storage area. This has been already described for other caves in southern France where Bouby et al. (2005) reported a maximum moisture content of 14.5 % for successful and safe grain storage in Canada (Jayas and White 2003). Nevertheless, the absence of sprouted grains might be related to the occasional occupation of the cave during short periods, perhaps repeated in time, if the cereals represent just the amount brought to the cave for immediate consumption during those short periods. The excavation has uncovered remains of various domestic

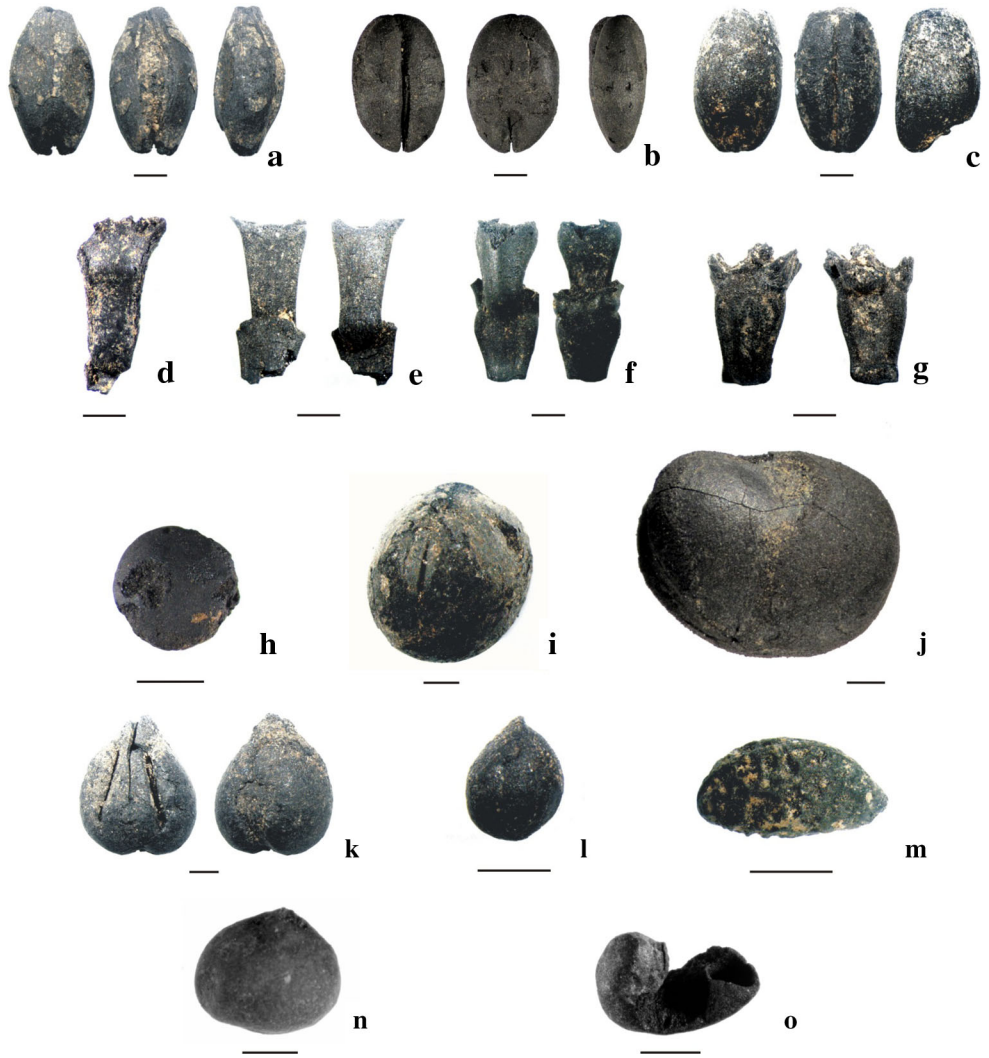

Fig. 4 The archaeological remains from Monte Meana: **a** *Hordeum vulgare*; **b** *H. vulgare* var. *nudum*; **c** *Triticum aestivum/durum*; **d** *H. vulgare* rachis 2/6 row; **e** *H. vulgare* rachis 6 row; **f** *T. durum* rachis; **g** *T. aestivum* rachis; **h** *Lens culinaris*; **i** *Pisum sativum*; **j** *V. faba*; **k**, *Vitis vinifera* ssp. *sylvestris*; **l** *Ficus carica*; **m** *Rubus* sp.; **n** *Pistacia lentiscus*; **o** *Myrtus communis*

activities represented by the presence of hearths, pottery, plant remains, animal bones and slag which show the use of this space for living. During the MBA, overall data point to a more continuous human presence. There is evidence of storage of agricultural products (cereals and legumes) and of domestic activities taking place in the cave.

Archaeobotanical data from the MBA sites of Sipoi and Sa Osa provide information on the variety of crops grown in Sardinia during this period. Hulled *Hordeum* and free-threshing *T. aestivum/durum* were the main cultivated species except for Sipoi where only a single caryopsis of hulled *Hordeum* has been reported. A further exception is Duos Nuraghes where both species are absent, which may be related to the small quantity of the sediment sampled, as cereals appear well represented in the previous period.

Triticum dicoccum (emmer) chaff is present at Duos Nuraghes with a single spikelet base (Bakels 2002). This species does not seem to have been common during the Sardinian MBA which is opposite to the pattern observed for continental Italy where *T. monococcum* and *T. dicoccum* are present throughout the BA (Bellini et al. 2008; Bouby 2011; Carrà et al. 2007; Ciaraldi 1998; Costantini et al. 2001, 2007; Giachi et al. 2010; Mariotti Lippi et al. 2009, 2010; Mercuri et al. 2006; Nisbet 1984).

An interesting aspect is the absence of naked *Hordeum* from Sardinia at least from the MBA. This could be related to the abandonment of its cultivation in favour of the free-threshing *T. aestivum/durum* which were more suitable for bread making and of higher productivity. This pattern is also observed in areas of continental Italy, southern France and the Iberian Peninsula (Buxó 1997; Lister and Jones 2013).

Sa Osa is the only site where rachis of hulled *Hordeum* and *T. durum* have been found. It is likely, therefore, that

some of the caryopses identified as *T. aestivum/durum* represent the tetraploid durum wheat. Legumes of this period are represented by *V. faba*, *P. sativum* and *L. culinaris*. Amongst the wild plants, figs and grapes were consumed and have been identified in large quantities at Sa Osa. These concentrations may represent fruit storage and preservation. Although it is still unknown whether both species were already under cultivation at the time, these fruits were certainly part of the plant diet of the BA communities.

A moderate amount of *Juniperus* seeds was found, representing the gathering of juniper fruits. Today, juniper grows abundantly by the Oristano coast. Its consumption has been recorded in several villages of the island even if this tradition seems to have faded out, except for the use of its berries for meat flavouring (Atzei 2003).

The plant assemblage also included several olive stones which could have been consumed as fruit or used for oil production. Wild Mediterranean species are represented at Sa Osa by the presence of seeds of *P. lentiscus*, which have traditionally been used for oil extraction in Sardinia (Loi 2013) and in other Mediterranean regions (Morales et al. 2013). Wild legumes are represented by *Vicia/Lathyrus* and *Medicago* seeds along with numerous other ruderal plants. Some weeds have also been identified, although their interpretation is difficult. They may represent waste from the cereal cleaning steps which was thrown into the wells, particularly wells U and V.

Archaeobotanical data from the LBA comes from two sites, the Cuccurada Nuraghe and Tower A of Duos Nuraghes which show an agricultural system rather similar to that of the previous period, the main cereals being hulled *Hordeum* and free-threshing *T. aestivum/durum*. Legumes are scarcely represented with a single *V. faba* cotyledon from Cuccurada, although it is likely that other legumes such as *P. sativum* or *L. culinaris* were also grown, as in the previous periods.

Fruit consumption is shown by the presence of at least five taxa, *F. carica*, *Olea europaea*, *Prunus spinosa*, *Rubus* sp. (*ulmifolius*) and *V. vinifera*, which suggests the significant role of fruit trees. There is also evidence of other wild trees and shrubs such as *P. lentiscus*, *M. communis*, *Phillyrea* sp. and other shrubs of the maquis/heather. These plants have been recorded in all the phases of the BA, pointing to a common use perhaps as firewood for cooking food or firing pottery. As suggested earlier, seeds from the mastic tree (*Pistacia*) have traditionally been used for extraction of their oil (Atzei 2003; Loi 2013; Morales et al. 2013). Data on weed seeds which could throw light on crop processing are very scarce.

The latest phase of the BA (Final BA) is represented by the site of Adoni, which has yielded a large amount of cultivated plants. Again, free-threshing *T. aestivum/durum* and hulled *Hordeum* together with *P. sativum* and *V. faba* were the main crops. Weeds and chaff were absent, indicating the storage of fully processed and thoroughly cleaned crops. Overall the pattern of this last phase is identical to previous periods.

Conclusions

BA agriculture in Sardinia was based on the cultivation of four main cereals, naked and hulled *Hordeum*, *T. aestivum* and *T. durum*, which appear associated with three legumes, namely *V. faba*, *L. culinaris* and *P. sativum*. The plant-based diet of the BA communities of the island included wild fruits, in particular *V. vinifera/sylvestris* (a common find in all phases examined) along with *F. carica*, *Rubus* sp. (*fruticosus* (*ulmifolius*)/*idaeus*), *Sambucus nigra* and *P. spinosa*. This study has provided numerous insights into the subsistence and agriculture practised in Sardinia during the BA. The strategic position of the island within the Mediterranean basin and the insular character of the territory have shaped the way local populations have exploited its natural resources. The possibility to study plant remains from archaeological sites in Sardinia offers, therefore, a unique opportunity to explore human-plant relationships in the past and to gain knowledge on the way agriculture developed in the island. The authors hope that this work will stimulate future research in the area to increase our knowledge of the way human groups interacted with the surrounding environment, an area still little explored in Sardinia.

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References

Annis MB (2007) La produzione della terracotta nel Campidano tra gli anni Venti e gli anni Ottanta del Novecento. In: Nuoro IE (ed) Ceramiche: storia, linguaggio e prospettive in Sardegna. Ilisso Edizioni, Nuoro, pp 119–260

Atzei AD (2003) Le piante nella tradizione popolare della Sardegna: documentazione sugli usi alimentari, aromatizzanti, profumieri, artigianali, cosmetici, medicinali, veterinari, magici, ornamentali, rituali, religiosi, tintori, antiparassitari e vari, delle piante. C. Delfino, Sassari

Atzeni E, Cicilloni R, Marini S, Ragucci G, Usai E (in press) Fasi finali e riutilizzo di età storica nel Nuraghe Cuccurada di Mogoro (OR)

Bacchetta G (2006) Flora vascolare del Sulcis (Sardegna Sud-Occidentale, Italia). GuineanA 12. Universidad del País Vasco, Leioa

Bakels C (2002) Plant remains from Sardinia, Italy with notes on barley and grape. Veget Hist Archaeobot 11:3–8

Beijerinck W (1947) Zadenatlas der Nederlandsche Flora. H. Veenman & Zonen, Wageningen

Bellini C, Mariotti-Lippi M, Mori Secci M, Aranguren B, Perazzi P (2008) Plant gathering and cultivation in prehistoric Tuscany (Italy). Veget Hist Archaeobot 17:103–112

Berggren G (1969) Atlas of seeds and small fruits of Northwest-European plant species (Sweden, Norway, Denmark, East Fennoscandia and Iceland) with morphological descriptions, part 2: Cyperaceae. Swedish Natural Science Research Council, Stockholm

Berggren G (1981) Atlas of seeds and small fruits of northwest-European plant species (Sweden, Norway, Denmark, East Fennoscandia and Iceland) with morphological descriptions, part 3: Salicaceae-Cruciferae. Swedish Natural Science Research Council, Stockholm

Bojňanský V, Fargašová A (2007) Atlas of seeds and fruits of central and east-European flora: the Carpathian Mountains region. Springer, Dordrecht

Bouby L (2011) L'économie agricole à l'Âge du Bronze en France méridionale Apports récents de la carpologie. In: Garcia D (ed) L'âge du bronze en Méditerranée. Recherches récentes. Éditions Errance, Paris, pp 101–114

Bouby L, Fages G, Treffort J (2005) Food storage in two Late Bronze Age caves of Southern France: palaeoethnobotanical and social implications. Veget Hist Archaeobot 14:313–328

Bronk Ramsey C, Lee S (2013) Recent and planned developments of the program OxCal. Radiocarbon 2–3:720–730

Buxó R (1997) Arqueología de las plantas: la explotación económica de las semillas y los frutos en el marco mediterráneo de la Península Ibérica. Crítica, Grijalbo Mondadori

Campus F, Leoneli V (2012) Il nuraghe Adoni di Villanovatulo (CA): due contesti del Bronzo recente. In: Istituto Italiano di Preistoria e Protostoria (ed) Atti della XLIV Riunione Scientifica - La presistoria e la protostoria della Sardegna (Cagliari, Barumini, Sassari 23–28 novembre 2009), vol II- Comunicazioni. Ist. Italiano di Preistoria, Firenze, pp 703–708

Cappers RTJ, Bekker RM, Jans JEA (2012) Digitale Zadenatlas Van Nederland/Digital Seed Atlas of the Netherlands. (Groningen Archaeological Studies 4) Barkhuis, Groningen

Carrà M, Cattani L, Rizzi M (2007) Sussistenza e paleoambiente a Villaggio delle Macine (Lago di Albano, Castel Gandolfo - Roma). Studio carpologico. In: Istituto Italiano di Preistoria e Protostoria (ed) Atti della XL Riunione Scientifica "Strategie di insediamento fra Lazio e Campania in età preistorica e protostorica", in memoria di Amilcare Bietti (Roma, Napoli, Pompei, 30 Novembre–5 Dicembre 2005), vol II. Ist. Italiano di Preistoria, Firenze, pp 776–785

Ciaraldi M (1998) The role of plant economy at Pratola Serra (Avellino, southern Italy) in the context of the Italian Bronze Age. Origini 22:251–266

Ciaraldi M (2000) Drug preparation in evidence? An unusual plant and bone assemblage from the Pompeian countryside, Italy. Veget Hist Archaeobot 9:91–98

Cicilloni R (2007) Il nuraghe Cuccurada di Mogoro (OR) nel contesto archeologico dell'alta Marmilla. In: Angiolillo S, Giuman M, Pasolini A (eds) Ricerca e confronti 2006. Giornate di studio di archeologia e storia dell'arte. Edizioni AV, Cagliari, pp 35–41

Costantini L, Lauria M, Tecchiati U (2001) I resti carpologici dell'antica e media età del bronzo del Riparo del Santuario di Lasino (Trento) - Scavi 1996. Annali del Museo Civico di Rovereto 17:3–40

Costantini L, Costantini Biasini L, Delle Donne M (2007) L'agricoltura del villaggio protostorico di Nola, loc. Croce del Papa (Napoli). In: Istituto Italiano di Preistoria e Protostoria (ed) Atti della XL Riunione Scientifica "Strategie di insediamento fra Lazio e Campania in età preistorica e protostorica", in memoria di Amilcare Bietti (Roma, Napoli, Pompei, 30 Novembre–5 Dicembre 2005), vol II. Ist. Italiano di Preistoria, Firenze, pp 705–717

Depalmas A (2009) Il bronzo medio della Sardegna. In: Istituto Italiano di Preistoria e Protostoria (ed) Atti della XLIV Riunione Scientifica "La Preistoria e la Protostoria della Sardegna" (Cagliari, Barumini, Sassari, 23–28 novembre 2009), vol 1. Ist. Italiano di Preistoria, Firenze, pp 123–130

Giachi G, Mori Secci M, Pignatelli O, Gambogi P, Mariotti Lippi M (2010) The prehistoric pile-dwelling settlement of Stagno (Leghorn, Italy): wood and food resource exploitation. J Archaeol Sci 37:1,260-1,268

Hopf M (1991) South and Southwest Europe. In: Van Zeist W, Wasylikowa K, Behre KE (eds) Progress in old world palaeoethnobotany. Balkema, Rotterdam, pp 241–277

Jacomet S (2006) Identification of cereal remains from archaeological sites, 2nd edn. IPAS, Basel University, Basel

Jayas DS, White NDG (2003) Storage and drying of grain in Canada: low cost approaches. Food Control 14:255–261

Lister D, Jones M (2013) Is naked barley an eastern or a western crop? The combined evidence of archaeobotany and genetics. Veg Hist Archaeobot 22:439–446

Loi C (2013) Preliminary studies about the productive chain of lentisk oil through ethnographic witness and experiments. In: Lugli F, Stoppiello AA, Biagetti S (eds) Ethnoarchaeology: current research and field methods conference proceedings, Rome, Italy, 13th–14th May 2010. (BAR Int Ser 2472) Archaeopress, Oxford, pp 58–62

Lugliè C (2009a) Il Mesolitico. In: Istituto Italiano di Preistoria e Protostoria (ed) Atti della XLIV Riunione Scientifica "La Preistoria e la Protostoria della Sardegna" (Cagliari, Barumini, Sassari, 23-28 novembre 2009), vol 1. Ist. Italiano di Preistoria, Firenze, pp 31–36

Lugliè C (2009b) Il Neolitico Antico. In: Istituto Italiano di Preistoria e Protostoria (ed) Atti della XLIV Riunione Scientifica "La Preistoria e la Protostoria della Sardegna" (Cagliari, Barumini, Sassari, 23–28 novembre 2009), vol 1. Ist. Italiano di Preistoria, Firenze, pp 37–47

Mariotti Lippi M, Bellini C, Secci MM, Gonnelli T (2009) Comparing seeds/fruits and pollen from a Middle Bronze Age pit in Florence (Italy). J Archaeol Sci 36:1,135-1,141

Mariotti Lippi M, Bellini C, Mori Secci M (2010) Palaeovegetational reconstruction based on pollen and seeds/fruits from a Bronze Age archaeological site in Tuscany (Italy). Plant Biosyst 144:902–908

Melis RT, Sechi S (2011) L'insediamento nuragico di Sa Osa-Cabras (OR). Studio geoarcheologico. In: Mastino A, Spanu PG, Usai A, Zucca R (eds) Tharros Felix 4. Dip. Storia Università di Sassari, Carocci, pp 187–191

Mercuri A, Accorsi C, Mazzanti M, Bosi G, Cardarelli A, Labate D, Marchesini M, Grandi G (2006) Economy and environment of Bronze Age settlements – Terramaras – on the Po Plain (Northern Italy): first results from the archaeobotanical research at the Terramara di Montale. Veget Hist Archaeobot 16:43–60

Morales J, Pérez-Jordà G, Peña-Chocarro L, Zapata L, Ruíz-Alonso M, López-Sáez JA, Linstädter J (2013) The origins of agriculture in North-West Africa: macro-botanical remains from Epipalaeolithic and Early Neolithic levels of Ifri Oudadane (Morocco). J Archaeol Sci 40:2,659-2,669

Nisbet R (1984) Vegetazione e agricoltura durante l'età del Bronze al Riparo Gaban (Trento). Preistoria Alpina 20:301–310

Orrù M, Grillo O, Lovicu G, Venora G, Bacchetta G (2013) Morphological characterisation of *Vitis vinifera* L. seeds by image analysis and comparison with archaeological remains. Veg Hist Archaeobot 22:231–242

Peña-Chocarro L, González Urquijo JE, Ibáñez Estévez JJ, Moreno García M, Zapata Peña L (2005) An ethnoarchaeological project in the Western Rif (Northern Morocco): first results. Quaderni del Laboratorio di Archeobiologia 1:17–28

Pignatti S, Anzalone B (1982) Flora d'Italia, vol 3. Edagricole, Bologna

Reimer PJ, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Grootes PM, Guilderson TP, Haflidason H, Hajdas I, Hattž C, Heaton TJ, Hoffmann DL, Hogg AG, Hughen KA, Kaiser KF, Kromer B, Manning SW, Niu M, Reimer RW, Richards DA, Scott EM, Southon JR, Staff RA, Turney CSM, Van der Plicht J (2013) IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years cal BP. Radiocarbon 4:1,869–1,887

Sadori L, Tanda G, Follieri M (1989) Macrofossili vegetali provenienti dalla necropoli neolitica a domus de jana di Molia Illorai (Sassari). Giornale Botanico Italiano 123:14

Sebis S, Pau L (2012) L'insediamento nuragico di Sipoi (Baratili S. Pietro-OR). In: Istituto Italiano di Preistoria e Protostoria (ed) Atti della XLIV Riunione Scientifica "La Preistoria e la Protostoria della Sardegna" (Cagliari, Barumini, Sassari, 23–28 novembre 2009), vol IV- Posters. Ist. Italiano di Preistoria, Firenze, pp 1,393–1,398

Tanda G, Basciu V, Paglietti G, Peña-Chocarro L, Ucchesu M, Zedda M (2012) Grotta di Monte Meana (Santadi, Carbonia-Iglesias), campagne di scavo 2008-2009. Notizia preliminare. In: Istituto Italiano di Preistoria e Protostoria (ed) Atti della XLIV Riunione Scientifica "La Preistoria e la Protostoria della Sardegna" (Cagliari, Barumini, Sassari, 23–28 novembre 2009), vol II-Comunicazioni. Ist. Italiano di Preistoria, Firenze, pp 635–642

Trump DH (1990) Nuraghe Noeddos and the Bonu Ighinu Valley: excavation and survey in Sardinia. Oxbow Books (in association with the Ministero per i Beni culturali e ambientali), Oxford

Ucchesu M (in press) I resti vegetali del villaggio di Canelles (Zetadomus) – Selargius (Ca) Relazione preliminare. Quaderni della Soprintendenza Archeologica di Cagliari e Oristano

Ugas G (2006) L'alba dei nuraghi. Fabula, Cagliari

Usai A (2011) L'insediamento prenuragico e nuragico di Sa Osa-Cabras (OR). Topografia e considerazioni generali. In: Mastino A, Spanu PG, Usai A, Zucca R (eds) Tharros Felix 4. Dip. Storia Università di Sassari, Carrocci, pp 159–185

Usai A, Sebis S, Depalmas A, Melis RT, Zedda M, Carenti G, Caruso S, Castangia G, Chergia V, Pau L, Sanna I, Sechi S, Serreli PF, Soro L, Vidili S, Zupancich A (2012) L'insediamento nuragico di Sa Osa (Cabras-OR). In: In: Istituto Italiano di Preistoria e Protostoria (ed) Atti della XLIV Riunione Scientifica "La Preistoria e la Protostoria della Sardegna" (Cagliari, Barumini, Sassari, 23–28 novembre 2009), vol II- Comunicazioni. Ist. Italiano di Preistoria, Firenze, pp 771–782

Vigne JD (1998) Preliminary results on the exploitation of animal resources in Corsica during the Preneolithic. In: Balmuth MS, Tykot RH (eds) Sardinian and Aegean chronology. (Studies in Sardinian Archaeology 5) Oxbow Books, Oxford, pp 57–62

Webster GS, Webster MR (1998) The Duos Nuraghes Project in Sardinia: 1985–1996 Interim Report. J Field Archaeol 2:183–201

Zapata L (2000) La recolección de plantas silvestres en la subsistencia mesolítica y neolítica. Datos arqueobotánicos del País Vasco. Complutum 11:157–169

Zapata L, Peña-Chocarro L (2003) Uso y gestión del bosque en la Euskal Herria atlántica: Aprovechamiento tradicional de los recursos forestales en Encartaciones y Gorbea. Zainak 22:201–215

Zohary D, Hopf M, Weiss E (2012) Domestication of plants in the Old World. The origin and spread of cultivated plants in west Asia, Europe and the Nile valley. Oxford University Press, Oxford