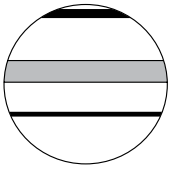

Research paper

The Holocene
2016, Vol. 26(4) 603–613

DOI: 10.1177/0959683615612567
hol.sagepub.com

The contribution of archaeological plant remains in tracing the cultural history of Mediterranean trees: The example of the Roman harbour of *Neapolis*

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Abstract

In this paper, we present a detailed record of the plant remains recovered on the palaeo-seafloors of *Neapolis* harbour, spanning ≈700 years, between the 2nd century BC and the 5th century AD, thus intersecting the entire Roman Imperial Age. The site preserved many cultivated or cultivable plant remains, especially from food related trees. This particular feature provided the opportunity to reconstruct the puzzling history of planting them and the Roman economy, especially with respect to food production, the market and to dietary habits. The evidence suggests that *Prunus persica, Castanea sativa, Juglans regia* and *Pinus pinea* were locally grown all along the investigated period, testifying for a well advanced arboriculture. A broad presence of *P. pinea* cones could be related to their large use as stoppers for amphorae which probably was among the driving force for planting it actually influencing its original range. The seafarers had extensive access to dry fruit such as walnut, hazelnut and chestnut that for its imperishable nature and the high energy density, would probably have been part of the food-stocks of the galleys. Chestnut consumption, attested throughout the entire period in the harbour, represents the first strong archaeobotanical evidence of chestnut as food in the Western Mediterranean in Roman time. This evidence shed light on the cultural-social significance of these fruits that was probably eaten mainly or almost exclusively by low social classes. The exceptional find of *Hyphaene thebaica* for the first time outside its native range is also reported.

Keywords

Castanea sativa, food, *Hyphaene thebaica*, Imperial Age, Italy, *Pinus pinea*, waterlogged remains

Received 22 May 2015; revised manuscript accepted 18 September 2015

Introduction

Mediterranean Basin has a long history of civilisation and unique cross-cultural development over the last millennia. This long history of human societies has strongly impacted landscape for so long that Di Castri (1981) refers to its as 'coevolution' of ecosystems and humans, and Blondel (2006) bears on it as 'design' of the Mediterranean landscape. The history of many Mediterranean trees is closely related to the interest that humans devoted to them with respect to their demands of fuel, timber, food, but also for ritual, marking boundary, medicine and so on. The development of agronomic competences together with the cultural and environmental diversities of the places contributed in shaping the landscape as a mosaic of different cultivated crop plants and trees.

The 'globalization' of Roman Age implied that plants moved throughout the empire assuming also different cultural significance and uses; both trades and cultivation in loco supplied all the demands of plant-based raw materials, and food.

In this perspective, the role of archaeobotany (namely the study of botanical remains from human-related context) becomes essential to assessing past plant landscapes and agricultural economies, because it provides direct evidence of all the issues relating to plants (e.g. Edwards et al., 2015; Mercuri et al., 2010, 2015; Sadori et al., 2010b).

Several ancient harbours, submerged sites and shipwrecks have been found along the coast of Mediterranean Sea, providing valuable data for ancient maritime, economic and naval history studies (e.g. Gianfrotta and Pomey, 1981; Keay and Boetto, 2010; Peña-Chocarro and Zapata Peña, 2003; Pomey and Rieth, 2005; Šoštarić and Küster, 2001). In recent decades, three ancient ports, spanning Roman times, have been discovered along the Tyrrhenian coast of Italy: the fluvial docking site of ancient *Pisae* and the maritime ports of Rome and Naples (Bruni and Cosci, 2003; Giampaola et al., 2006; Keay and Paroli, 2011).

The terrestrial nature of these excavations and the waterlogged preservation of the organic remains have proved to be particularly suited to archaeobotanical analysis and have opened up new perspectives in ancient harbour studies. Thus, besides classical

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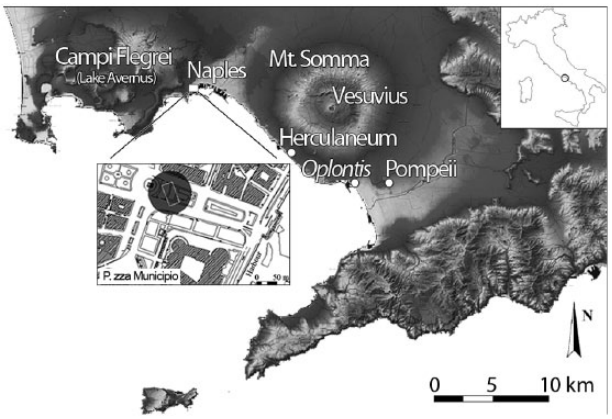

Figure 1. Study area: the harbour of *Neapolis* at Piazza Municipio (Naples) and main sites cited in the text.

archaeological studies, a major role has been played by multidisciplinary work involving palynological (Bellini et al., 2009; Benvenuti et al., 2006; Russo Ermolli et al., 2014; Sadori et al., 2010a) and archaeobotanical research, such as the study of plant remains (Bertacchi et al., 2008; Mariotti Lippi et al., 2007; Pepe et al., 2013) and the wooden elements of several ships (Allevato et al., 2010; Giachi et al., 2003). A recent synopsis, reporting also some preliminary results concerning plant remains from the *Neapolis* harbour (Sadori et al., 2015), highlighted the importance of such works in contributing to the reconstruction of natural and cultural landscapes of the past.

In this paper, we present the study of the plant remains from the Roman harbour of *Neapolis* discovered in 2003 in Piazza Municipio, few hundred metres behind the present-day docks (Figure 1). Here, several macroscopic plant remains were recovered on the palaeo-seafloors of *Neapolis* harbour spanning almost 700 years between the 2nd century BC and the 5th century AD.

The harbour represents an example of preventive archaeology in which, besides standard excavation work, a significant amount of work has been done also in geomorphological (Amato et al., 2009; Carsana et al., 2009), palynological (Russo Ermolli et al., 2014) and archaeobotanical studies (Allevato et al., 2010). The entire sedimentary succession, about 6 m thick, is chronologically well constrained by numerous datable archaeological artefacts, between the 3rd century BC and the 6th century AD when the site was progressively and definitively buried because of overfill (Amato et al., 2009; Carsana et al., 2009; Giampaola et al., 2006).

Although the presence of *Neapolis* harbour on the site in question was hypothesised by several authors as early as the 19th century, the evidence of its existence and extent was never proved before the recent archaeological excavation (Carsana et al., 2009; Giampaola et al., 2006). Historical sources (Capasso, 1905) and recent archaeological finds (Giampaola et al., 2006) have extensively documented the prosperity of this harbour and the wealth of its trade. The onset of harbour activity dates back to the end of the 4th century BC, and evidence of dredging testifies to the regular maintenance of the harbour basin until the 2nd century BC. Thereafter, the sea floor was only sporadically dredged in order to keep the water depth suitable for ship transit (Amato et al., 2009; Carsana et al., 2009).

Study area

Naples is located within the graben structure of the Campania plain which developed between the western sector of the Apennine chain and the eastern margin of the Tyrrhenian Sea. Two volcanic areas, spaced less than 10 km apart, are situated at the boundaries of the Naples area: the volcano Mt. Somma–Vesuvius and the volcanic district of the Campi Flegrei (Figure 1).

The climate is Mediterranean, humid type. Mean minimum temperatures never fall below 0°C. The coldest month is February (mean $T = 8.5$°C), while the hottest is August (mean $T = 24.1$°C). Cumulated mean annual precipitation is 1012 mm, with a maximum in November (152 mm) and a minimum in July (24 mm).

The city of Naples is extensively built-up: native and alien woody vegetation is restricted to the slopes of the Somma–Vesuvius complex and the Phlegrean craters, while a few patches of relict native vegetation are also present on the hills behind the town. Mixed mesoxerophilous forest dominated by *Quercus pubescens* Willd. and *Castanea sativa* Miller partially cover the northern and the less steep slopes. *Quercus ilex* forest stands and Mediterranean evergreen sclerophyllous shrubs occupy the southern slopes and the Phlegrean craters at the western border of the town (Mazzoleni, 2001). Farmland activity still persists on traditional man-made terraces known as *ciglionamenti* (Tarolli et al., 2014).

Material and methods

Archaeobotanical research on Italian sites is rather scarce and not systematic, above all in those contexts where artefacts are abundant and for those historical periods for which literary sources do exist. Moreover in rescue archaeology, archaeologists 'run behind the bulldozers' trying to make rapidly and with limited financial resources the best before the site gets destroyed (Demoule and Landes, 2009). In this respect, the *Neapolis* harbour represents an emblematic example of that, since archaeobotanical studies were considered subsidiary to archaeology and a sampling strategy for plant materials was not planned in advance.

In this excavation, being a rescue archaeology intervention, archaeologists focused their sampling efforts on areas where they were able to see the botanical remains (mainly seeds and fruits) with naked eye. A total of 425 samples spanning seven centuries from the 2nd century BC to the 5th century AD were recovered from 25 archaeological layers chronologically well constrained between the end of the second half of the 2nd century BC and the end of the 5th century AD along ~6 m of the sedimentary succession (Figure 2) (Amato et al., 2009; Carsana et al., 2009; Giampaola et al., 2006). A moderate amount of sediment ranging between ~30 and 50 mL was present in all the storage boxes associated with the sampled visible remains; thus, recovering of additional small-sized plant remains was performed in the laboratory by dry sieving with a mesh of 0.5-cm size of these sediments. The plant remains were classified according to their macromorphological traits, atlases and the specialised literature (Cappers et al., 2006; Gellini and Grossoni, 1996; Pignatti, 1982), and compared with the reference collection at the Laboratory of Vegetation History and Wood Anatomy at the University of Naples Federico II, living plants and herbarium specimens. The specimens were counted, whole plant remains (individuals) and fragments being distinguished. When more than half of the fruit or of the seed was present, it was considered whole and counted as individuals.

Since the assemblages cannot be considered fully representative, the data are here examined with a mostly qualitative approach, and bias due to the sampling methodology is well taken in account.

Results

Due to the extraordinary preservation state of the remains and the well constrained chronology, the data, although biased by unconventional sampling procedure, greatly contribute in the knowledge on food habits and trades. A total of 16 taxa wholly ascribable

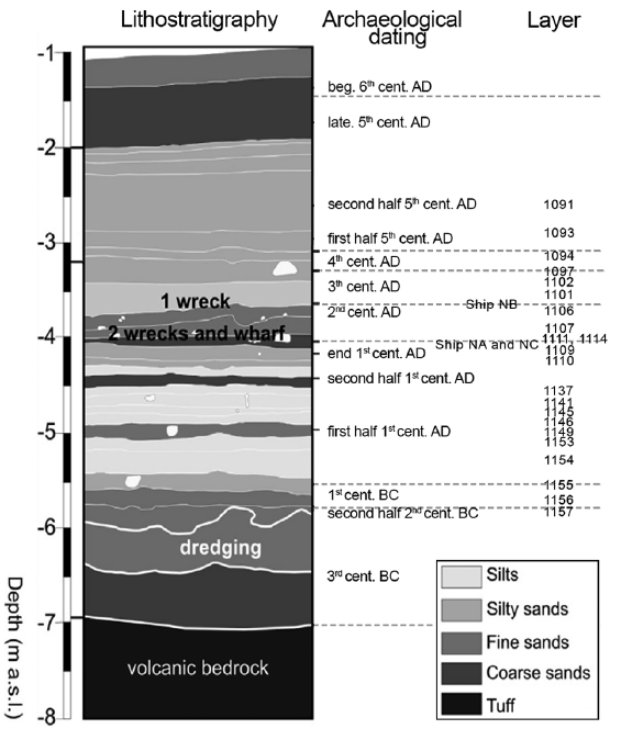

Figure 2. Details of a section exposed in the Municipio excavation. Lithostratigraphy is after Amato et al. (2009); archaeological dating follows Giampaola et al. (2006).

to tree species (apart from the endemic steno-Mediterranean marine species *Posidonia oceanica*) were identified. The absolute count of the archaeobotanical remains according to their layer of recovery and the relative chronology (Figure 2) is reported in Table 1, and the kind of remains according to the organ of the plant is also indicated.

The assemblage includes mainly arboreal species, mostly related to fruit production.

Food-related *taxa* are widely represented until the end of the 5th century AD by *Prunus persica* (Figure 3b) and *Juglans regia* (Figure 3d) that both appear in the first decades of the 1st century AD, *Corylus avellana* (Figure 3e), starting at the low boundary of the 1st century AD, and *Castanea sativa* (Figure 3c), early appearing since 1st century BC. *Olea europaea* (one stone in the 2nd century AD) and *Vitis vinifera* (three pips in all, two in the 5th century AD and one in the 2nd century AD) are less widely represented. At the same time, very few stones (respectively two and one) of *P. dulcis*, and *P. avium/cerasus* were recovered in the layers dated after the second half of the 2nd century AD.

Pinus pinea is the most commonly represented *taxon* and it was present during the whole period considered as testified by cones (Figure 3a.1), cone scales, seeds (Figure 3a.2) and outer bark fragments (Figure 3a.3). Cones belonging to *P. halepensis* and *P. pinaster* (Figure 3f) were found in the 1st century AD. Two cones of *Cupressus sempervirens* were recovered respectively in 2nd century BC and 5th century AD layers. One *Quercus* sp. nut was found in a layer dated to the end of the 2nd century AD, beginning of the 3rd century AD. The recovery in a 1st century BC layer of one mesocarp of *Hyphaene thebaica* (Figure 4) is singular given that it is an exotic palm species.

Discussion

The origin and the significance of the remains

The site preserved plant remains which can be mainly classified as cultivated or cultivable crops (Table 1). Wild plants are nearly absent probably because of the little size of most of the weed seeds, which was probably loss. Of interest is the first recovery outside Africa of the palm *H. thebaica* in a 1st century BC layer, whose economic value is mainly related to what is known as 'vegetable ivory' from the endocarp and less to food. In most of the remains (*C. avellana, O. europaea, V. vinifera, P. dulcis, P. avium, P. persica, C. sativa* and *J. regia*), the economic value is related to their use as food.

In this respect, although the assemblages cannot be considered fully representative, the macroremains from the harbour of *Neapolis* constitute a good opportunity for reconstructing the Roman food economy, especially with respect to food production, the market and to dietary habits, given that, in the other ancient ports mentioned above, wild flora is represented either predominantly at *Pisae* (Bertacchi et al., 2008) or exclusively at Rome (Pepe et al., 2013).

As regards the origin of the recovered remains, we may hypothesise that they were probably accidental spills from port loading or unloading operations or in part may have realistically been thrown down of rubbish including mainly food left over from crew meals and seafarers. The evidence of chiefly cracked shells of *C. sativa, J. regia* and *C. avellana*, presumably to extract the edible part, strengthens this latter hypothesis.

With respect to geographical origin, since there was an extensive well-established maritime trade network in the Roman world, distinguishing whether the remains found in the harbour are imports or they came from local cultivation is often very difficult. In this respect, the pollen record from the *Neapolis* harbour sediments (Russo Ermolli et al., 2014), showing a strictly overlapping chronology with the macroremains, might be considered a useful resource to assess their local presence in the landscape. However, since the pollen catchment area of the harbour bay is very restricted (~3 km^2, Russo Ermolli et al., 2014), the pollen sequence mainly represents the vegetation in the near surroundings of the harbour close to the ancient urban area of Naples, and only a smaller amount of pollen may be considered as wind- or current-borne from further away.

Apart from tree species, no small-sized remains such as those of herbaceous plants are detected. This is probably affected by the non-systematic sampling strategy which did not allow the fully representative recovery of plant macroremains of different size category (Antolín et al., 2013; Van der Veen and Fieller, 1982). That said, it is conceivable that taxa with small-sized remains could be underrepresented as the case of *V. vinifera*. The grape pips preserved in the waterlogged sediments may have been the leftovers of consumed fresh or dried fruits. However, it may be safely assumed that grape cultivation was chiefly aimed at wine production, which was a well-established practice in Roman Campania (Allevato et al., 2012 and references therein).

O. europaea, P. avium/cerasus and *P. dulcis* are very scarce throughout the period, but we should exclude the possibility of underrepresentation due to hand picking because of the relatively big size of these remains which keeps them well visible to the naked eyes and the ligneous feature of hard stones and nutshells which keeps them well preserved (Hopf, 1991).

Cultural and economic significance of forest products

Remains belonging to four coniferous tree species were found: *C. sempervirens, P. halepensis, P. pinaster* and *P. pinea*. Two female wood cones belonging to *C. sempervirens* were found in the sediments respectively dated to the 2nd century BC and the 5th century AD.

C. sempervirens was believed to be cultivated in Italy since Etruscan times (Pignatti, 1982; Quézel and Médail, 2003), and gradually this tree has become a characteristic element of the cultural landscape (Di Pasquale et al., 2004). At Pompeii, the

Table 1. Absolute frequencies of waterlogged plant remains from *Neapolis* harbour according to their layer of recovery and the relative chronology.

		Taxon	*Cupressus sempervirens*	*Pinus pinea*			*Pinus cfr halepensis*	*Pinus pinaster*	*Corylus avellana*			*Juglans regia*			*Castanea sativa*			*Olea europaea*	*Vitis vinifera*	*Prunus persica*		*Prunus amigdalus*	*Prunus avium–cerasus*	*Cfr Malus*	*Hyphaene thebaica*	*Quercus* sp.	*Posidonia oceanica*	Sum entire	Sum fragment
		Part of plant	c	c	sc	s	b	c	c	p	f	ca	p	f	ca	p	f	ca	s	s	e	f	e	e	l	e	s	a		
Century	Chronology	Layer	Absolute count																											
5th AD	2nd half 5th cent. AD	1091		2	2	9					6					2	2	1			2								17	9
	1st half 5th cent. AD	1093	1	6	50	3	1			2	12	1		18	2		25	1			59	3		1				5	127	62
4th AD	2nd half 4th cent. AD	1094			15	7				2	2				1	1	44	1		2	17	2							44	50
3rd AD	End 3rd–beg. 4th cent. AD	1097		5	22	12				3	12	1	3	13	1	2	62	2			27	4	1						75	95
	End 3rd–beg. 4th cent. AD	1102																			40	2							40	2
	Beg. 3rd cent.	1101		5	22	20					3		1	11		3	67	9							1				52	90
2nd AD	End 2nd–beg. 3rd cent. AD	Ship NB		1																									1	
	2nd half 2nd–beg. 3rd cent. AD	1106		2	18	10				5	36			34		2	68	11		1	53						1	3	95	149
	2nd half 2nd cent. AD	1107		1	39	27					2										2		1						70	2
1st AD	End 1st cent. AD (up to AD 150)	1111									1						14													15
	End 1st cent. AD (up to AD 80)	1114												1			3													4
	End 1st cent. AD	Ship NA		1																	2								3	
	End 1st cent. AD	Ship NC								7	7						7		1										8	14
	First half 1st cent. AD (AD 30–100)	1109			6	3					1						14	1											9	16
	First half 1st cent. AD (AD 30–100)	1110																			2								2	
	First half 1st cent. AD (AD 20–60)	1137												1			5													6
	First half 1st cent. AD (AD 20–60)	1141									1			1																2
	First half 1st cent. AD (AD 20–50)	1145		2	10	10			1		1						8												23	9
	First half 1st cent. AD (AD 20–50)	1146						1			1										1	1							2	2
	First half 1st cent. AD (AD 10–50)	1149		2	12	11																							25	
	First half 1st cent. AD (AD 10–50)	1153									1					1	2				3								4	3
	First half 1st cent. AD (AD 14–37)	1154			7	1		1	1								2												10	2
1st BC	End 1st BC–beg. 1st cent. AD (15 BC–AD 15)	1155		1	7	6					1							4											14	5
	End 1st cent. BC	1156																								1			1	
2nd BC	2nd half 2nd cent. BC	1157	1	3	26	3																							33	
		Sum	2	31	236	122	1	2	2	19	87	2	4	79	4	11	323	30	1	3	208	12	2	1	1	1	1	8	655	537

c: cone; sc: scales; b: bark; p: pericarp; f: fragment; ca: cast; e: endocarp; s: seed; a: aegagropyl.

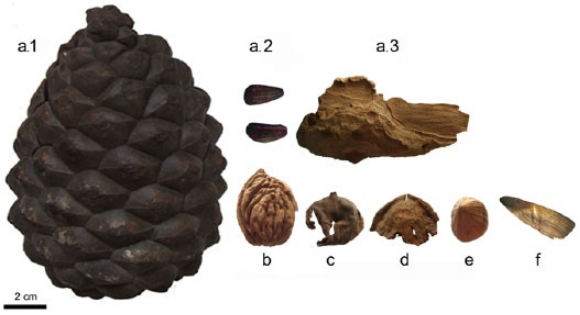

Figure 3. Waterlogged plant remains from *Neapolis* harbour: (a) *Pinus pinea* 1 – cone, 2 – seeds, 3 – outer bark; (b) *Prunus persica*: endocarp; (c) *Castanea sativa*: pericarp; (d) *Juglans regia*: pericarp; (e) *Corylus avellana*: pericarp; (f) *Pinus pinaster*: seed.

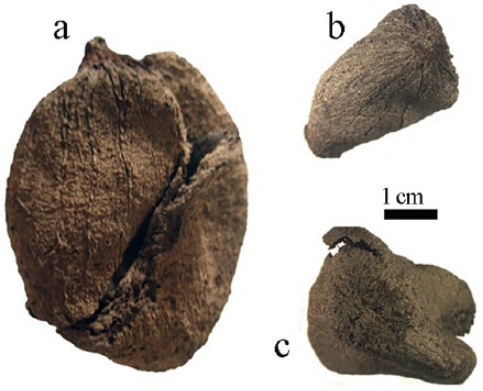

Figure 4. *Hyphaene thebaica*: mesocarp cylindrical-ovoid, fibrous, 5.2 cm × 3.9 cm: (a) front view, (b) top and (c) bottom view.

presence of cypress is attested both in urban environment (Murphy et al., 2013) and in a rural villa where cone scales and leaves were used to prepare a drug (Ciaraldi, 2000). In the Vesuvius district, clear evidence does exist for cypress cultivation, probably for timber production, in the eastern Vesuvian area where several stumps, planted in a quincunx spatial pattern, were found under the AD 79 eruption deposits (Ruggiero, 1879). In the same area, at Herculaneum, cypress is the second most widely used tree for the rafters of the roofs (Moser, personal communication). Cypress was also used ornamentally in some Pompeii gardens (Jashemski, 1979; Ruggiero, 1879). The two cones found on the palaeo-seabed at *Neapolis* could be probably related to the presence of a tree plantation close to the port.

The recovery of all the 'Mediterranean' pines (*P. pinea, P. halepensis* and *P. pinaster*) also deserves mention.

Two cones of *P. halepensis* and two cones of *P. pinaster* were found among 1st century AD deposits. Both the pines were employed in the naval shipyards of Naples (Allevato et al., 2010). As in the case of cypress, these cones could also be related to trees growing in the harbour area. However, their presence related to human consumption could also be taken into account; indeed, *P. halepensis* cones/seeds are today of interest throughout Tunisia and other Arabic countries because its seeds are used for many consumption purposes both in terms of food and drinks (Fekih et al., 2014).

P. pinea was the most frequent plant species found during the investigated period. It is widely represented by seeds, cones, cone scales and bark fragments as well. Currently, stone pine has a scattered distribution throughout the Mediterranean Basin covering ca. 650,000 ha from sea level up to 1000 m (Quézel and Médail, 2003). This large area is the result of ancient cultivation starting at least 3000 years ago (Martìnez and Montero, 2004; Prada et al., 1997). With regard to our study area, evidence for the existence of pine stands was found on the slopes of Mt. Somma where both charred trunks and cones were found in a natural context in AD 79 volcanic products (De Fiore, 1916). Hence, a local origin of the remains from the harbour is quite conceivable. Stone pine macroremains have been found throughout the Mediterranean area (e.g. Bouby and Marinval, 2004; Robinson, 2002; Rovira and Chabal, 2008), even in northern Europe (Bakels and Jacomet, 2003; Zach, 2002), in Egypt and in England (Kislev, 1988; Willcox, 1977). Besides several attestations of its use in human nutrition, the cones have often been found in sacral contexts where it was related to cult practices (Kislev, 1988; Van Zeist, 1991; Willcox, 1977). The widespread use of stone pine both for food and sacred offerings is well attested also in the Pompeii area (Ciaraldi, 2000; Jashemski et al., 2002; Meyer, 1988; Robinson, 2002). The presence of cones both in Mediterranean ancient harbours and in wrecks is very widely documented (Gianfrotta and Pomey, 1981; Girard and Tchernia, 1978; Peña-Chocarro and Zapata Peña, 2003; Ramsay, 2010), demonstrating that cones were actually traded. Several cones found on the *Albenga* wreck (Liguria, 1st century BC) were used as plugs for wine amphorae (Arobba et al., 2014; Lamboglia, 1952). Interestingly, these amphorae came from the central-southern Tyrrhenian area and the ship was carrying several goods from Campania (Pallarés, 1983). The recovery in the harbour of Naples attests a continuous use throughout the investigated period, and given the need to maximise efficiency when shipping goods (Twede, 2002), whole pine cones are unlikely to have been transported to have their seeds extracted as food once they reached their destination, especially since as much as ~50 kg of cones are needed to extract ~10 kg of seed (Bernetti, 1995). The use of the cones for sealing amphorae seems a more realistic functional hypothesis at least during the period of use of the *Dressel 1* wine amphorae, for which there is clear archaeological evidence attesting their plugging with stone pine cones (Arobba et al., 2014).

We hypothesised that they might have fallen into the sea during or before the operations of plugging amphorae. This latter hypothesis is consistent with Roman transport practices because wine would have been taken to the port in skins and transferred into amphorae there (Twede, 2002). Also for the bark of pine (*Pinus* sp.) a strong attestation does exist for its use as amphora stoppers on the southwest coast of Turkey (Gorham, 2000).

To sum up, it seems that the use of pine cones and bark for sealing amphorae should be added to most noted uses such as food, timber, ornamental and ritual (e.g. Kislev, 1988; Meiggs, 1982; Richardson, 2000). In this respect, it seems interesting that all the places where *P. pinea* is considered probably native, overlap with ports of the main ancient naval routes (Bernetti, 1995); thus, the demand of the cones in commercial harbours was probably a further driving force for it to be planted along the seashores besides the old hypothesis of timber requirement for shipbuilding formulated by Zangheri (1965) and Giacomini (1968).

Among the remains, a large number of prevailing cracked hazelnut (*C. avellana*) shells were regularly found between the first decades of the 1st century AD and the first half of the 5th century AD. At present, *C. avellana* characterises the understorey of broadleaf forests between 0 and 1700 m a.s.l. in Campania and throughout Italy (Pignatti, 1982). In prehistoric times, it represented a common food resource because of its availability in the wild, while in Roman times it was certainly cultivated in several varieties (Zohary and Hopf, 2000). In this respect, it is intriguing that the specific Latin epithet *Avellana* already attested by Cato the Elder (1st century BC) could come just from *Avella*, a town in the northern Vesuvius area (Meyer, 1988) where hazelnut cultivation is still today one of the main sources of farm incomes. However, *Abellana* is also said to be derived from Abellina in Asia

(likely the present valley of Damascus), which Pliny the Elder believed was the origin of hazelnuts (Rosengarten, 2004).

In the Vesuvius area, some fragments of fruit shells and casts formed by the hardened volcanic ash were found in Pompeii and in a *villa rustica* close by (Jashemski, 1993; Meyer, 1988), and a few shell fragments were recovered in the urban area of Pompeii among food waste (Murphy et al., 2013). Evidence of trade in hazelnuts from Campania and/or Latium comes from a Roman *navis oneraria* (1st century BC, Albenga, northern Tyrrhenian area) where several nuts were recovered in an amphora from the hold (Arobba et al., 2014). Also on the coast of north-western Tuscany, in the port of *Pisae*, whole nuts are recorded between the 1st century BC and the 2nd–3rd century AD (Bertacchi et al., 2008). At our site, the prevailing of cracked shells indicates that these fruits were consumed by sailors, suggesting ordinary usage.

J. regia is widely present from the beginning of the 1st century AD. Its cultivation is attested by frequent botanical remains in European countries, especially from the Roman Age onward, and because these remains generally consisted of fruits this tree was commonly considered by scholars exclusively for fruit production (Zohary and Hopf, 2000). In ancient Campania, *J. regia* nutshells were also found in Pompeii among the most frequent fruits (Murphy et al., 2013) and also as offerings to the gods and for medicinal preparations (Ciaraldi, 2000; Meyer, 1988; Robinson, 2002). As in the case of hazelnut, the large number of cracked shells suggests their consumption *in loco*. Given that, in the harbour, walnuts constituted common food for seafarers, we can infer that these fruits were easily accessible. It is worth pointing out that, in this area, the tree provided raw material both for furniture (Mols, 2002) and for shipbuilding (Allevato et al., 2010). These data strongly suggest that here *J. regia* was cultivated for both food and timber, and the tree may well have been widely cultivated. Still today, *J. regia* is one of the main tree crops in the region, with a traditional local cultivar being grown. Intriguingly, in the Etruscan town of Pontecagnano, ca. 50 km south of Naples, intensive cultivation began from the 3rd century BC (Russo Ermolli et al., 2012) while pollen records in Western Europe show a very later onset of cultivation, during the Imperial Roman Age (Conedera et al., 2004).

Finally, the most interesting finding is represented by several fruit shells from edible chestnut (*C. sativa*) in the harbour sediments from the end of the 1st century BC to the 5th century AD because *Neapolis* harbour is the first site documenting systematic chestnut consumption as food throughout the entire Imperial Age. This strong evidence of fruit consumption constitutes a *unicum* in Roman Age and predates much of the Carolingian Middle Ages when chestnut actually became a major food resource (Buonincontri et al., 2015).

Chestnut showed more than other trees a great geographical complexity both in its biogeographical and cultural history, and the study of archaeobotanical remains greatly helped to trace the timing and the routes of chestnut–human interactions (e.g. Allevato et al., 2012; Buonincontri et al., 2015; Di Pasquale et al., 2010; Mercuri et al., 2013).

The most recent findings, mainly based on the direct evidence of botanical remains (charcoal, Allevato et al., 2010; charcoal and fruits, Buonincontri et al., 2015; pollen, Conedera et al., 2004; Mercuri et al., 2002) seems to rework the traditional believing that chestnut was introduced and then diffused from Roman time, and above all it seems refuted the conviction that fruit production was the driving reason for its earliest planting. In this respect, it is interesting to note that throughout Roman Age quite frequent evidence exists for the use as timber but fruit remains are almost absent in both Northern Europe (Livarda, 2011; Van der Veen et al., 2008) and in the Mediterranean area (Hopf, 1991).

Even throughout the entire Vesuvius area, Di Pasquale et al., (2010) and Allevato et al., (2012) documented a massive use of chestnut timber between the 1st century BC and the 4th century AD, but only two chestnut fruits were found in 'Villa A' at *Oplontis* (Borgongino, 2006) and no one was found in Pompeii, where extensive archaeobotanical studies have been carried out (Murphy et al., 2013). The absence of fruit remains has been interpreted to the difficulty of preserving the thin pericarp (Greig, 1996) or perhaps because of the use of pericarps for burning (Bandini Mazzanti et al., 2005). To this point, the presence of chestnut fruit in the harbour could be probably related to the waterlogged condition of the site, but accurate critical review of the literature relevant to archaeobotany shows that chestnut fruit is absent even in similar waterlogged depositional environments all along the Roman Age (Buxò i Capdevila, 2005; Peña-Chocarro and Zapata Peña, 2003; Ramsay, 2010; Van der Veen et al., 2008; Willcox, 1977). Few fragments, dated to the Imperial period, come also from the port of *Pisae* (Bertacchi et al., 2008), reinforcing the idea of chestnut consumption in Italy, but also highlighting that regular consumption of chestnut fruit must be considered a local feature in Campania.

This evidence highlights the peculiarity of the finding at *Neapolis* and suggests that chestnut was a well known resource both in terms of wood/timber (Allevato et al., 2012) and fruit in ancient Campania. This peculiarity could be due to an earlier man–chestnut interaction related to the supposed existence of a refuge area for this tree at the northern slope of Mt. Vesuvius (Di Pasquale et al., 2010).

Their presence confined to the harbour area is probably related to the restricted consumption of this food by seafarers and dockworkers. The scarce presence on the markets and the fact that chestnuts were destined mainly for low social classes should agree with the low appreciation for this fruit in the Roman world. Indeed, although references to the chestnut in classical literature are frequent, neither Latin nor Greek authors praised the properties of the chestnut as food considering it indigestible.

On the whole, it seems that dry fruit such as walnut, hazelnut and chestnut is a well-represented category of remains in the harbour. Considering their imperishable nature and also the high energy density of this food (Brufau et al., 2006), all these nuts could be part of the food-stocks of the galleys or part of the dockworkers' diet. The presence of them all – even if chestnut is very scarce – also in the harbour of Pisa (Bertacchi et al., 2008) could further reinforce this hypothesis.

Orchards

The scarcity of olive fruit in the harbour does agree with archaeobotanical data at regional scale: in Pompeii, olive stones are poorly represented (Di Pasquale et al., in press; Meyer, 1988; Murphy et al., 2013; Robinson, 2002); at the same time, on the northern side of Mt. Vesuvius (Mt. Somma), in the so-called Villa of Augustus, olive is scarcely sampled (collected or detected) both in the charcoal and in macroremains (Allevato et al., 2012). Here, the highly fertile andic Vesuvius soil was probably intended to cultivate higher-income crops like the grapevine (Allevato et al., 2012). To sum up, although selection and cultivation of the olive by the Romans are well documented by numerous historical sources (see Meyer, 1988), the archaeobotanical evidence seems scarce.

Two interesting cases of the use of olive wood come from this area: young olive branches were used to weave a basket for fishing found in the *garum* factory in Pompeii (Di Pasquale et al., in press) and pruning residues of olive were probably used as pins in the ship Napoli B (Allevato et al., 2010). This scarcity both in macro- and microfossils suggests that few olive stands were probably present in the area, agreeing also with the evidence of the large-scale arrival of olive oil from northern Africa (Arthur, 1985; Arthur and Williams, 1992; Savino, 2005). In this respect, it is

important also to stress that the literary sources should be used with caution because ancient agrarian writers did not aim to give a comprehensive description of production and concentrated on special crops such as vines and olives probably just because the production of these 'luxury' items was an elite activity (Lomas, 1993).

Three species belonging to the *Prunus* genus were found: cherry – *P. avium*/*cerasus*, almond – *P. dulcis*, and peach – *P. persica*, of which only peach is well represented along the whole chronology, while almond and cherry are very scarce. Sweet or sour cherry is found at *Neapolis* in only one sample in the 5th century AD, which is consistent with the very scant evidence of consumption of this fruit in the Vesuvius area, where it seems that its ornamental value in gardens played a greater role (Jashemski et al., 2002; Meyer, 1988; Moser et al., 2013; Murphy et al., 2013). Also on the Tyrrhenian coast of central Italy, at the harbour of *Pisae*, endocarps of cherries were recovered in small amounts comparable with those of *Neapolis* (Bertacchi et al., 2008) while in northern Italy (Parma), cultivated cherry was recovered only from the Middle Ages onward (Bosi et al., 2011). This concordance in the data could confirm that cherry was not widely grown during the Roman Age in Italy. Rather, it seems more common in the northern part of the Empire. Indeed, it constituted very common remains in the Roman harbour of Oiasso (present-day Irun) on the Atlantic coast of Spain (Peña-Chocarro and Zapata Peña, 2003), which according to Parker (1973) exported cherries together with other goods. During the Imperial Age in central Europe, the cherry was undoubtedly cultivated and usual fruit consumption is attested in all social classes (Bakels and Jacomet, 2003).

The almond was one of the earliest fruit trees to be domesticated in the Old World (Zohary and Hopf, 2000) and, according to the classical authors, it was a highly prized food on Roman dinner tables, but the scarcity in the layers of *Neapolis* (only one find in the 2nd century AD) could suggest that trade and consumption of this fruit was uncommon in this area. An alternative explanation could be related to the previously supposed origin of the macroremains on the sea bed as food waste from seafarers and therefore, this scarcity could suggest that almonds were a precious food not available to low social classes like sailors. However, the data from Herculaneum and Pompeii (Meyer, 1988; Murphy et al., 2013; Robinson, 2002) confirm the moderate presence of this fruit at least in the Vesuvius region and reinforce the hypothesis of a scant presence of almonds among the eating habits of this area. However, broadly speaking, it seems that cultivation and trade was probably not very widespread. Indeed, almond is also absent in the assemblage of Pisa harbour (Bertacchi et al., 2008), and remains have rarely been found from the Roman period, either in Italy (Mazzanti Bandini et al., 2000), the rest of the Mediterranean area (Peña-Chocarro and Zapata Peña, 2003) or in Northern Europe (Bakels and Jacomet, 2003). *P. persica* appears among the most common remains in the harbour from the early decades of the 1st century AD, between AD 10 and 50, which could pre-date the introduction of peach into Italy with reference to the date of AD 40 given by Pliny the Elder in his *Naturalis Historia.* The peaches at *Neapolis* are the oldest remains found in Italy together with those at Modena (AD 15–40) and those from the Angera and Manerbio necropolis in northern Italy (29 BC–AD 37) (Sadori et al., 2009). Concerning the source of these remains, a first general consideration can be made on the perishable nature of these fruits, which could exclude trade from distant areas. However, the historical sources mention transporting peaches over long distances by preserving them using various techniques like drying or storage in amphorae in honey or wine (Andre, 1981; Callender, 1965; Willcox, 1977). The existence of an effective transport system for peaches is further confirmed by the recovery of peach stones in a shipwreck dated to the 1st century AD (Buxó i Capdevila, 2005) with its supposed route between France and Spain (Nieto and Picon, 1986); some support for its trade is provided also in northern European sites (Livarda, 2011). Peach stones have also been found in ports such as *Pisa*e (Bertacchi et al., 2008) and Irun in Atlantic Spain (Peña-Chocarro and Zapata Peña, 2003); peach was even found in the military port of Velósen on the North Sea in the early 1st century AD where it must have been an imported foodstuff (Bakels and Jacomet, 2003). In Italy, the recovery of peach stones related both to human consumption in ordinary usage and to funerary/votive offering, is frequent from the second half of the 1st–2nd century AD onward, testifying that this fruit was appreciated and widespread among Romans (Sadori et al., 2009 and references therein). Even in the southern part of central Europe, peach was one of the more widespread fruits and probably cultivated *in loco*, while in the north it was found exclusively in connection with military sites as an imported good, representing a luxury product consumed, most probably, only by officers (Bakels and Jacomet, 2003).

In ancient Campania, peach stones were found at Pompeii where these appear in scarce amount both in urban and rural contexts (Ciaraldi, 2000; Robinson, 2002); in the city of Pompeii, from an entire insula only 26 stones were found (Murphy et al., 2013); here, the interest in this fruit on the part of wealthy Romans is also indicated by a fresco from Herculaneum dated to ca. AD 62–79 (Jashemski et al., 2002).

The presence of fruit remains in a range of different anthropic contexts suggests that these fruits were part of the Roman way of life and were widely consumed. The abundance of stone remains in the harbour is certainly related to the texture of these remains and its high preservation rate; however, the high number of stones could indicate that in Naples this food was probably accessible also to the lowest social levels such as seafarers. Therefore, we regard peach not as an imported luxury food and suggest it may have been locally grown.

H. thebaica (L.) Mart

The exceptional occurrence of a single endocarp of doum palm, *Hyphaene thebaica* (= *H. sinaitica* Furtado), from the 1st century BC was unexpected. Being one of the most distinctive palms for its regular branching habit (Figure 5), *H. thebaica* is native to northern and north-eastern Africa from Egypt to Somalia (Thulin, 1995), where it is widespread in coastal areas, oases, gullied slopes and wadis on alluvial, sandy and gypseous soils (Boulos, 2005; Riffle, 2008). The doum palm is also recorded in the Arabian peninsula and Israel, likely as a result of ancient cultivation. In Yemen, it is the most characteristic tree in gardens of the older Tihama towns (Wood, 1997). Furthermore, according to Dransfield (1986) the frequent records of *H. thebaica* in eastern Africa are due to confusion with *H. compressa* H. Wendl.

The doum palm is at present an important species for local farmers who harvest the fruit for food, the foliage for local crafts, the stem for construction material (Lucas, 1962), and the roots for medicinal use (Edwards et al., 1997; Trotter, 1915). A long record of utilisation is reported in ancient Egypt (Riffle, 2008), where the species is used in traditional medicine for treatment of hypertension and a soft drink is obtained from the fruits (Boulos, 2005; Hetta et al., 2005).

The doum palm was sacred to the Ancient Egyptians, with seeds recovered in several tombs of the pharaohs (El-Gendy et al., 2008; Hetta et al., 2005), and was cultivated in gardens as early as 1800 BC (Jones, 1995). Although *Hyphaene* has several archaeobotanical records from the Palaeolithic in Egypt (i.e. Cappers, 2006 and references therein; Tomlin, 1992 and reference therein), its fruits have never been found outside the African continent.

In its area of origin, it seems that *H. thebaica* was not an attractive food for the Romans. A large amount of its fruit was

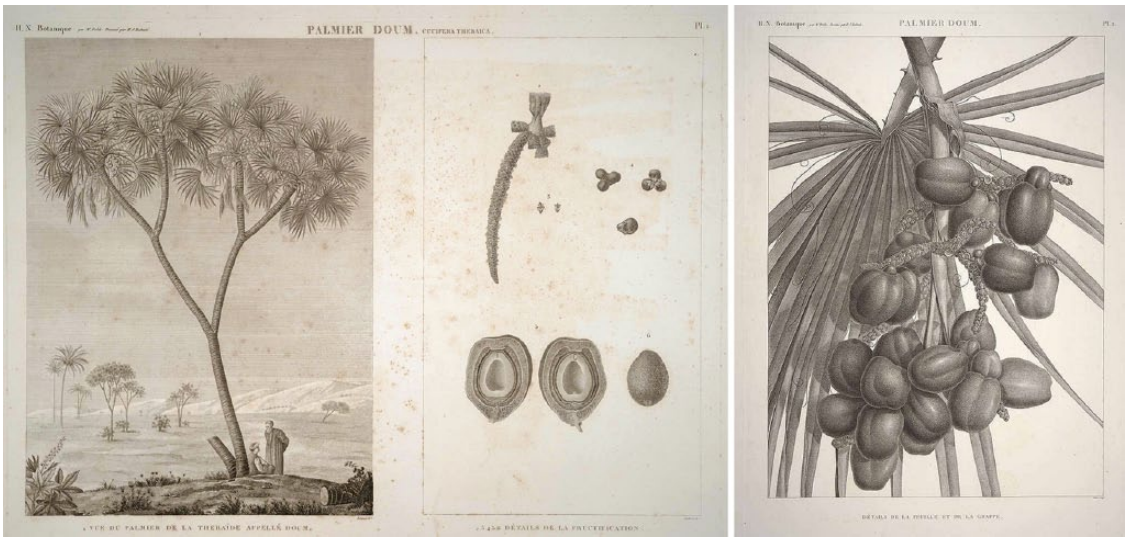

Figure 5. *Hyphaene thebaica*. From Raffeneau-Delile (1813). Image courtesy Missouri Botanical Garden. http://www.botanicus.org.

found at Berenike in the 4th–5th century AD, when the influx of local populations was probably stronger (Cappers, 2006). Rather, its value for the Romans could be related to the hard endocarp of this palm yielding quite a valuable vegetable ivory, which is confirmed in classical literary sources. Indeed, in the 4th century BC Theophrastus reported the ornamental use of *H. thebaica* endocarps (Cappers, 2006). The trade with Egypt is widely documented in the Roman Empire (Van Zeist, 1991). Archaeobotanical studies carried out in the Roman harbour of Berenike in Egypt also revealed the extensive presence of Mediterranean imported foodstuffs between the 3rd century BC and the 5th century AD (Vermeeren and Cappers, 2002).

Evidence of the export of doum palm has been found at Carlisle in Britain, where a sherd from a Roman 'carrot' amphora has a painted inscription in Greek referring to the fruit of the doum palm (Caruana et al., 1992; Tomlin, 1992).

The single mesocarp found does not permit to speculate about the putative reason for it being in Naples harbour, but confirms that there was active trade with north-eastern Africa in the 1st century BC.

Concluding remarks

Analysis of plant remains from harbour basins is a promising field of research, giving the opportunity to shed light on food access and on economic and cultural significance of plants in ancient times. The finds from the ancient harbour of *Neapolis* prove no exception to this, with also two major notable findings such as the first strong attestation of chestnut consumption as food between the 1st and the 5th century AD in western Mediterranean area, and the first recovery of the exotic palm *H. thebaica* in a European country which confirms that the harbour was handling trade with eastern Africa at the time.

It is feasible that seafarers had extensive access to dry fruit such as walnut, hazelnut and chestnut. Given their abundance in the harbour area, their imperishable nature and the high energy density, they appear to have been part of the food-stocks of the galleys. In this respect, these nuts must be considered as non-luxury food and especially chestnuts were probably eaten at that time mainly by low social classes.

Taken together, the evidence in this region also suggests that *P. persica, C. sativa, J. regia* and very probably *P. pinea* were locally produced.

In this respect, our data attest for a well advanced arboriculture in Roman Age both for fruit and for timber in Campania, and it is interesting to note that still today chestnut, hazelnut and walnut are among the major tree crops in the region with several ancient and local varieties. The early introduction of the peach, which once confirmed the advanced agricultural economy of Campania, should also be noted.

The recovery of stone pine cones cannot be explained unambiguously because of the many uses of the cones, but the use as stoppers seems the most feasible, and the demand for them was probably a further driving force for planting *P. pinea* close the seashore of commercial harbours.

Finally, since the sampling methodology can affect the results, archaeobotanical analysis should not be considered subsidiary to archaeology, but systematic sampling for plant materials should be carefully planned with archaeologists in order to have a fully accurate, complete record.

Acknowledgements

The authors express gratitude to the *Soprintendenza Speciale per i Beni Archeologici di Napoli e Pompei* and in particular Daniela Giampaola for giving them the opportunity to study the organic matter content from the Piazza Municipio excavation. Two anonymous reviewers are thanked for their fruitful comments on the manuscript which improved the quality of the article.

Funding

The authors acknowledge the financial support of the Azienda Napoletana Mobilità SpA EA was supported with fund granted to AS.

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