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ORIGINAL PAPER

Plant remains in an Etruscan-Roman well at Cetamura del Chianti, Italy

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Abstract
An abundance of plant remains (pollen, seeds/fruits and wood) and wood artefacts was found during the excavation of an Etruscan-Roman well located at Cetamura del Chianti in Tuscany, Italy, which contained rich cultural and ecofact assemblages in a stratified context. The findings provide evidence for the presence of a mixed oak forest during the time span of the usage of the well. The main decline of deciduous *Quercus*, possibly due to forest clearance, is recorded during the late Etruscan period (ca. 300–100/50 B.C.). A diffusion of *Quercus ilex* occurred during the Roman period (from ca. 50 B.C. to 68 A.D.). Food plants are well represented in the well, particularly cereals and grapevine. The morphometric analysis of the grape pips suggests that fully domesticated forms were cultivated, and that wild fruits may have been gathered in the woods or harvested from weakly domesticated individuals. Some botanical finds could possibly be linked to ritual practices, although the state of preservation of the seed/fruit record, the majority waterlogged, does not meet criteria for carbonized remains used for attributing the plant remains to ritual offerings.

Keywords Palynology · Wood/charcoal analysis · Carpology · Morphometry · Grapevine domestication

Introduction

The excavation of an Etruscan-Roman well ("Well #1") at Cetamura del Chianti in Tuscany, Italy (Fig. 1), provided abundant plant micro- and macroremains recovered from a detailed stratigraphy and chronology (see de Grummond 2017; Fig. 2). They include pollen grains, spores, starch grains, wood and charcoals, and seeds/fruits. The presence of an Etruscan sanctuary on Zone II (Fig. 1b) of the same archeological area establishes Cetamura as a sacred site ("The site of Cetamura and the well" section of this article).

Regarding the possible origin of the plant remains recovered in a well, it must be emphasized that sediment accumulation in this peculiar environment is a complex process that involves natural deposition by wind, rain, or animals and occasional dropping of materials of different size and meaning to the bottom of the shaft (Ruas 2000; Kislev et al. 2004; Figueiral et al. 2010; Arobba et al. 2013; Sabato et al. 2015; de Grummond 2017). These last materials may have incidentally fallen or even been voluntarily thrown into the well. When intentionally thrown down in the shaft, seeds, fruits, branches, and other plant parts may represent offerings to deities or waste, while pollen can reach the bottom of the well together with flowers or other polliniferous material. Due to the possible different origins, it is not always easy to establish the meaning or origin of every single plant remain found in the well, as indeed in many other archeological contexts, where

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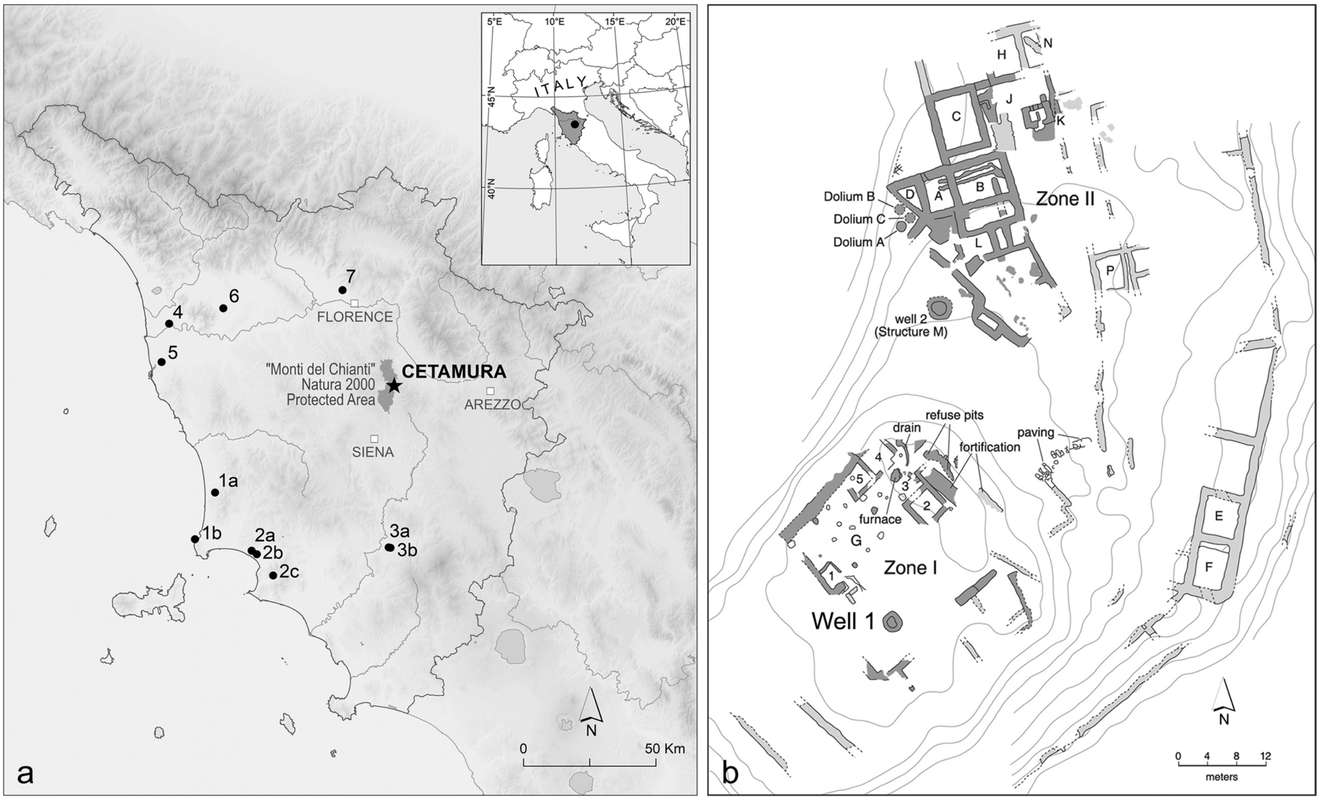


Fig. 1 **a** Location of Cetamura and the other Tuscan archaeological sites cited in the text. 1a Donoratico, 1b Populonia (Buonincontri et al. 2013). 2a Follonica, 2b Pian d'Alma, 2c Val Petraia (Mariotti Lippi et al. 2000). 3a San Martino, 3b Poggio Amore (Rattighieri et al. 2013). 4 Pisa San Rossore (Benvenuti et al. 2006; Mariotti Lippi et al. 2007). 5 Bientina (Giachi et al. 2010a). 6 Livorno Stagno (Giachi et al. 2010b). 7 Sesto Fiorentino (Coradeschi et al. 2013). **b** Map of the Cetamura archaeological site

the significance and transport of pollen (and macroremains) by humans/animals and wind, natural or anthropic deposition, and paleoethno-inferences have to be discussed in detail (Mercuri 2008). In spite of this difficulty, a lot of data and interesting information may be gathered from the study of the well sediments (e.g., Bandini Mazzanti et al. 2005).

The archeobotanical analyses of the infilling of the Cetamura well consist in the study of both micro- and macroremains coming from the layers ranging from the Etruscan to the Roman period (Fig. 2, *loci* 83–112). The aims of this study are (1) to reconstruct the vegetation surrounding the well and its possible changes over time; (2) to investigate the human-plants interactions, i.e., exploitation of the local resources and cultivation, using both standard methodologies and modern morphometrical procedures; (3) to assess which plant remains were possibly of ritual origin and could help to better understand the ritual practices already identified at the site (de Grummond 2017; Holland 2017). The joint use of micro- and macroremains and the integration of different approaches were carried out in order to achieve better insights into this complex context.

The new evidence from the well sediments will enrich the previous data collected at Cetamura in the sanctuary of the Etruscan Artisans, dated to the second century B.C., and from a kiln of the third century B.C. of the same site (Cottini 2009). Given the scarcity of this kind of research in Etruscan sites, the abundant materials from Cetamura assume considerable importance. For both the Etruscan and Roman periods, the site under study is without parallel in ancient Chianti.

Previous archeobotanical studies in sacred contexts

Up to now, archeobotanical analyses in sacred or ritual contexts are not very numerous if funerary contexts are excluded. Only a few of them concern deposits, pits, or wells close to sanctuaries or sacrificial areas. Analyses in these contexts have generally revealed the occurrence of both cultivated and wild seeds/fruits among which medicinal herbs, spices, or exotic plants were often recorded (e.g., Bosi et al. 2011; Robinson 2002). The plant remains were often found together with animal bones and a number of artifacts, which also were observed in the Cetamura Well #1 (de Grummond 2017). At Etruscan Tarquinia, in the "Monumental Sacred Complex", the remarkable 4-layer *deposito reiterato* (seventh through fifth centuries B.C.) contained oilseeds (poppy and *Camelina* seeds), food plants (grape pips, fig achenes), and weeds (Bagnasco Gianni 2001; Rottoli 2001; Bagnasco Gianni 2005). Similar assemblages were found inside votive

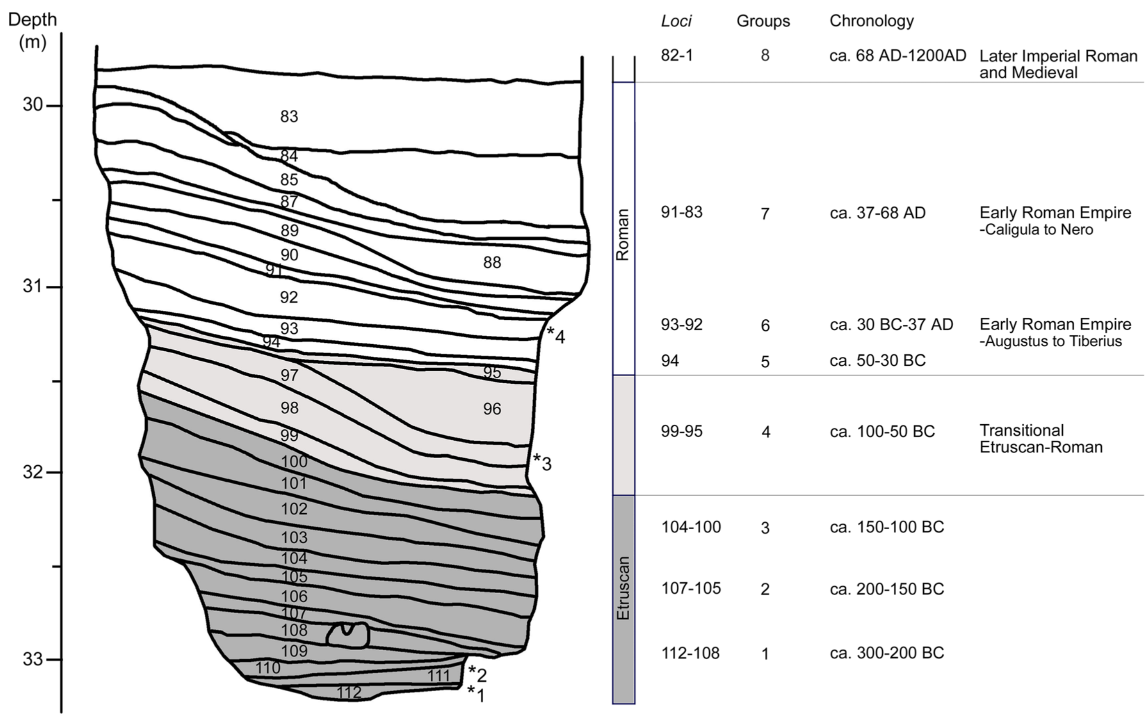


Fig. 2 Stratigraphical section and chronology of the Cetamura Well #1. *Locus* 86 is not located within this cross-section. Dating based on diagnostic artifacts as published in de Grummond 2017. *Radiocarbon ages. *1 Cal 480–390 B.C. *2 Cal 395–350 B.C. Cal 305–210 B.C. *3 Cal 170 B.C.–5 A.D. *4 Cal 90 BC–55 A.D

soil depressions connected to the ritual of foundation (the Roman and medieval town of Parma in Northern Italy, Bosi et al. 2011; the harbor of Roman Lattara in Southern France, Rovira and Chabal 2008) and in pits or deposits inside or close to sanctuaries and sacrificial areas (the Roman site of Mainz in Germany, Zach 2002; Monte Papalucio, South-Eastern Italy, Fiorentino and Caracuta 2010; Primavera et al. 2019). At Pompeii, Southern Italy, they were found buried in the soil of gardens and interpreted as remains of domestic offerings (Ciaraldi and Richardson 2000; Robinson 2002); numerous carbonized remains were recovered in the Shrine of the Insula VI.1, among which are charred cereals and pulses which were component of Roman ritual offerings (Murphy et al. 2013). Archeobotanical researches also revealed the offering of food preparations, probably part of a ritual meal; a poppy seed cake and ring-shaped biscuit in the House of the Wedding of Hercules, and bread in the House of the Vestals (Ciaraldi and Richardson 2000). Offerings of bread are also testified in the Archaic-Hellenistic sanctuary of Monte Papalucio (Primavera 2015) and by means of miniature clay λικνα, i.e., baskets containing bread, e.g., Acrocorinth (Brumfield 1997). Charred *Pinus* cones, scales, or seeds have been found in temples and domestic votive assemblages throughout Europe and the Mediterranean Basin (Kislev 1988; Robinson 2002; Megaloudi 2005; Lodwick 2015), suggesting the combustion of resiniferous materials during the rituals (Lodwick 2015). Regarding sacred wells, charred cereal caryopses, legume seeds, olive stones, charcoal of oak, and fruit trees such as *Pistacia* and *Prunus*, possibly connected with the religious activities of a sanctuary, were found in a Middle Bronze Age well close to the Temple of the Rock at Ebla, Syria (Fiorentino and Caracuta 2010). Charred olive stones and grape pips were found in a well at Pompeii (Murphy et al. 2013). Numerous wooden objects, wood offcuts, and charcoals were recovered in a Roman well at Rothwell Haigh, Leeds, England (Cool and Richardson 2013), together with pottery and animal bone assemblages; anyway, the study did not allow to definitively state the meaning of the different deposits within the well.

In the above-mentioned studies, all the food plant remains that were found charred—even when consumption does not require cooking—and intermingled with charcoals were interpreted as offerings and the charcoals were related to the fuel used for the sacred fires. Indeed, according to Lodwick (2015), the charred state, the particular spatial distribution of the remains, the simultaneous occurrence of votive artifacts, and the similarity to the assemblages occurring in funerary contexts are convincing criteria for attributing the plant remains to ritual offerings. Otherwise, it is not easy to individuate plant offerings, except in the case of exotic plants. Other considerations, such as the potential calorific value of wood/charcoal and their size (Veal 2013) may offer supplementary information about the origin of the assemblage.

The site of Cetamura and the well

Cetamura del Chianti (43°29′35″N, 11°25′54″E, 695 m a.s.l; Fig. 1) is a hilltop settlement located in the heart of the original zone of the production of Chianti Classico wine, ca. 20 km northeast of Siena, on the property of the Badia a Coltibuono (Gaiole in Chianti). Its highest point is recorded at 695 m above sea level, placing it among the higher ridges in the chain of the Chianti Mountains. Today, the site of Cetamura is located in a mixed oak forest, a plant community currently well-represented in the Chianti area. It coexists with holly oak forests and chestnut groves as well as herbaceous cultivations, vineyards, and olive groves. In the close vicinity of the well, *Quercus cerris* L. is the most abundant tree. It is mixed with *Castanea sativa* Miller, *Juniperus communis* L., *Ostrya carpinifolia* L., *Prunus spinosa* L., *Erica arborea* L., *Pyrus pyraster* Burgsd., *Cornus mas* L., *Rosa* sp., and *Hedera helix* L.

The cultural history of the site relates to the Etruscans (ca. 700/600–500 B.C., ca. fourth–first century B.C.), Romans (ca. 50 B.C. to fourth century A.D.) and medieval inhabitants (up to ca. 1200 A.D.). The excavation began in 1973, under director John J. Reich, and is still ongoing under the direction of Nancy de Grummond (for a history of excavation, see de Grummond et al. 2009). Installations identified include an Etruscan artisans' quarter (third–first century B.C.; iron-working, making of brick and tile, spinning and weaving, and other crafts); an Etruscan sanctuary to the gods Lur and Leinth (second century B.C.); Roman baths (first century B.C.–first century A.D.); a medieval fortified residence referred to as Civitamura (ca. 1000-1200 A.D.). Two Etruscan wells have been excavated and have yielded enormous amounts of cultural and botanical materials from all of these time periods (de Grummond 2017). The well under investigation (Well #1; Fig. 1b) contained various objects, some fragmentary and some whole and even precious (de Grummond et al. 2015), which seem to be connected with some ritual purpose (Holland 2017; de Grummond 2017; see catalog numbers below). Certainly there were many actions, both natural and anthropogenic, by which items entered into the well (32.42 m deep), i.e., settling, discarding, dumping, dropping, falling, collapsing, even growing inside (de Grummond 2017, 15). Of special interest is the evidence that the well was also a focal point for rituals of gift offering and divination. Numerous miniature ceramic votive cups (e.g., cat. nos. 38–48) and shallow cups made from ring-foot ceramic bases (e.g., cat. nos. 49–62) were present. Many of the items seem to have been ritually cut in half or broken systematically as part of the act of offering. Some 79 two-sided tokens, made of ceramics or occasionally of stone (e.g., cat nos. 24–37) suggest that worshippers asked a binary question (yes or no), and after using the token to get a prophetic response, would throw the object into the well. The presence of numerous thin wooden tablets of various shapes (e.g., cat. nos. 21–22) in the Etruscan and Transitional periods (ca. 300–50 B.C.) together with the simultaneous presence of astragali and ceramic and stone tokens, suggests the possibility of the ritual use of the wooden tablets for prophecy or omens as well. Corbino and Fonzo (2017) found evidence of rituals of animal sacrifice as well. Finally, it should be noted that some 60 coins in both Etruscan and Roman levels indicate rituals of offering to the gods (e.g., cat. nos. 83–84, 146–147, 225–230). There is very little evidence of any burning ritual, as occurs in the second century B.C. Etruscan sanctuary on Zone II at Cetamura, where the deposits were broken and buried in the ground (de Grummond et al. 2009). It is assumed that the casting of the items into the open cavity and into deep water was a sufficient act of consigning material to the gods. The names of the gods of Cetamura, Lur, and Leinth occur in inscriptions found near the sanctuary (de Grummond et al. 2009, cat. nos. 126-127). All of these rituals are consistent with the spheres of influence—fortune and fate—of these gods.

Materials and methods

The stratigraphy of the Cetamura Well #1 was subdivided into layers named *loci* (sing. *locus*). The excavation was initially carried out in thin layers, ca. 10–25 cm each, following the natural slope of the sediments and their features. The subsequent study of the stratigraphy and the chronology of the artifact content allowed to relate groups of *loci* to the different spans of time of its actual usage, from the late Etruscan to the Roman imperial period (de Grummond et al. 2017; Fig.2).

Microremains

For the pollen analysis, one or two samples were collected from each *locus* of Well #1 (35 samples in total) and stored in 3% Preventol®RI80 solution in water, a medium (quaternary ammonium salts) which prevents the development of fungi and bacteria on organic and inorganic substrates, allowing their long preservation. After repeated washing, 3 g of dried sediment for sample were sieved at 0.5 mm, processed with HCl, HF, sodium hexametaphosphate, NaOH, and subjected to acetolysis. Pollen identification was made at light microscopy (Leica DM2500), operating at 630 ×, with the help of literature (Andersen 1979; Moore et al. 1991) and the reference pollen collection of the Dipartimento di Biologia, Università degli Studi di Firenze, Italia. Pollen grains belonging to the *Quercus robur/petraea* type (Smit 1973), such as *Q. robur* L., *Q. petraea* (Matt.) Liebl., *Q. pubescens* Willd., and the grains similar to those of the local *Quercus cerris* were collectively reported as "deciduous *Quercus*." The fenestrate pollen grains of Asteraceae were attributed to Cichorieae (Florenzano et al. 2015).

Pollen concentration (absolute pollen frequency (APF)) is reported as number of grains per gram of sediment and was calculated on at least 50 μl per sample. Pollen percentages of AP (arboreal pollen) and NAP (non-arboreal pollen) were calculated on the total pollen and spores sum. Pollen diagrams were drawn using TILIA 2.0. A moss cushion gathered near the well, treated with the same procedure, was used for recording the current pollen rain which is directly referable to the present vegetation (Spieksma et al. 1994).

For starch analysis, soil samples were shaken in sodium hexametaphosphate, sieved at 250 μm, treated with HCl, and then subjected to heavy liquid separation using zinc chloride (Revedin et al. 2010). Identification of the starch grains, based on morphometric parameters (shape, dimensions, hilum type and position, presence of lamellae) was performed at light microscopy and under a polarizing microscope, with the help of literature (Seidemann 1966) and reference material.

Macroremains

Wood/charcoal

Waterlogged wood and charcoal remains (510 items were examined in total), both parts of plants and artifact fragments, were sampled for taxa identification. Where existing, the connections among different portions/fragments were found in order to sample the same item only one time; moreover, the numerous wood findings excavated in each *locus* were grouped based on similar autoptical characteristics and chosen for the analysis until no different taxa were recorded in each group.

Thin sections of waterlogged wood, obtained by handmade cutting on a freezing plate along the three diagnostic directions were observed by means of a transmission light microscope (Leitz, Ortholux II Pol-BK). Charcoals were fractured along the main sections of wood and observed through a stereomicroscope (Nikon, SMZ 800) and, when needed for their bad state, through a scanning electron microscope (FEI, Quanta 200). The identification of the wood was carried out in accordance with the Italian technical standard UNI 11118: 2004, by the comparison of the collected diagnostic characteristics with a reference database collected in the laboratory and literature (Schweingruber 1990).

Seeds/fruits

In order to recover plant macroremains (Cini et al. 2017), the sediment of every bucket of material from each *locus* was washed in sieves with a fine mesh of 0.5–1 mm. Over the 5 seasons in which the mud, rock, brick, tile, artifact, bone, and plant remains were removed from the well, hundreds of buckets were processed. Remains visible to the naked eye were selected; a method of retrieval which favored the recovery of the larger carpological remains which are easily recognizable. The selection deliberately favored grape pips, on which to perform morphometric and DNA studies. The interest in these remains was dictated by the geographical location of Cetamura, which is located in the protected area of the "Monti del Chianti" (Fig 1), in the Chianti Classico wine production area. Moreover, *Vitis* cultivation has a long history in Tuscany, with early cultivation traces in the Massaciuccoli Basin (4000–3000 BP; Menozzi et al. 2003). As a consequence, in this paper we present a selection of the carpological remains found in Well #1.

Identification was performed with the help of reference literature, atlases (Neef et al. 2012; Cappers and Bekker 2013), and reference seeds collection. The recovered waterlogged *Vitis* (grapevine) pips were subjected to morphometrical analyses.

Morphometrical analyses of grape pips

A total of 484 waterlogged grape seeds or fragments of seeds were retrieved from Well #1. Of these, 310 specimens were selected for morphometric examination (Bouby et al. 2017). The largest concentrations belonged to the *loci* of the late Etruscan period (*loci* 104–100; 150–100 B.C., $N = 52$ pips) and more especially to the early Roman Empire period (*loci* 91–83; 37–68 A.D., $N = 212$ pips). The pips of *loci* 104–100 were found in an area so dense in artifactual material (de Grummond et al. 2017, pp. 46–47) that a period of dumping has been hypothesized (de Grummond 2017, p. 15; de Grummond et al. 2017, pp. 46–47), a factor that suggests caution in evaluating the data.

Due to waterlogged conditions, these grape pips were very well preserved, allowing a geometric morphometric analysis (Fig. 3) in order to compare (1) the pip shapes from different layers of the well with (2) the archeological seeds to a large set of modern wild and domesticated *Vitis* seeds. Through the quantitative description of seed outlines, geometric morphometrics allow a powerful discrimination of wild and domesticated grapevines and characterization of the changes in the cultivated diversity of grape through time (Terral et al. 2010; Pagnoux et al. 2015).

Elliptic Fourier transform (EFT) analysis was performed on dorsal and lateral seed outlines following Terral et al. (2010), Pagnoux et al. (2015), and Bouby et al. (2016).

The pips from several Groups from Well #1 were compared using principal component analysis (PCA) performed on 48 shape variables. Archeological seeds were also compared using linear discriminant analysis (LDA) to a balanced reference collection of 4854 pips from modern wild grapevines and cultivars originating from various areas of Europe, the Mediterranean and the Caucasus.

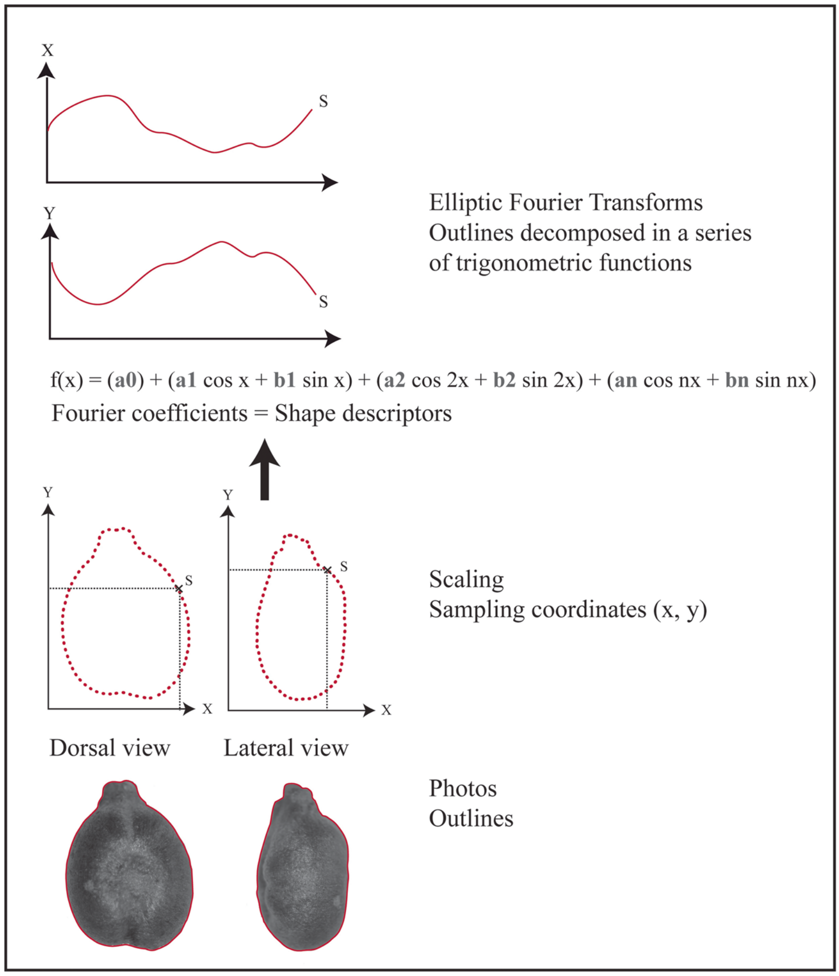


Fig. 3 Geometric morphometric analysis of grape pips (*Vitis vinifera*) using the elliptic Fourier analysis of closed outlines (dorsal and lateral views)

Results

Microremains

Palynology

Pollen grains were well-preserved in the majority of the samples collected. APF (Fig. 4) ranged from 960 to 14,400 grains/gram with the exception of *locus* 102.1, which had 200 grains/gram but displayed a high number of taxa. *Loci* 103.2, 107.1, and 107.2 were sterile or very poor in grains. The number of taxa per sample were influenced by the high number of herbaceous taxa (Fig. 4). AP were more than 60% of the total pollen grains in approximately two-thirds of the samples (Fig. 4).

In the majority of *loci*, the largest concentrations of the pollen grains belonged to deciduous *Quercus* (oak) (Figs. 5a, 6); they often occurred in clumps of 5–15 or more, sometimes enveloped in tissue fragments and displaying different developmental stages. Plants typical of the mixed oak forest such as *Carpinus betulus* (hornbeam), *Ostrya*/*Carpinus orientalis* (hop hornbeam or oriental hornbeam), *Cornus mas* (Cornelian cherry), *Corylus* (common hazel) were well represented through all of the stratigraphy. *Quercus* cf. *ilex* was better represented in the upper part of the sequence. *Vitis* and *Juglans* (walnut) pollen reached their highest percentages in *loci* 111.1 and 112.2 (Fig. 6).

Among NAP (Fig. 6), wild Poaceae dominated. Cereal pollen grains belonging to *Avena*/*Triticum* group and *Hordeum* group occurred in the lower part of the stratigraphy, up to the sample 99.2, with main peaks respectively in *loci* 101.1 and 102.1, both belonging to the late Etruscan period (within the hypothesized dumping episode). Ruderal plants, nitrophilous plants, and weeds occurred in most of the samples, even if discontinuously.

Pollen of plants with large, colored flowers was randomly recorded in noticeable amount. This is the case of *Crocus* (*locus* 90.1, Figs. 5b, 6), *Asphodelus* (*locus* 103.2), *Centaurea nigra* type (110.1). Numerous pollen grains of Apiaceae, mainly belonging to *Falcaria vulgaris* type, were found in *locus* 102.1, and Ranunculaceae with different morphotypes were well recorded in *locus* 106.2.

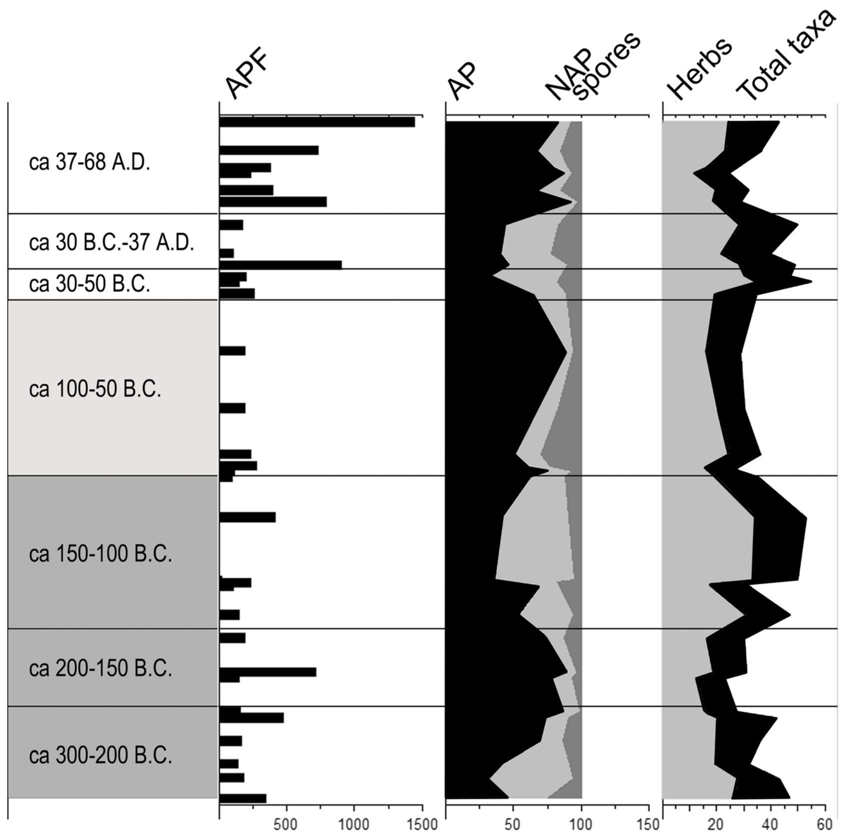


Fig. 4 Cetamura Well #1. Absolute pollen frequency (× 10), AP /NAP (spores evidenced), number of herbaceous taxa and the total taxa

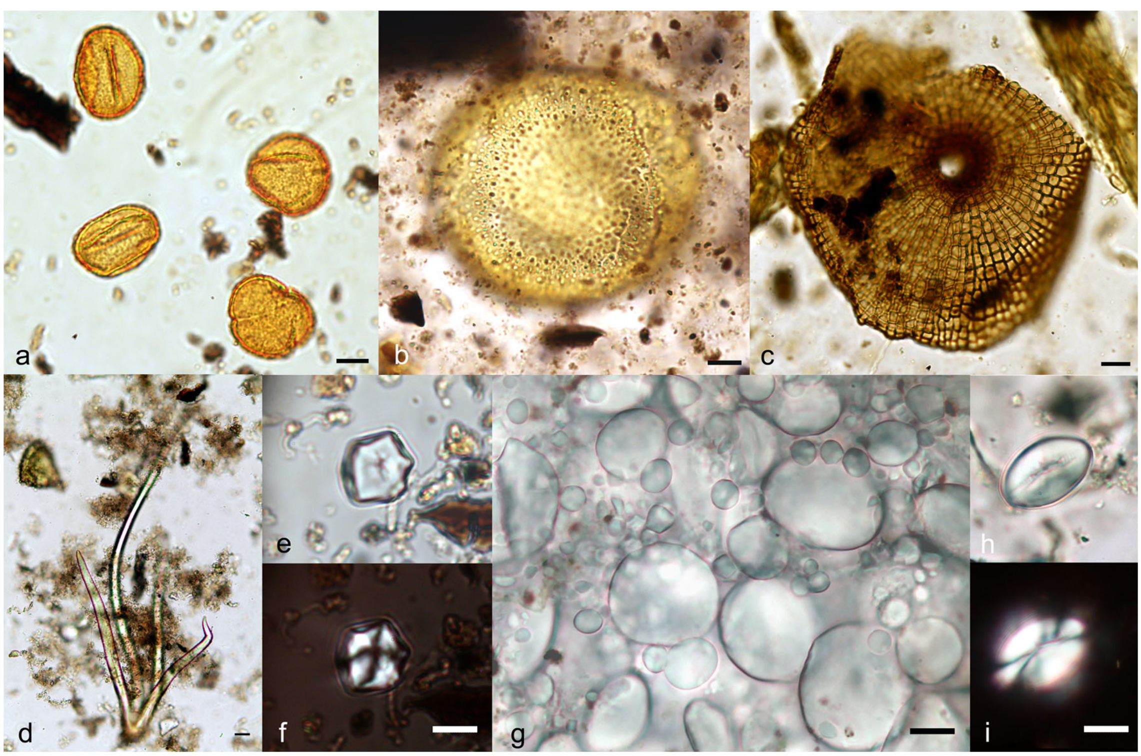


Fig. 5 Microremains from the Cetamura Well #1. **a** Deciduous *Quercus* pollen grains. **b** Pollen grain of *Crocus*. **c** Fruiting bodies of Microthyriaceae. **d** Stellate trichome. **e**, **f** Starch grain morphotype I at l.m. and polarizing l.m. **g** Group of grains probably belonging to *Triticum*. **h**, **i** Starch grain morphotype III at l.m. and polarizing l.m.

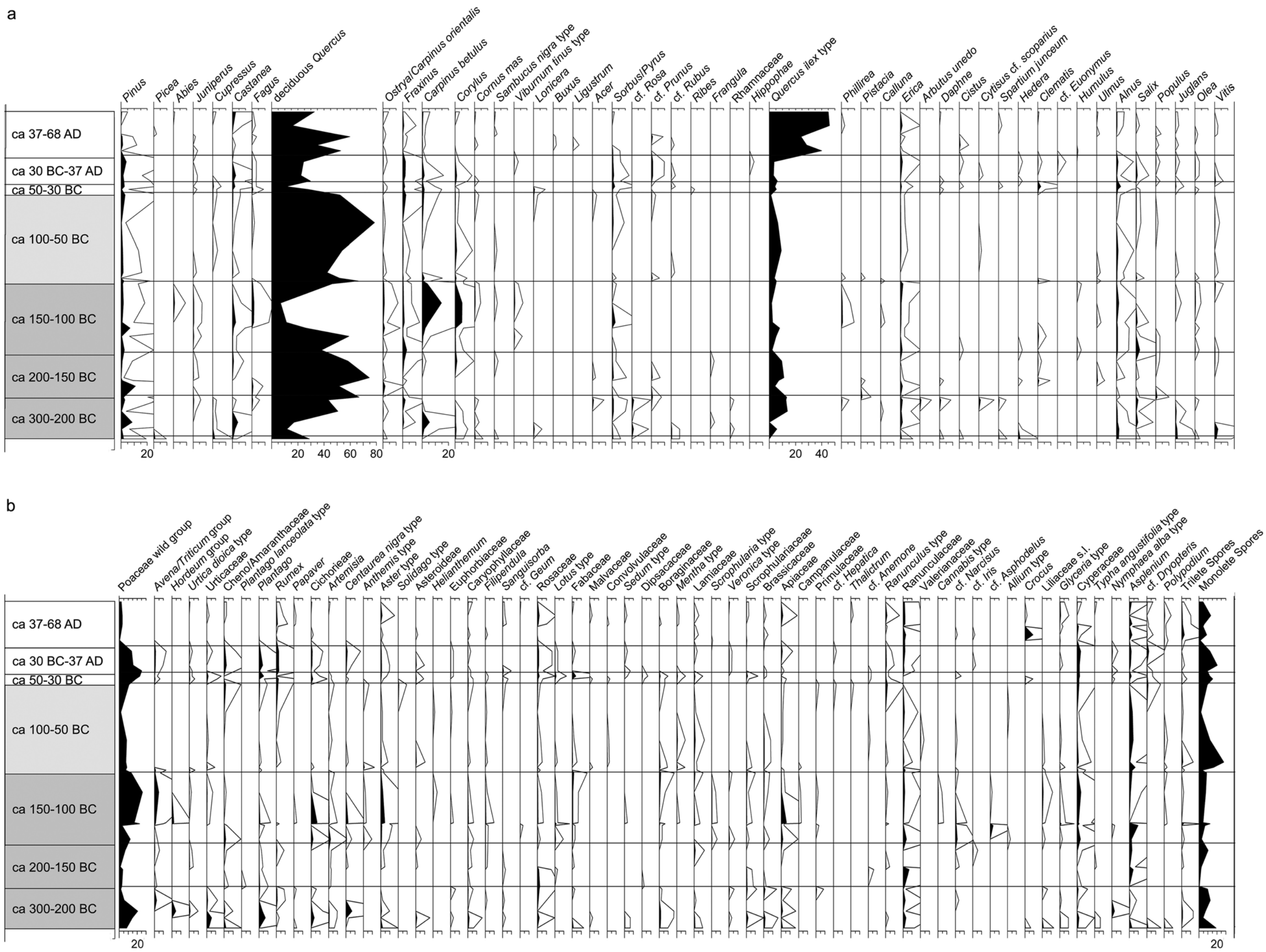


Fig 6 Cetamura Well #1. AP (**a**) and NAP (**b**) percentages calculated on total pollen and spores. Exaggeration, 10 ×

Asplenium and monolete spores, often in clusters, were well recorded in the spectra (Fig. 6). Moreover, entire fern sporangia or their fragments occurred in almost all of the samples.

The analysis of the moss cushion (APF 42,000, 62 taxa) revealed the dominance of deciduous *Quercus* pollen in the current pollen rain; the grains were often in clusters, sometimes enveloped in fragments of anthers. The presence of cultivated plants in the surroundings, not exceeding 1 km as the crow flies from the well, is reflected by percentages that range from 0.6 (*Vitis*) to 0.1 (cereals).

All the samples contained fungal spores, fruiting bodies of Microthyriaceae (Fig. 5c), a large amount of microcharcoals, sporadic fibers, tissue fragments referable to epidermis and stellate trichomes (Fig. 5d) similar to those present on the leaf blade of oaks.

Starch analysis

Small starch grains (≤ 5 μm), lacking of diagnostic characteristics, were observed in many samples. Larger starch grains were sporadic (Table 1). They presented different features:

- Morphotype I. Irregularly subspherical starch grains, faceted with rounded vertices, 15–20 μm in diameter; centric hilum generally surrounded by radiating fissures; extinction cross radially symmetrical. They may be attributed to millets (Fig. 5e–f).
- Morphotype II. Lenticular starch grains with circular to elliptic outline, centric closed hilum, main axis or diameter 15–30 μm; extinction cross radially symmetrical, sometimes faded. Easily visible lamellae in many of them. They may belong to *Hordeum* or *Triticum*. In *locus* 98.1, they were also found grouped with very numerous spherical small grains, the most part measuring about 2 μm. These groups most probably belong to *Triticum* (wheat, Fig. 5g).
- Morphotype III. Ovoid starch grains with a mesial longitudinal cleft fissure often ragged, main axis 20–25 μm. Lamellae more or less evident; extinction cross bilaterally symmetrical. These grains, found in very small amount, are ascribable to Fabaceae (Pea family, Fig. 5h, i).
- Morphotype IV. Spherical to ovoid starch grains with centric closed hilum, diameter 7–13 μm or main axis up to 18 μm; extinction cross radially symmetrical. The grains

Table. 1 Distribution of the starch grain morphotypes in the examined samples

Locus	Morphotype I	Morphotype II	Morphotype III	Morphotype IV
88.1				+
96.2		+		
98.1		+		
99.2	+			
102.1				+
102.2	+		+	
103.2	+			
108.1	+			
109.1		+		

did not display features that allow their attribution to a definite group of plants.

Macroremains

Wood and charcoal

Sixteen different wood taxa were represented in Well #1, one softwood (Gymnosperm) and fifteen hardwoods (Angiosperms). They consisted in waterlogged wood fragments, twigs, or briarwood fragments, worked or possibly worked wood, charcoal, or partially carbonized wood (Table 2).

Only a few wood examples of larger size, uncharred or partially burnt, constituted worked woods; the greatest part of them was found in the earliest Etruscan *loci*. Charcoal or partially carbonized wood essentially referred to the Etruscan (300–200 B.C. and 150–100 B.C.) and the early Roman Imperial *loci* (30 B.C.–68 A.D.). Deciduous *Quercus* were abundantly testified all throughout the well. Among them, identification of *Q. cerris* was not always possible. Worked items (de Grummond 2017; catalog numbers below) were mostly realized with deciduous *Quercus* wood, as shown especially by those of the earliest Etruscan period (ca. 300–200 B.C.), small, thin tablets (and fragments), and two tablets of square shape (cat. nos. 21–22); two grooved objects (cat. nos. 16–17); a handle with perforation (cat. no. 19). Dating to a slightly later Etruscan period (probably ca. 150–100 B.C.) were other artifacts of *Quercus* wood, a thin rectangular tablet and a large wood beam (cat. no. 10) with one parallelepiped fragment, probably part of the well foundation. Sometimes also briarwood is worked as, for example, in the case of a large rounded fragment (about 15 cm wide, 7 cm high, 3 cm thick) with clear traces of cut on the outer surface. *Fagus* wood was also frequently used for artifacts, as seen in the production ranging from the Etruscan time to the transitional Etruscan-Roman period (ca. 300–50 B.C.), and in particular, it was identified in a broken and incomplete bucket (cat. no. 11). *Juglans* wood was also used to create a bucket and a spatula (cat. no.13), whereas *Ulmus* wood was used for a double paddle with a hole on one end (cat. no. 14), probably an element to support a pivot, and other worked (or probably worked) fragments. *Buxus*, *Cornus*, and *Corylus* were also probably worked, but the remaining fragments were too small or fragmentary to attribute them to any original function. A pulley or spool was made of *Carpinus*/*Ostrya* wood (cat. no. 12). *Abies alba* is present from ca. 200 B.C. onwards and in the transitional strata from Etruscan to Roman periods; among artifacts, it mostly was used for small, thin tablets (cat. no. 21). The utilization of *Corylus* twigs for preparing wood strips (cat. no. 18), possibly to produce baskets or linings for containers, is well testified in the transitional Etruscan-Roman period. Sporadic was the presence of twigs of spindle tree. *Q. cerris* was the most represented oak type among the charcoals.

Seeds and fruits

The carpological remains, except grape pips (originally 484 in total), are 67 (Table 3). Among them, there were a few remains of burnt cereals, with emmer (*Triticum dicoccum*, a caryopsis and a base of a spikelet) and perhaps one specimen of naked wheat (*Triticum* cf. *aestivum/durum*, a caryopsis). Also to be related to the processing of cereals were other carbonized remains of weeds, a caryopsis of brome (*Bromus* sp.), one of darnel (cf. *Lolium temulentum*), and one seed of black-bindweed (*Fallopia convolvulus*). More abundant were fruits, Cornelian cherries (*Cornus mas*), hazelnuts (*Corylus avellana*), olives (*Olea europaea*), pine nuts from domestic pine (*Pinus pinea*), peaches (*Prunus persica*), and acorns (*Quercus* sp.). The remains of fruits were waterlogged, except for a few grape pips and Cornelian cherry pits.

The sieving also allowed the recovery of a gall (*locus* 111) seemingly produced by the attack of a cynipid insect, *Andricus quercustozae* (gall wasp), which is a typical parasite on oaks.

Morphometrical analysis of grape pips

The first biplot of the PCA (35.5% of variance) showed no strong organization of the pips according to their chrono-stratigraphic origin (Fig. 7; Supplementary 1). The groups from the earliest phases of the well (Group 1, Etruscan to Group 4, transitional Etruscan/Roman) tended to be located in the left-upper part of the graph, while the centroids of the most recent groups (Groups 6 and 7, early Roman Empire, Augustus to Tiberius and Caligula to Nero; 30 B.C.–68 A.D.) resulted in the right-lower part. This would suggest some kind of weak chronological change in the shape of the pips and therefore in the diversity of grapes used in Cetamura.

Table. 2 Woods and charcoals from the Cetamura Well #1. *A* worked wood, *C* carbonized wood, *T* twigs, *A(?)* wood possibly worked, *W* waterlogged wood fragments

Locus	*Abies alba*	*Fagus sylvatica*	*Quercus cerris*	Deciduous *Quercus*	*Ostrya carpinifolia*	*Carpinus/ Ostrya*	*Fraxinus* sp.	*Carpinus betulus*	*Corylus avellana*	*Cornus mas*	*Euonymus europaeus*	*Buxus sempervirens*	*Acer* sp.	*Quercus ilex*	*Ulmus* cf. *minor*	*Juglans regia*	
71.1	A																Post 68 A.D.
83.A2			C														ca. 37–68
83.C		C	C	C			C		C								A.D.
84		W,T		W													
86.A			C	W,C									C		C		
86 B		W															
86 C			C														
87.2	C	W															
88.3				W													
88.A				W,C													
88.B				W													
88.C	W																
89.2		C		C													
90.1			A(?)														
91.1												W,A(?)			W,A(?)		
91.2		W,A(?)		W													
91.A																W	
92.1	C	T,C		C					C						A		ca. 30
93.1																	B.C.–37
93.2	W,C																A.D.
94.A	C		C						C				C				ca. 50–30
94.2				W								A(?)					B.C.
95.1	A	W,C		W,C													ca. 100–50
96.1	W																B.C.
96.2		A	A						T	A,T				A			
97.1	W			W					W								
97.2		W															
98.1				W				W									
98.2		A							W	T							
99.2									W			W			W		
100.1									T						A(?),T)		ca. 150–100
101.1	W	W		W						W							B.C.
102.1				W,C					W,T		T				W		
102.2	W	A		T				T	T						A		
102.A				W.T													
103.1				W											W		
103.2			C	C													
104.1		W		W						T	T						
104.A		C				C										A	
105.1				W									C				ca. 200–150
106.1		W,C		W,C					W,C							W,C	B.C.
106.2		C							T							W	
107.1				A					T								
107.2	W			W													

Table. 2 (continued)

Locus	*Abies alba*	*Fagus sylvatica*	*Quercus cerris*	Deciduous *Quercus*	*Ostrya carpinifolia*	*Carpinus/ Ostrya*	*Fraxinus* sp.	*Carpinus betulus*	*Corylus avellana*	*Cornus mas*	*Euonymus europaeus*	*Buxus sempervirens*	*Acer* sp.	*Quercus ilex*	*Ulmus* cf. *minor*	*Juglans regia*	
108.1				W						T					W	W	ca. 300–200 B.C.
108.2		A							W	W					W		
108.A				W													
109.1				W,A,C		C		W,C		W,C							
110.1				W,C		A		W,C		W,C							
111.1		W,A		W,A					A(?)	A(?)						A	
112.1		W,A		W,A	A				T	W					A		
112.2				W	W				W	W							

However, the comparison of the two big ensembles (Groups 1–4 versus Groups 6 and 7) using an ANOVA shows no significant difference either on axis 1 ($R^2 = 0.007$, $F = 0.522$, $p = 0.47$, Tukey post hoc = NS) or axis 2 ($R^2 = 0.039$, $F = 3.276$, $p = 0.071$, Tukey post hoc = NS).

Based on a balanced modern sample of 2427 pips of wild grapevines and 2427 pips of cultivars, leave-one-out cross-validation in the LDA allows us to classify correctly 96.1% of the modern pips (95.4% for domesticated pips and 96.8% for wild pips). The archeological pips could then be safely classified in this LDA as supplementary individuals (Table 4).

Wild and domesticated morphotypes (Fig. 8) were both recognized in all the chronostratigraphy. Only a minor proportion of the pips (8.71% in total) could not be classified (the probability threshold has been arbitrarily set at $p > 0.75$). The domesticated morphotype was largely predominant in the whole sample (83.88%) as well as in each group. The representation of the wild morphotype was possibly slightly higher in the most ancient groups (Etruscan to transitional Etruscan/ Roman). It was especially low in the early Roman Empire group (7, Caligula to Nero), the most recent one.

Discussion

The huge list of plants (ca 130 taxa in total) provided by the archeobotanical analyses in Well #1 included numerous trees, shrubs, and a large variety of herbs. Some plants are present both among the macro- and microremains, even if their identification reached a different taxonomic level in the two records; this is the case of numerous trees (i.e., *Abies alba*, deciduous *Quercus*, *Carpinus betulus*, *Cornus mas*, *Corylus avellana*, *Evonymus europaeus*, *Fagus sylvatica*, *Juglans regia*, *Ostrya carpinifolia*, *Ulmus* cf. *minor*) and cultivated plants, such as *Vitis* and cereals.

Even if the information from the archeobotanical data is consistent, it is reasonable to suppose that the most abundant plant remains, especially pollen grains, belonged to plants which grew in the site (Mercuri 2014) and, in our case, to plants which grew in proximity of the well, perhaps standing with their canopy over the well itself or growing on the shaft wall, a condition suitable for causing their over-representation in the sediments.

Paleoenvironmental reconstruction

Deciduous *Quercus* was the most frequent record in the well filling, both among the micro and macroremains (Figs. 5, 6; Table 2, 3), high percentages of well-preserved pollen grains, clustered pollen grains at different stage of development, anther fragments, twigs, acorns, and stellate trichomes similar to those occurring on the oak leaves. The same records are present in the current pollen rain and on the soil of the Cetamura

Table 3 Seeds and fruits from the Cetamura Well #1. *Unbr*, unbroken; *Fr*, fragments; *c*, charred; *w*, waterlogged

Age				112	111	110	109	107	106	103	102	101	100	99	98	97	96	94	93	92	91	90	89	88	87	86	85	84	83	
							Etruscan								E/R															
Cereals																														Total
Triticum dicoccum	Caryopsis	Unbr/fr	c	1																										1
Triticum dicoccum	Spikelet fork	Fr	c															1												1
Triticum cf. *aestivum/durum*	Caryopsis	Unbr/fr	c																									1		1
Cerealia/Poaceae	Caryopsis	Fr	c																									8		8
Fruits																														
Cornus mas	Fruit stone	Unbr/fr	w	1		4	2																							7
Cornus mas	Fruit stone	Fr	c	3		6																								9
cf. *Cornus mas*	Fruit stone	Fr	c															1												1
Corylus avellana	Fruit	Unbr	w	1		3	1																							5
Corylus avellana	Nutshell	Fr	w	5				1	2																					8
Olea europaea	Fruit stone unbr	Unbr/fr	w	1		1																								2
Pinus pinea	Shell	Fr	w															5												5
Pinus pinea	Cone	Unbr	w														1													1
Pinus pinea	Cone scale unbr	Unbr/fr	w		3												2													5
Prunus persica	Fruit stone	Unbr	w																				1							1
Quercus sp.	Acorn	Unbr/fr	w						1														1							2
Quercus sp.	Epicarp	Fr	w	1																										1
Andricus quercustozae	Gall	Unbr	w		1																									1
Sambucus sp.	Fruit stone	Fr	w																											1
Vitis vinifera	Pip	Unbr/fr	w	12	3	8				1	21	30	7	2	4	6	3	1	10	17	50	9	10	31	33	114	26	9	71	478
Vitis vinifera	Pip	Fr	c																				6							6
Vitis vinifera	Pedicel	Fr	w																							2				2
Weeds																														
Bromus sp.	Caryopsis	Fr	c																									1		1
Fallopia convolvulus	Fruit	Unbr	c																										1	1
cf. *Lolium temulentum*	Caryopsis	Unbr	c																										1	1
Unidentified	Bud	Unbr/fr	w																				2							2
Total S/F				25	7	22	3	1	3	1	21	30	7	2	4	6	6	8	10	17	50	9	20	31	33	116	26	19	74	551

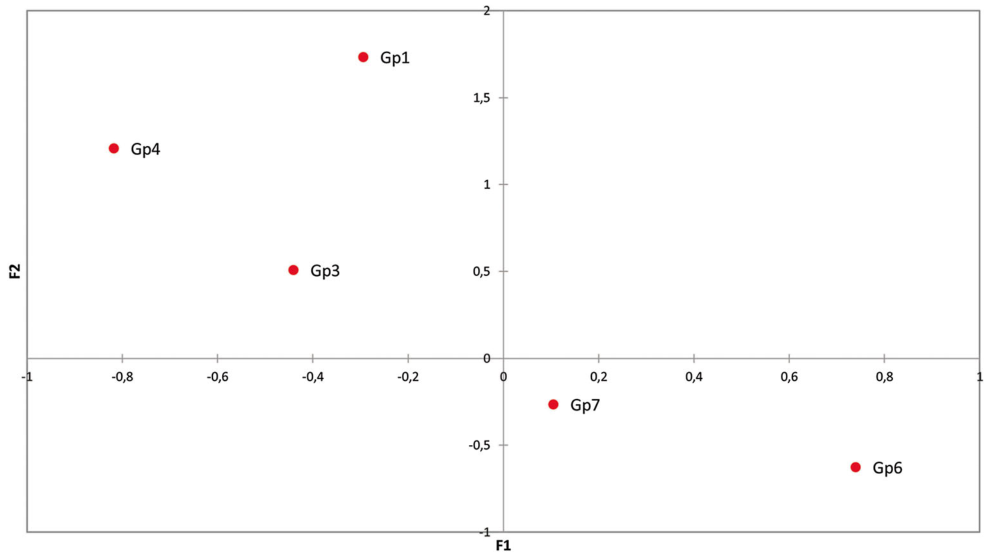


Fig 7 Principal component analysis (PCA) of the grape pips according to their chrono-stratigraphic origin

wood. In addition, fruiting bodies of Microthyriaceae, which often occur on the dead leaves of Fagaceae, and a gall seemingly due to *Andricus quercustozae* were found in the well. The presence of a mixed oak forest is well supported by the whole AP composition, which includes numerous trees usually growing in this plant community, such as *Fraxinus*, *Carpinus betulus*, and *Corylus*. A mixed oak forest could have been present through the Etruscan and transitional Etruscan-Roman period, even if the deciduous *Quercus* curve displays an irregular trend. The main decline of deciduous *Quercus* occurred in the *loci* of the late Etruscan period, around 150–100 B.C., when there seems to have been a good bit of clearing, dumping, and building at Cetamura. It is noteworthy that the decrease of deciduous *Quercus* pollen is coincident with the increasing values of *Carpinus betulus, Corylus* and other trees common in the mixed oak forest which are also recorded among the macroremains (Fig. 6; Table 2, 3). This hints that forest clearances principally affected *Quercus*. However, the long list of herbs recorded in these samples, together with the possible dumping episode, suggests caution in considering the relative APF values reliable in reconstructing the local vegetation. Later, during the Roman period, the pollen record suggests the diffusion of *Q. ilex*.

Table. 4 Classification of the grape pips according to LDA

	Dom	Wild	NS	Total
Gp7 (37–68 A.D.)	186 (87.7%)	10 (4.7%)	16 (7.5%)	212
Gp6 (30 B.C.–37 A.D.)	16 (84.2%)	2 (10.5%)	1 (5.3%)	19
Gp5 (50–30 B.C.)			1 (100%)	1
Gp4 (100–50 B.C.)	8 (72.7%)	2 (18.2%)	1 (9.1%)	11
Gp3 (150–100 B.C.)	43 (82.7%)	5 (9.6%)	4 (7.7%)	52
Gp1 (300–200 B.C.)	7 (46.7%)	5 (33.3%)	3 (20%)	15
Total	260 (83.9%)	24 (7.74%)	26 (8.4%)	310

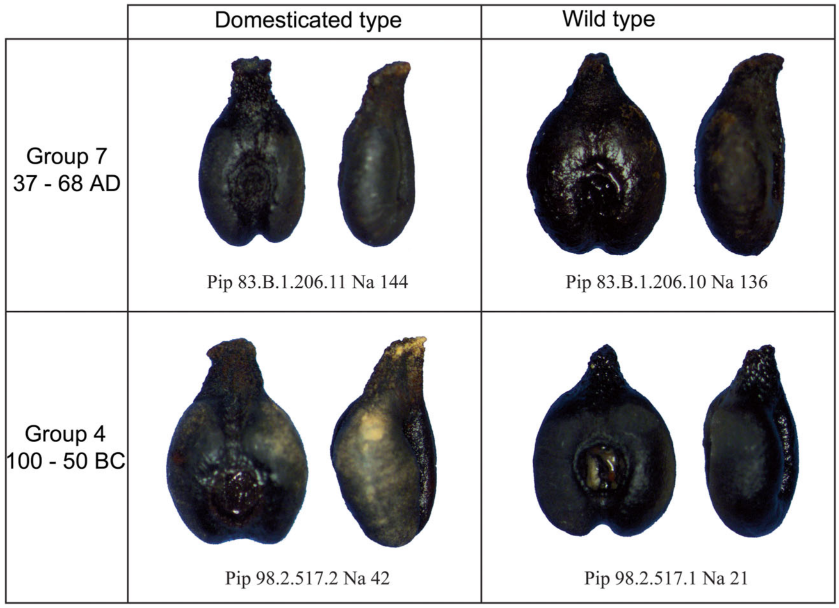
Previous studies in Southern Tuscany indicated the occurrence of degraded evergreen *Quercus* forest from the third century B.C. to the end of the Roman Age (Buonincontri et al. 2013), following a decreasing trend probably started during the previous centuries and largely due to the impact of the Etruscan metallurgical activity (Mariotti Lippi et al. 2000). In South-Eastern Tuscany, archeobotanical studies in Roman farmhouses (Rattighieri et al. 2013) evidenced cultivation of cereal and forage in a landscape that was fairly treeless and the confinement of the woods on the hills, far from the sites. Changes in the plant cover as a consequence of warmer climate during the Roman period are well recorded by pollen analysis in Northern Tuscany (Benvenuti et al. 2006; Mariotti Lippi et al. 2007).

Single and clustered fern spores and entire sporangia were well represented in Well #1 (Fig. 4, 6), suggesting that ferns possibly grew close to the well or even on the wall of the shaft, releasing spores and old blades with sporangia into the well, even if voluntary dropping of their fronds cannot be excluded.

Wood exploitation

Concerning the exploitation of the natural resources, wood analyses (Table 2) showed the utilization of numerous woods. *Quercus* was extensively used in the entire time span represented in the well, both for making artifacts and possibly as fuel. Deciduous oak wood was already found at Cetamura and seems to have been preferred for ritual fire (Cottini 2009). Oak timber has been largely used in Italy from the Prehistoric period because of the easy availability (Mariotti Lippi et al. 2014), the high durability of its duramen, its wear resistance and mechanical strength, and probably because tables could be easily obtained from trunks by simple splitting in the radial direction (Gale and Cutler 2000; Giachi et al. 2010a; Giordano 1980). A sophisticated use of oak timber has been highlighted

Fig. 8 *Vitis vinifera* morphotypes from Well #1



by the findings of hundreds of hut piles in Northern Italy since the Bronze Age, where *Quercus* exploitation is coincident to a decrease of pollen curves (Mercuri et al. 2015b). In Tuscany, charred, semi-carbonized, but also waterlogged foundation poles and tables of deciduous oak were found at the Final Bronze Age settlement of Bientina, Pisa, where pollen analysis attested the presence of a mixed oak forest in the plain (Giachi et al. 2010a). At Stagno, Leghorn, oak timber was used for the foundation poles of a dwelling settlement of the Final Bronze Age (Giachi et al. 2010b). Carbonized, rarely waterlogged deciduous oak trunks were used as vertical poles supporting the roofs at Sesto Fiorentino, Florence, in a settlement dated back to the Final Bronze Age, beginning of Middle Bronze Age (Coradeschi et al. 2013).

Fagus, which furnishes one of the strongest European timbers, is widely represented at Cetamura. Over time, it has been used for various purposes also as a replacement of *Quercus* (Gale and Cutler 2000). No significant trend in the presence of the identified wood taxa was found along the investigated time span, although the greater part of artifacts occurred in the more ancient Etruscan strata. Artifacts confirm the utilization of different woods depending on their characteristics, in particular those of *Quercus* and *Fagus*. *Corylus*, a small, often coppiced tree, was used as fuel in the hearths and for producing wood strips from its twigs.

Wild and cultivated food plants

Food plants (both wild and cultivated) are well represented in Well #1 (Figs. 6, 7, 8; Table 3, 4), as happens in numerous sanctuaries and other sacred sites (Ciaraldi and Richardson 2000; Robinson 2002; Zach 2002; Fiorentino and Caracuta 2010; Rovira and Chabal 2008; Bellini et al. 2011; Bosi et al. 2011) and resulted in previous investigation at Cetamura too (Cottini 2009).

Some of the food plants found in the Well #1 filling, such as olive, could have been gathered both from wild and domesticated plants. Some plants may be cultivated (including undomesticated species, like *Pinus*) and some may just be under anthropogenic influence, i.e. growing in anthropogenic environments. *Cornus* and *Corylus*, for example, which grow wild in the mixed oak forests, could also have been cultivated.

The most abundant food plant remains are grape pips, but considering the large amount of sediment excavated and screened, the concentration of these finds also seems to be quite low. Regarding microremains, *Vitis* pollen was discontinuously recorded (Fig. 6) and showed higher percentages in two samples at the bottom of the well than in the current pollen rain. The results of LDA performed on shape descriptors of *Vitis* pips (Fig. 7) suggest that they mostly originated from domesticated grapevines. This is not a surprise in an Etruscan-Roman settlement but it confirms that most of the pips found at the site came from cultivated grapevines and that these pips were probably brought and/or deposited by people into the well rather than representing fruits accidentally fallen from wild plants growing nearby. The small proportion of pips (7.7%) allocated to the wild morphotype (Table 4) could be an evidence of fruits gathered from the wild, but most probably they represent wild or weakly domesticated individuals which were cultivated together with the fully domesticated forms. At Cetamura, ancient DNA analyses on grape pips evidenced the occurrence of grapevines which had genetic affinity with wild populations, but also displayed genetic similarities to domesticated Italian varieties. They could be hybrids of wild and domesticated vines (Wales et al. 2017). In Roman Mediterranean France pips of the wild-type have been identified in all the sites studied up to now, often in much higher proportions than in Cetamura (from 6.4 to 68.7%). This condition led to the hypothesis that these wild-looking pips could actually come from cultivated grapevines that have no equivalent in the modern domesticated compartment (Bouby et al. 2013).

Only weak chronological changes seem to occur in the cultivated diversity of grapes at Cetamura, which should be interpreted as an indicator of stability in viticulture economy from Etruscan to Roman times. These small changes seem to involve a slight diminution of the proportion of wild morphotype pips. Such a trend has been previously assessed in a Roman site in North-Eastern France, in a much different ecological context (Zech-Matterne et al. 2011).

As for viticulture and the cultivation of olives, cultivation of other trees or shrubs was a practice certainly advanced in the zone for several centuries. Little is known about the diffusion of domestic pine, a species with Mediterranean-wide territory, certainly undergoing cultivation in antiquity, but a spontaneous presence in the region is not to be excluded. Pine nuts are perhaps related to ritual practice. The species is documented in various contexts, including outside the natural area of growth or cultivation of the plant, in relation to a cult setting (see, for example, Megaloudi 2005 and Lodwick 2015). For its strong symbolic value, it was commonly used as an offering in Roman cremations (e.g., Bouby and Marinval 2004; Rottoli and Castiglioni 2011).

Especially important for reconstructing the history of the peach tree is the discovery of a peach pit in a stratum of the early Roman imperial period (*locus* 89.2; ca. 37–68 A.D.). This could be one of the earliest attestations of peach inasmuch as the cultivation of this tree, on the basis of the present state of knowledge (Sadori et al. 2009), was begun in Italy exactly in this century or a few decades before.

In the pollen spectra, *Juglans* and *Olea* were also discontinuously recorded. No remains of shell of walnut was recovered, although walnut wood was used for an artifact, a spatula, found in a stratum of the fourth–third century B.C. (*locus* 111).

Cereals were recorded by pollen grains (*Avena/Triticum* group and *Hordeum* group), which were more abundant during the Etruscan period (300–100 B.C.) than the Roman one (50 B.C.–68 A.D.) (Fig. 6), spikelet forks (*Triticum dicoccum*), caryopses (*Triticum dicoccum* and *T.* cf. *aestivum*/*durum*), and scarce amount of starch grains (Table 3). The latter could be residues of degraded caryopses or could point to the introduction in the well of different flours together with offerings, for example bread. The latter hypothesis is supported by the presence of starch grains with faded extinction cross and radiating fissures around the hilum which may be interpreted as damages due to processing. During previous investigations at Cetamura, caryopses of *Triticum dicoccum*, *T. aestivum*, and *Hordeum vulgare* were found in different contexts. *T. dicoccum* caryopses and husk were found in the dump outside the wall of the sanctuary on Zone II, suggesting its cultivation and processing around the site; caryopses were found in a ritual pit among the offerings on Zone II (Cottini 2009).

Urticaceae, Cheno-Amaranthaceae, Cichorieae, *Plantago* (pollen; Fig. 6) and *Bromus*, *Fallopia,* cf. *Lolium*, *Sambucus* sp. (seeds; Table 3) may be related to human frequentation and activities in the surrounding area. These plants were well represented during the Etruscan period, particularly in the second lowest sample of the well, and the early Roman Empire. The few weed plants are mostly indicative of winter sowing of cereals.

Plant offering?

Rather surprising is the sporadic record of abundant pollen grains belonging to plants generally poorly represented in the spectra. *Centaurea nigra* type pollen reached a peak (6.5%) in *locus* 110, in the lowest part of the stratigraphy (Fig. 6). Interestingly, a high amount of *Centaurea nigra* type pollen was found in a votive context at Parma (Bosi et al. 2011). The authors suggest that *Centaurea* and other wild flowers, could have been used for weaving garlands (see Ovid, *Fasti* I; Pliny, *Naturalis Historia* XXI). Pollen grains of *Crocus* (saffron) were discontinuously recorded at Cetamura, reaching a noticeable value (8.9%) in *locus* 90.1 (Fig. 6) belonging to the early Roman Empire period. *Asphodelus* pollen occurred in two samples of the late Etruscan period (Fig. 6), with significant abundance in *locus* 103.2 (3.2%). These values are hardly interpretable as the result of the natural pollen dispersal, but hint at an intentional introduction of flowers in the well. At present, these plants are growing in the Chianti woodlands and meadows, but their pollen has a short diffusion and it was not recorded in the current pollen rain. Consequently, the presence of these plants in the filling of Well #1 suggest the occurrence of ritual practices at the site. Further, the same fill contains various objects, some fragmentary and some whole and even precious, which indicate an intentional deposit reasonably connected with some ritual purpose (de Grummond 2017; Holland 2017). Even in light of this consideration, it is not definite that the presence of abundant pollen grains of showy flowers does not indicate occasional dropping. Moreover, it is difficult to establish which among the other botanical remains could have ritual origin. Most of the fruits and seeds from cultivated plants identified in Well #1 are common in Roman ritual contexts (e.g., Rottoli and Castiglioni 2011; Riso et al. 2018), especially pine nuts—even if they are also regularly found in domestic contexts—and it is likely that these food plant remains were used by man for ritual purposes. The state of preservation of the seed/fruit record, for the most part waterlogged, does not meet all the criteria used for attributing the plant remains to ritual offerings (Lodwick 2015), which include the recovery of all the food plant remains charred, even when their consumption does not require cooking, and they are not generally carbonized in the seed/fruit records of the archeological excavations. It is worth noting that in a previous study at Cetamura, numerous Rosaceae stones, olive stones, and grape pips which were interpreted as ritual offerings were found in a carbonized state of preservation or at least toasted (Cottini 2009). Therefore, we could argue that plant foods and flowers were brought to Cetamura for ritual purposes, and their presence at the site is attested to by remains found in the well, though it is not definitely clear whether they were introduced into the well as ritual offerings.

Conclusion

The huge amount of plant remains found in the Cetamura Well #1 resulted in a long list of plants (ca 130 taxa), providing a great amount of information about the flora of the region and the plants connected to human activities.

The different types of plant remains and their abundance concur in indicating the occurrence of a mixed oak forest with dominance of deciduous oak, probably similar to that of the present day. Over time, its composition could have changed, particularly around 150–100 B.C. when the main decline of deciduous *Quercus* was recorded, possibly as a consequence of forest clearances that principally affected this plant. Later, during the Roman period, climatic changes and/or human intervention could have provoked a diffusion of *Q. ilex*, a trend observed in Southern Tuscany from the third century B.C. to the end of the Roman Age (Buonincontri et al. 2013).

Regarding the human-plant relationship, the wood used for making the artifacts found in the well testifies to the technical skill and knowledge of the wood relating to plants that were available in the area. Crop cultivation is well documented by micro- and macroremains. The morphometrical analyses of grape pips, which were recovered in noteworthy amount (484 in total), clearly indicate grape cultivation. The occurrence of a small amount of pips displaying wild morphotype may be due to fruits gathered from the wild or, most probably, to wild or weakly domesticated individuals (perhaps hybrids too) growing in the vineyards. Cultivated grapes seem to undergo only limited changes from Etruscan to Roman times.

The presence of plants used as offerings or referable to ritual practices in the Well #1 is not completely clear, in spite of the presence of objects connected with some ritual purpose (de Grummond 2017; Holland 2017). A detailed analysis of the plant list and of their amount, particularly in pollen spectra, has suggested that the presence of some botanical finds, for example *Crocus* pollen, could be linked to rituals. On the other hand, the state of preservation of most parts of the seeds and fruits recovered in the well makes it difficult to consider them solely as ritual offerings. In fact, plant offerings are generally found in a carbonized state of preservation, as happened in other archeological contexts (Kislev 1988; Ciaraldi and Richardson 2000; Robinson 2002; Megaloudi 2005; Fiorentino and Caracuta 2010; Murphy et al. 2013; Lodwick 2015). Independent of the factors that produced the accumulation, it is clear that the study of the botanical material provides data on the environment, both natural and anthropogenic, the agrarian production, and the management of the territory even when it has been altered through cultural or religious choices. Data on the landscape and economy of Tuscany in the Etruscan era are still lacunose, because interest is relatively recent and excavations conducted in the previous century for the most part have paid attention largely to the cemeteries, indicating the presence of botanical remains only occasionally. For the Roman era, the studies of macroremains and of pollen that have dealt with these issues are more numerous, but the distribution of the data around the territory though wide is still very uneven (see Mercuri et al. 2015a; see the 192 sites in the database BRAIN online, https://brainplants.unimore.it/index.html). Every new study can add something to those already published as it is especially important for reconstructing agriculture, the cultivation of fruits, and the forest landscape before and after the Roman conquest. The joint use of micro- and macroremains and comparison of contexts of different types (residential or artisanal) can allow a better reconstruction of the economy of the site and can indicate more explicit choices made by the inhabitants (Sadori et al. 2010).

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