Vegetation History and Archaeobotany
https://doi.org/10.1007/s00334-023-00960-y

ORIGINAL ARTICLE

The first extensive study of an Imperial Roman Garden in the city of Rome: the *Horti Lamiani*

Alessia Masi[1,2] · Cristiano Vignola[1,2] · Alessandro Lazzara[1] · Claudia Moricca[1] · Mirella Serlorenzi[3] · Antonio F. Ferrandes[4]

Received: 31 December 2022 / Accepted: 3 July 2023

Abstract
This paper presents the first systematic results of integrated plant macrofossil and pollen analyses from the *Horti Lamiani* (1st-3rd century CE), an aristocratic residence with a luxury garden which was established on the Esquilino (Esquiline Hill) in Rome during the time of the first Emperor, Caesar Augustus (27 BCE-14 CE) and later became one of the most famous Imperial gardens around the ancient city. Different types of plant remains such as charcoal, seeds and fruits and pollen were recovered from pits and pots in the garden and reflect the presence of plants there. There seem to have been ornamental shrubs which were probably grown as decorative modelled hedges and/or isolated bushes, as well as cultivated trees. Several ornamental flowering plants grew in pots. Although this archaeobotanical assemblage could represent some patches of wild vegetation still growing in the study area at the time of the Imperial garden, it is likely that most of the identified plants were intentionally planted and organised to create a glimpse of the past wild landscape of Rome. They have special characteristics, such as bearing coloured flowers or fruits and offering shade, that made them suitable for embellishing a magnificent garden. Moreover this reflects the Roman desire to control nature, testified by the expansion of luxury gardens during the Imperial period and the spread of decorative horticultural techniques, like the miniaturisation of trees and shaping of trees and shrubs by topiary.

Keywords Gardens · Rome · Imperial age · Macro-remains · Pollen · Ollae perforatae

Introduction

During the Imperial period (27 BCE-395 CE) Rome was a large city with a million inhabitants and it was the centre of the Roman Empire with its extensive trade routes, bringing people and resources from the Mediterranean and beyond. Its wealth is highly testified through the use of plants. Apart from the movement of huge amounts of food, an impressive quantity of timber was imported for building, and plants from many regions were grown there for ornamental purposes and as signs of wealth. Unbelievably, archaeobotanical research on ancient Rome is scarce and patchy. Since most of the previously studied macro-remains came from the earliest occupational levels of the city dated to the 8th-6th centuries BCE, the time of the Roman Kingdom (ca. 753–509 BCE), the main focus of archaeobotanical studies has been the urbanisation process during this time (Helbæk 1956; Costantini and Giorgi 2001; Motta 2002; Larocca and Celant 2004). Another main area of interest has been the diet and introduction of new crops during the Republic (ca. 509–27 BCE), rather than the reconstruction of the past urban landscape (Sadori et al. 2009; Pagnoux et al. 2013).

Most archaeobotanical assemblages from the Republican and Imperial periods have low densities and poor preservation of remains, apart from the abundant material from sites near Vesuvius and in northern Italy. Although from a few

Communicated by J. Beneš.

✉ Cristiano Vignola
cristiano.vignola@uniroma1.it

1 Department of Environmental Biology, Sapienza University of Rome, Piazzale Aldo Moro 5, Rome 00185, Italy

2 Palaeo Science and History (PS&H) Independent Research Group, Max Planck Institute of Geoanthropology, Kahlaische Strasse 10, Jena 07745, Germany

3 Soprintendenza Speciale di Roma Archeologia, Belle Arti e Paesaggio, Piazza dei Cinquecento, 67, Rome 00185, Italy

4 Department of Ancient World Studies, Sapienza University of Rome, Piazzale Aldo Moro 5, Rome 00185, Italy

Published online: 11 October 2023

restricted areas, this evidence has shown the use of food in diet, rituals and burial practices (Murphy et al. 2013; Caracuta and Fiorentino 2017; Rowan 2017; Bosi et al. 2020). In the last decades, evidence from pollen has been added to that from macrofossils. Pollen grains preserved in archaeological sediments shed light on past vegetation growing within and near the site (Sadori et al. 2010). This multiproxy approach, integrating plant macrofossil evidence with that from pollen, is still rare but has been validated by the inclusion of pollen data in the Botanical Records of Archaeobotany Italian Network (BRAIN; Mercuri et al. 2015), and an increasing number of studies on changing landscapes during and before the Roman occupation are now being produced (Bosi et al. 2015; Moricca et al. 2021).

Horti (Roman gardens) are potential archaeological contexts for the analysis of plant remains through multi-disciplinary studies. In the Roman world, *hortus* represented restful nature compared to the chaotic city, where plants were grown for consumption, therapeutic and aesthetic purposes (von Stackelberg 2009). This space of private houses changed from a vegetable patch with a utilitarian function in the Early Republican period (Pliny the Elder, *Naturalis Historia* XIX, 52) to a luxury garden with a mainly decorative function in the Late Republican and Imperial periods ca. 100 BCE-395 CE (Pliny the Younger, *Epistulae* 8, 18, 11). Frescoes with a glimpse of the latter landscaped gardens are common in the Roman *villae* (country houses or farm estates) (Dietrich 2017). Archaeobotanical reconstructions of domestic gardens have been extensively produced for sites near Vesuvius and, to a lesser degree, for other Italian regions (Mariotti Lippi and Bellini 2006; Montecchi and Mercuri 2018), but there is little evidence from Imperial gardens in Rome. These urban spaces were arranged as open areas and structures which were built by the aristocracy and later by the Emperor, where plants, sculptures and fountains decorated large gardens within the city following the tradition of Greek and Near Eastern palaces. By showing the status of their owners, they can be considered at the border of private and public architecture in terms of social and political significance (Marzano 2022). During the Imperial period they composed a "green ring" on the hills of Rome (Cima and La Rocca 1998), with the most important ones being *Horti Enniani* on Aventino (the Aventine Hill), *Horti Luculliani* and *Horti Sallustiani* (Pincio, Pincian Hill), *Horti Agrippinae* (Vaticano, Vatican Hill), *Horti Mecenatis* and *Horti Lamiani* (Esquilino, Esquiline Hill). A large portion of the latter has been brought to light since 2006 as a result of extensive rebuilding activities within the city centre and a huge amount of archaeological materials has been recovered from there, including plant remains. After many years of excavation campaigns carried out by *Soprintendenza Speciale di Roma* (Barbera et al. 2010; Alagia 2014; Serlorenzi 2014, 2016) the site of *Horti Lamiani* is now a museum (Museo Ninfeo, https://www.museoninfeo.it/) (Fig. 1).

This paper presents the first systematic results of integrated plant macrofossil and pollen analyses from an Imperial garden in the city of Rome. The aims of the study are (1) to reconstruct the use of plants in the context of *Horti Lamiani* for both utilitarian and decorative purposes and (2) to interpret the urban landscape of the ancient city and its development through time.

The site and its evolution between the republican and early imperial periods

The excavation in the south-eastern corner of the modern Piazza Vittorio Emanuele II on the Esquiline Hill revealed a long settlement sequence, between the Middle Republican period and the 20th century. During this time span the area changed its function several times. The first evidence (Period 1, 4th-mid 2nd centuries BCE) indicates a prolonged use of the land for farming, which was interrupted around the mid 2nd century BCE (Period 2), when mining activities were started to extract the *pozzolana*, a volcanic ash used in building. The quarries were finally abandoned around 70/60 BCE (Ferrandes 2014). From a topographical point of view, throughout the Republican period this area was located immediately outside the *Urbs* (city) next to its walls, in an area used as a cemetery, the Esquiline necropolis. In the time of Emperor Augustus, a garden was created in the area previously occupied by the quarries (Period 3, late 1st century BCE to second half of the 1st century CE). This green space has been identified as part of the *Horti Lamiani*, one of the aristocratic residences that were created around the city from the mid 1st century BCE onwards, and which was probably built by Lucius Aelius Lamia, a consul in 3 CE, or by his father (Alagia 2014). These residences formed a 'green ring' around the city, and they were destined to play a crucial role in the new Imperial organisation of Rome created by Augustus. The area was arranged on terraced floors which were made by cutting into the oldest deposits and constructing concrete walls. The finding of pits for plants, trenches for hedges, furrows aligned in parallel rows and *ollae perforatae* (planting pots with holes on the bottom for the drainage of water and the aeration of the roots), allows us to understand the changes undergone by the *Horti* through four different construction phases.

Four artificial terraced levels from the age of Augustus (Phase 3.1) were identified, oriented north-south and built on concrete walls about 1 m high which ended to the north against east-west oriented masonry which bordered a fifth terrace (T1/2). Numerous trenches and planting holes were found on the terraces, arranged parallel to the walls and with

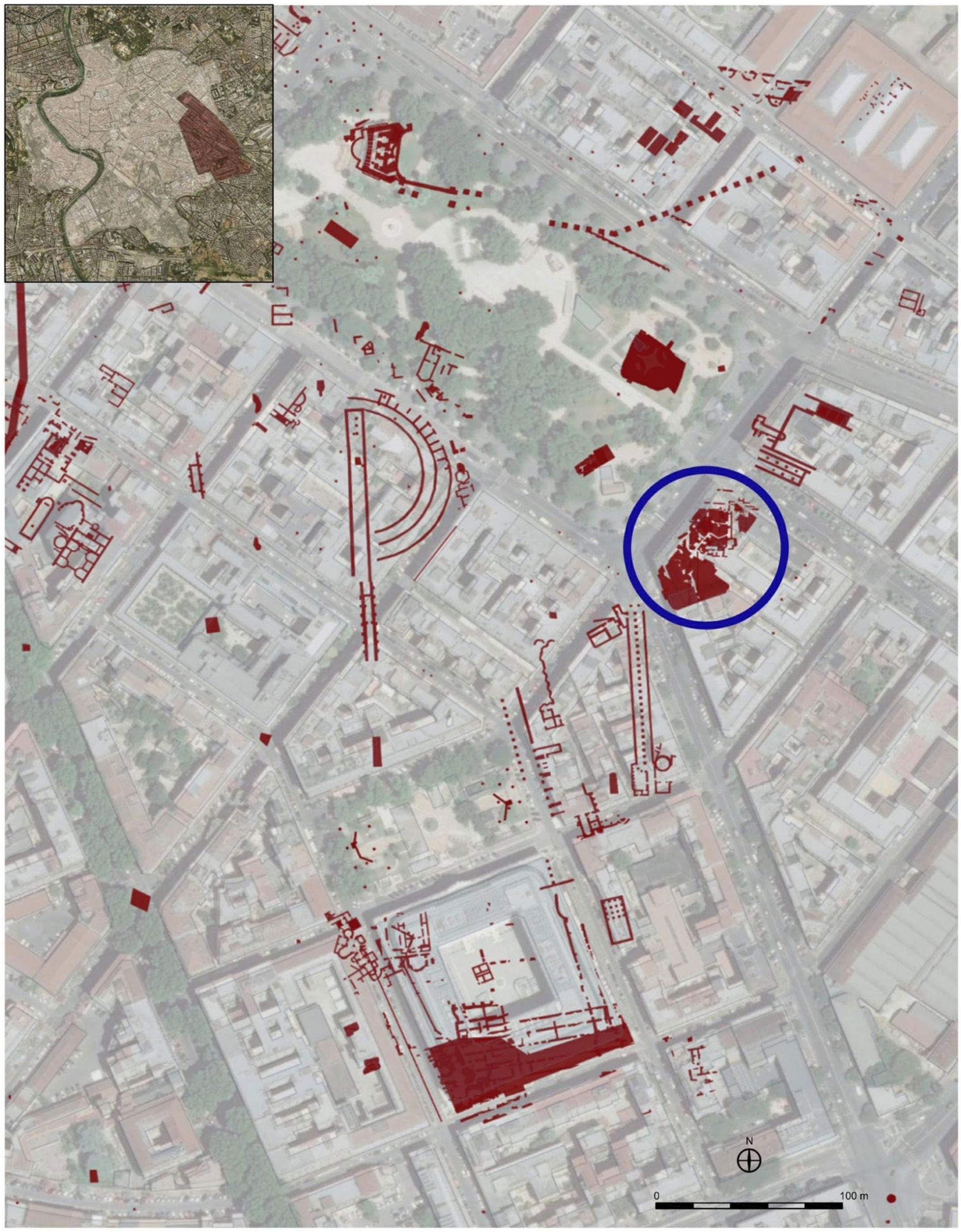

Fig. 1 *Horti Lamiani* (Esquiline Hill, Rome). Archaeological evidence of the *Horti Lamiani* structures (in red) on the aerial view of the modern city of Rome (data from SITAR - Sistema Informativo Territoriale Archeologico di Roma; https://www.archeositarproject.it/). The blue circle indicates the area excavated since 2006 from which the studied samples came. Inset, modern Rome within the Servian Walls (in light colour) with location of the Esquiline Hill (red area)

accumulations of tuff stones on the bottom for drainage and to prevent waterlogging of roots. Later, during the age of Tiberius and Caligula (Phase 3.2, 14–41 CE), a new terrace and a marble staircase were added to the original layout of the garden. These changes are associated with the creation of an irrigation system using lead pipes, connected with the cultivation of new plants which in some cases coexisted with those of the previous phase. Of particular interest is an arrangement of circular and square holes for plants, 0.05–0.2 m wide and 0.1–0.25 m deep, arranged individually or in double rows parallel to the terrace walls and about 0.8–1 m from them. Single smaller holes set closer together were found close to some of the walls, suggesting the presence of different types of plants in the garden. Several *ollae perforatae* were placed inside a flower bed, while some broken *amphorae* belonging to the same phase were buried in the ground to serve as flower pots.

These garden arrangements were destroyed during a third phase (Phase 3.3) in the time of Emperor Claudius (41–54 CE), when the plant pits were covered by a layer of soil. On the other hand, the trenches of Phase 1 did not seem to undergo significant changes. The sequence of the Imperial garden ended with a last phase dated to the early/middle Flavian dynasty period of Emperors Vespasian and Titus (Phase 3.4, ca. 69–81 CE), when a long and wide trench was dug parallel to the terrace walls of the Augustan period probably for improving drainage. After the garden period, the whole area was reorganised (Period 4) and around the beginning of the 3rd century CE a courtyard and a *nymphaeum* (a grotto dedicated to water nymphs) were created, richly adorned with marble and statues and destined to survive until the end of Antiquity.

Materials and methods

The soil samples for analysis came from the filling of the smaller planting holes and the *ollae perforatae* plant pots dated to Phase 3.2 (Fig. 2). Additional sediment samples were taken from *amphorae* and fill deposits of different structures such as drainage trenches belonging to this phase and to Phases 3.3/3.4, from a total of 223 stratigraphic units (SUs). The sediment samples were dry-sieved with meshes of 2, 1 and 0.5 mm. Plant remains were recovered from 72 samples. All remains were preserved by carbonization, except for the fruits of *Celtis australis* L. (hackberry, nettle tree) which were mineralized. Seeds and fruits were sorted using a stereomicroscope (magnification range: 8–50×) and identified using a reference collection and atlases with specific identification keys (Neef et al. 2012; Sabato and Peña-Chocarro 2021). Fragments of hackberry, *Olea europaea* L. (olive) and *Vicia faba* L. (broad bean) were weighed to estimate the number of remains they correspond to. The identification of the charcoal remains was carried out using a microscope with Nomarski phase interference contrast (magnification range: 50–500×) and atlases (Greguss 1955; Schweingruber 1990). Concentration was calculated as the number of remains/volume of sediment.

Pollen analysis was done on sediments preserved inside two plant pots. The samples were chemically processed following Fægri and Iversen (1989). A known amount of dry sediment (5–10 g) was treated for pollen extraction with a method including sieving and heavy liquid separation in accordance with van der Kaars et al. (2001) and Florenzano et al. (2012). Pollen identification was done using atlases (Reille 1992–1998; Beug 2004). The distinction of deciduous oaks (*Quercus robur*-type) from the other species of *Quercus* is based on pollen morphology according to Smit (1973). Cichorieae represents the only European tribe of Asteraceae with fenestrate pollen grains belonging to the subfamily Cichorioideae (Florenzano et al. 2015).

Results

The results of macro-remain analysis are presented in Table 1 and in ESM 1, 2. The concentration of plant remains varied, and the stratigraphic units (SUs) richest in seeds and fruits were 6452 (23.1 remains per litre of sediment), 6450 and 6683 (8/L) (ESM 1), whereas the greatest number of

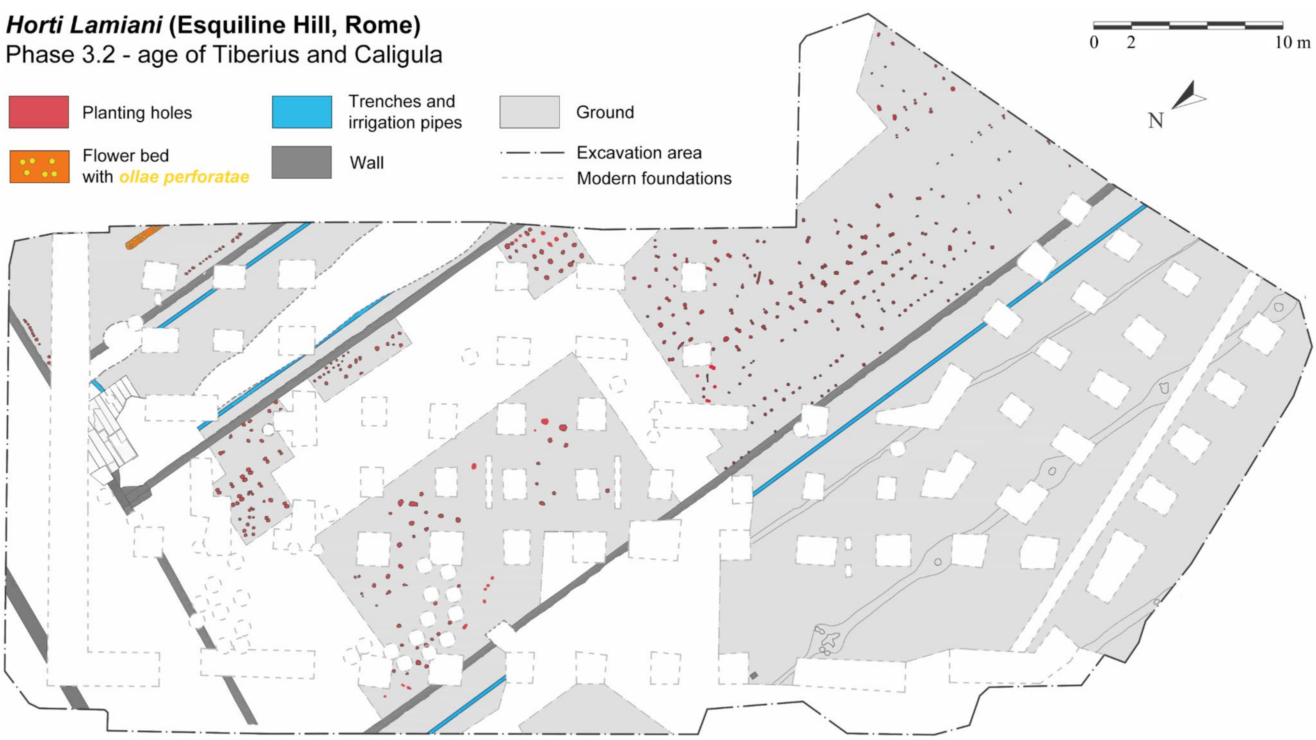

Fig. 2 *Horti Lamiani*. Plan of Phase 3.2 of *Horti Lamiani* dated to the age of Tiberius and Caligula (14–41 CE), to which most of the archaeological contexts included in this work belong. Planting holes (red) and the flower bed (orange) with *ollae perforatae* (yellow circles). White dashed squares indicate areas where the archaeological deposit was destroyed by pillars and walls of the modern building. (modified from the original plan by N. Saviane)

Table 1 *Horti Lamiani*. List of taxa with numbers of identified charcoal fragments, seeds, fruits and pollen grains from the Early Imperial period of *Horti Lamiani*, grouped by their archaeological contexts

Taxon	Common name	Charcoal			Seeds and fruits			Pollen
		Planting holes	Plant pots	Filling deposits	Planting holes	Plant pots	Filling deposits	Plant pots
Abies	Fir	3		3				
Acacia	Acacia	1						
Acer	Maple	6	2	23				
Amaranthaceae								1
Arbutus unedo	Strawberry tree	2						
cf. *Arctostaphylos uva-ursi*	Bearberry	1						
Brassicaceae								4
Buxus sempervirens	Box	1						
Carpinus sp.	Hornbeam	12						
Caryophyllaceae								2
Castanea sativa	Chestnut	2						2
Celtis australis	Hackberry	2		15	111		2	
Ceratonia siliqua	Carob	2						
Cichorieae								2
Cistus	Rockrose	1	1					
Cornus sanguinea	Dogwood	3						
Corylus avellana	Hazel	18	2					
cf. *Cneorum tricoccon*	Spurge olive	1						
Euonymus	Spindle	3						
Fabaceae undiff.		1			1			
Fagus sylvatica	Beech	18						
Fraxinus cf. *excelsior*	Ash	3		2				
Fraxinus cf. *ornus*/*F.* undiff.	Manna ash	1/2	/1	2				
Juglans regia	Walnut	1						
Lathyrus cf. *cicera*	Red pea				1			
cf. *Malus*	Apple				1			
Olea europaea	Olive	16	1	11	44	5		
Ostrya carpinifolia	European hop-hornbeam	23	2					
Pinus pinea/*P.* undiff.	Stone pine				1			/2.5
cf. *Pyrus*	Pear				1			
Pistacia sp.	Pistachio		1					
Plantago lanceolata-type	Ribwort plantain							2
Poaceae								2
Populus	Poplar	4	6	4				
Quercus robur group/type	Deciduous oaks	39	12	6				1
Quercus cerris group	Semi-evergreen oaks	26		5				
Quercus suber group	Evergreen oaks	58	9	2				
Quercus undiff.	Oak	2			1			
Ranunculaceae								2
Rhamnus/Phillyrea	Buckthorn/mock privet	3						
cf. *Rosa*	Rose	5		2				
Rosaceae Maloideae		17	5					
Rosaceae Prunoideae		3	4					
Taxus baccata	Yew	6		3				
Ulmus/Ulmaceae undiff.	Elm	10/2	6					
Ulmaceae undiff.		2						
Urtica	Nettle							2
Vicia faba	Broad bean				20			
Vicia/Lathyrus					1			

charcoal fragments came from 6637 (45/L), 6442 (40/L), 6671 (35/L), 6560 and 5899 (34.4/L) (ESM 2).

Seeds and fruits were recovered from 34 SUs and are from ten taxa (ESM 1). The most abundant finds are nutlets of *Celtis* (hackberry), stones of *Olea* (olive) and *Vicia faba* (broad beans). Single pips of cf. *Malus* (apple) and cf. *Pyrus* (pear) and a *Pinus pinea* L. (stone pine) shell were also identified. Each sample contained one or two taxa except for SU 6024 from which, other than olive stones, a variety of pulses were found: broad beans, *Lathyrus* cf. *cicera* (red pea) and *Vicia/Lathyrus*. Charcoal was present in 68 SUs and represents 36 taxa (ESM 2), mainly angiosperms like *Quercus robur* group, *Q. cerris* gr. (semi-evergreen oaks), *Q. suber* gr. (evergreen oaks), *Acer* (maple), *Olea*, *Celtis*, *Ostrya carpinifolia* Scop. (European hop-hornbeam), Rosaceae Maloideae, *Corylus* (hazel) and *Ulmus* (elm). There were only a few fragments of two conifers, *Abies alba* Mill. (fir) and *Taxus baccata* L. (yew). The variability of charcoal taxa within each sample is high, with up to 11 taxa from SU 6082.

The results of pollen analysis are reported in Table 1 and ESM 3. Due to the bad pollen preservation, the total pollen count is very low, with 17 pollen grains in SU 5955 and eight in SU 5956. Nonetheless a total of nine taxa in SU 5955 and six in SU 5956 were identified. Tree pollen from was scarce, with *Quercus robur*-type, *Castanea sativa* and *Pinus*. Most of the identified taxa correspond to herbaceous plants. Brassicaceae and Caryophyllaceae are ubiquitous, followed by Cichorieae, *Plantago lanceolata*-type, Poaceae, Ranunculaceae and *Urtica*.

Discussion and conclusions

The archaeobotanical assemblage from *Horti Lamiani* represents a unique case study for the reconstruction of the garden vegetation of Rome and the use of plants during the Imperial period. Over 600 macro-remains belonging to more than 40 plant taxa represent the richness of the garden flora (Table 1). Pits and pots in holes about 7 m apart in the parallel trenches certainly contained plants, although the identified taxa cannot be directly linked to the archaeological context (Fig. 2). Many of the shrubs might have been shaped and grown as hedges, such as *Buxus sempervirens* L. (box), *Taxus* and cf. *Rosa* (rose), and/or as isolated bushes such as *Arbutus unedo* L. (strawberry tree), *Cistus* sp. (rockrose), or *Rhamnus/Phillyrea* (buckthorn/mock privet). Further trenches in parallel to the walls and dated to the Augustan period and still present in the new arrangement in the period of Emperors Tiberius (14–37 CE) and Caligula (37–41 CE) were probably related to the presence of a hedge, despite the fact that none of the recovered sediments contained preserved plant remains. In addition, there is some evidence of the use by Roman gardeners of potted plants for propagation by aerial layering and for containing shrubs or small trees. In the Giardino di Ercole at Pompeii, where flowers were grown and sold, *ollae perforatae* were also used for aerial layering and to hold small *Citrus limon* or *C. medica* (lemons or citrons) (Jashemski 1979). The domestic garden of the Casa di Giulio Polibio at Pompeii contained numerous trees in pots, trained against a wall (espaliered) to create a natural wall-painting effect (Jashemski 1992). In Villa Oplontis near Naples rows of plant pots were set against the walls and colonnades of the house to allow plants to climb up like ivy (Jashemski 1992). A similar use can be suggested for the *ollae perforatae* of the *Horti Lamiani*, which were buried in the ground at the bottom of the terrace wall and might have contained fruit trees, as testified by olive stones and pips of apple and pear. Ancient authors referred to small trees grown in the gardens as *arbusculae* (for example, Valerius Maximus, *Factorum et Dictorum Memorabilium*, IX, 1, 4). The presence of apples and pears seems to be confirmed by charcoal of Rosaceae Maloideae, the subfamily to which these fruit trees belong, but *Olea* charcoal is almost absent (Fig. 3). However, legumes (Fabaceae), which are the only herbaceous taxa among the macro-remains, were abundant in the planting holes in the terraced area, suggesting the use of the upper part of the garden for growing food, although most of these cultivated plants have coloured flowers and could have been grown for decorative purposes. Indeed, most ornamental plants identified from charcoal remains (*Buxus*, *Taxus*, *Rosa*) have only been found in the pits (Fig. 3). It is noteworthy that Roman poets criticised the unnatural treatment of plants through the miniaturisation of trees, a horticultural practice probably imported from China through the trading activities across the Mediterranean basin during Imperial times (Landgren 2013). Despite the difference between seed/fruit and charcoal assemblages, we can argue that all the evidence from the macro-remains of *Horti Lamiani* reflects the range of taxa present in the garden as a whole.

In this respect, the wide range of taxa recognised in each sample is of great interest. The presence of charcoal from different taxa within the same plant hole or pot might be traced back to the practice of bonfires being used to burn prunings or brushwood at the *Horti Lamiani*, but none of the archaeological contexts showed any evidence of fire. The carbonization was not caused by the abandonment or destruction of the site, but it was rather an indication of the secondary deposition of plant remains and is possibly related to routine garden maintenance. It is likely that ash and charcoal were added to the soil to enhance plant growth, although a similar scattering of evidence was interpreted as "background noise" (random remains from various origins)

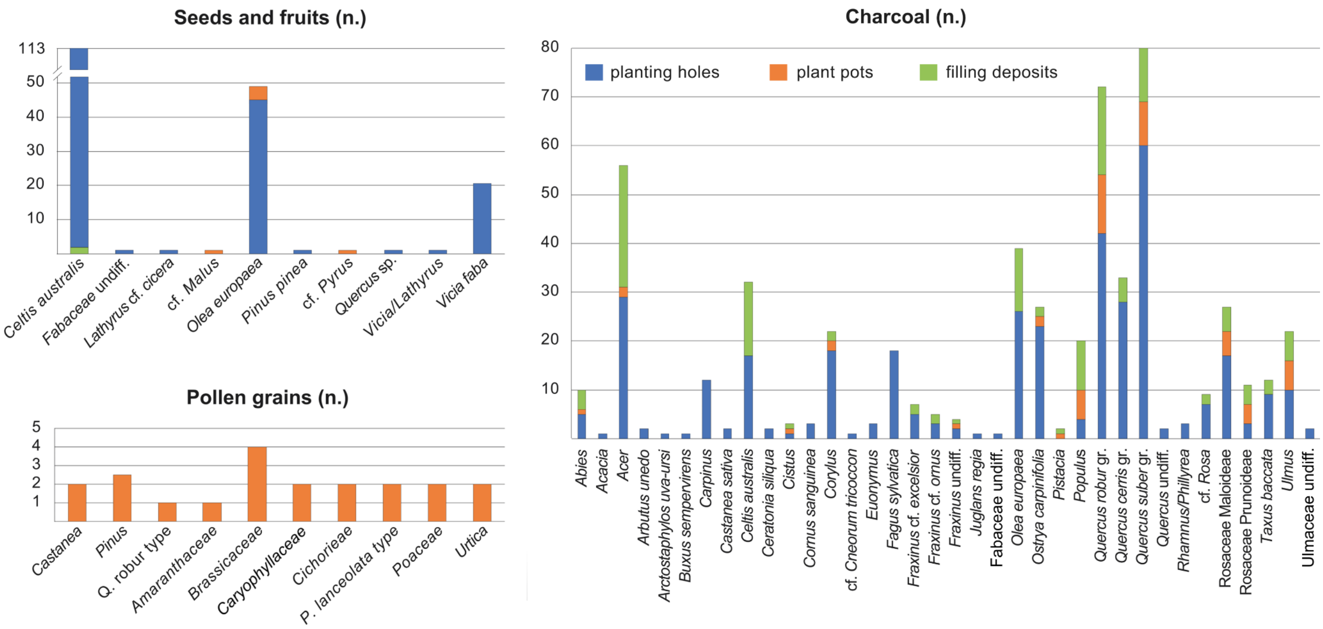

Fig. 3 *Horti Lamiani*. Bar graphs showing the numbers of the different types of plant remains from the Early Imperial period of *Horti Lamiani*

for Pompeii (Murphy et al. 2013). The only exception are the *Celtis* fruits preserved by biomineralization. The aragonite which encases the endosperm (fruitstone) favours preservation and, therefore, propagation of the fruits (Jahren et al. 1998). As already stressed, the presence of pulses might be linked to other activities in the garden, for example vegetable growing and food consumption, which would represent the productive function of Roman gardens. Nonetheless, their use as green manure should be taken into consideration since legumes fix nitrogen, an essential nutrient for plants, and have been used in this way since prehistoric times (Vignola et al. 2017). It is well known that the diffusion of ornamental plants during this period stimulated horticultural innovations, thus wine and the waste products of wine making were used by Roman gardeners for the same reason (Purcell 1996; Tally-Schumacher 2022).

Pollen provides information about some herbaceous plants whose macro-remains are hardly preserved in this kind of context. While the three arboreal pollen taxa had already been found as macro-remains, seven herbaceous taxa would have been omitted without this multi-disciplinary approach (Table 1; Fig. 3). The pots at *Horti Lamiani* might have held ornamental flowering plants such as members of the Brassicaceae, Caryophyllaceae and Ranunculaceae for a richness of shapes and colours that would have reached its peak during the spring. Similar pollen evidence comes from *Horti Luculliani*, the only other Imperial garden in Rome which was investigated using archaeobotanical analyses, where a similar range of herbaceous plants are thought to have been grown in pots (Giardini et al. 2006). Further pollen evidence from soil samples from the garden of Casa dei Casti Amanti at Pompeii seem to confirm that the herbaceous pollen spectra of the *Horti Lamiani* most likely represent the plants which grew in the pots (Mariotti Lippi and Bellini 2006). In general, the widespread growing of flowers in the Roman period is well known from archaeological evidence from the area around Vesuvius (Macaulay Lewis 2006). Pliny the Elder wrote about flower markets in *Naturalis Historia* XXI, 1).

Trees and shrubs from *Horti Lamiani* can be grouped into three categories: cultivated, *Olea*, *Juglans regia* L. (walnut), *Pinus pinea*, Rosaceae Maloideae, Rosaceae Prunoideae (the subfamily of plum trees); ornamentals, and wild plants. In particular, the latter represent different natural environments, such as the Mediterranean vegetation dominated by mainly evergreen *Quercus* and the mixed deciduous woodland with *Quercus*, *Acer*, *Fraxinus* cf. *ornus* (manna ash) and *Ostrya*. Wetland vegetation is represented by *Celtis*, *Ulmus* and *Fraxinus* cf. *excelsior* (ash), and the forest on higher land by *Fagus sylvatica* L. (beech) and *Abies* (Table 1; Fig. 3). It is known from various literary sources that the Roman hills were once covered by woods, some of which survived the demographic pressure of the growing city because they were sacred (Massari 1995). At the end of the Republic, these areas of wild vegetation were strongly reduced due to the continuous development of the city. According to Pliny the Elder (*Naturalis Historia* XVI, 37) and Varro (*De lingua latina* IV) their memory was maintained in the names of the areas formerly occupied by sacred woods. On the Esquiline Hill where the *Horti Lamiani* were established, it is said that the name of one of the three peaks of the hill, *Fagutal*, derives from the abundance of beeches in the sacred wood there (Sadori et al. 2007). Some remnants of this woodland might have still been there at the time of the Imperial garden, because of the relatively large amount of charred remains of beech wood which may have been obtained from the surroundings. Nonetheless, as already stated, the Roman desire to control nature in gardens could also suggest that most of the identified trees were intentionally planted and organised to create a glimpse of a wild landscape. According to Pignatti (1995), oak woods are widespread in the area around Rome, with deciduous *Quercus cerris* L. and *Q. frainetto* Ten. dominating flat land and evergreen *Q. ilex* L. on the steep slopes. Since oaks are the most abundant taxa identified from the *Horti*, we argue that patches of natural vegetation were still present within the city, and that the garden included a mix of natural and planted vegetation. *Acer* remains are also abundant in the analysed assemblage, and although it is a component of local mixed deciduous woodland, due to its bright coloured leaves in autumn, as well as its elegant appearance and adaptability to urban environments, maple might have been grown in the garden as an ornamental. Ornamentals are also represented by exotic trees such as *Acacia*, that could have conveyed a symbolic meaning if imported from newly conquered lands (Marzano 2014). Another important vegetation type is the wet woodland, on the floodplain of the river Tiber, from which the main component in the Imperial garden was *Celtis*. This seems to have been known by the Romans as *lotus* and also prized as a shade tree, as in a description of the house of *L. Licinius Crassus* on the Palatino (Palatine Hill) (Pliny the Elder, *Naturalis Historia* XVII, 1–5).

During the Imperial period, the urban landscape of Rome changed and ornamental plants were increasingly grown in gardens, where previously tree crops had mainly been cultivated. The value of these new plants was in their unproductive state, as they served as significant signs of wealth for the Roman aristocracy. The demand for new plants was so great that *topiarii*, specialised gardeners and designers, not only modelled trees and shrubs into beautiful shapes by topiary but also bred some plants into new cultivars, such as myrtle and cypress (Tally-Schumacher 2022). In this sense the absence of finds of *Cupressus* (cypress) remains from the *Horti* is noteworthy since its decorative value was greatly appreciated by Romans, although mainly restricted to funerary contexts as the Mausoleo di Augusto (Strabo, *Geographica* 5, 3.8). The recovery of olive remains is a confirmation of the presence of *Olea* in the Imperial garden with the dual function of an ornamental and cultivated plant (Landgren 2013). The same interpretation should be suggested for *Juglans* and *Castanea* since the spread of olives, walnuts and chestnuts through Europe is widely considered a sign of Roman influence (Mercuri et al. 2013). *Pinus pinea* was also spread throughout the Mediterranean by the Romans, but appears to have been introduced to Italy earlier by the Phoenicians (Moricca et al. 2021), and it was grown for its decorative value, timber, resin and pine nuts. A recent investigation of pollen from Pompeii has confirmed the role of the stone pine as a chronological marker for the arrival of Roman colonists in the city (Vignola et al. 2022). Similarly, there are archaeobotanical records of edible plants such as *Castanea*, *Vitis* and Fabaceae together with ornamental plants such as *Cistus* and Rosaceae Rosoideae (the subfamily of rose) from the *Horti Luculliani* in Rome (Giardini et al. 2006; Giardini and Sadori 2015).

The few preserved wall paintings of Roman *villae* and houses dated to this period can be of great help to reconstruct the design of *Horti Lamiani*. Such frescoes do not represent a true image of the gardens, but an idealised landscape in which all plants are in bloom simultaneously, regardless of the flowering or fruiting season. Cicero wrote that plants "clothed" buildings suggesting the relationship between plant decoration and architecture as in the Near Eastern palaces (Amrhein 2015). Plants like grapevine and ivy decorating walls and columns were a regular feature in the decorative scheme of Roman gardens such as Villa Oplontis near Naples (Gleason 2014). Most of the trees identified in the *Horti* are represented on the walls of Villa di Livia at Rome, such as *Pinus pinea*, *Arbutus unedo*, Rosa and several herbaceous plants (Caneva and Bohuny 2003). The same evidence comes from the Casa del Frutteto and Casa del Bracciale d'oro at Pompeii and Villa di Publio Fannio Sinistore at Boscoreale (Ciarallo 2006). Despite the poor state of preservation, some plants depicted in the wall paintings of *Horti Mecenatis*, bordering *Horti Lamiani* on the Esquiline Hill, are also present in our assemblage such as *Pinus pinea* and *Rosa* sp., confirming the presence of these plants in ancient Roman gardens (Caneva 2014). As already suggested for the arrangement of the plants in the *Horti* thanks to the results of this archaeobotanical analysis, what is indicated is not a merely wild, unruly landscape but rather an organised and productive space with a careful arrangement of ornamental plants and architectural elements. While most of the identified taxa could have been part of the natural vegetation in the area of Rome, they have special characteristics such as bearing flowers or fruits which make them particularly suitable for embellishing a garden that, based on the variety of plant remains and the abundance of imposing trees, must have been of absolute magnificence.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00334-023-00960-y.

Acknowledgements The team engaged in field research and currently working on editing the data that emerged from the investigations is composed by: M. Serlorenzi (research coordination and excavation management), G. Leoni (assistance to the scientific direction and organisation), G. Di Cola, L. Giovannetti, L. Pugliese, N. Saviane (stratigraphy); A.F. Ferrandes (general coordination of the study of contexts); S. Bellezza, V. Cardarelli, M. Casalini, D. Greco, G. Iacomelli, A. Pegurri, G. Schwarz, (A) Vivona (pottery); (B) Lepri (glass artefacts); (C) Schwarz (worked bones and ivory); G. Bison (metals); G. Pardini (coins); S. Fortunati (plasters and *stucco*); R. Oriolo (architectural coroplasty); (D) Alagia and S. Guglielmi (marble decorations); G. Soranna (faunal remains); A. Masi, C. Vignola (archaeobotanical remains); S. Boni, graphical reconstructions. To read the results of the archaeologists engaged in the first phase of research, please refer to Barbera et al. (2010).

Author contributions This study was designed by AM and CV. Data collection and analysis were performed by AM, CV, AL, CM. The first draft of the manuscript was written by AM and CV with the contribution of AFF and MS for the archaeological contextualization and all authors commented on it. Images were edited by CV, CM and AFF. All authors read and approved the final manuscript.

Funding Open access funding provided by Università degli Studi di Roma La Sapienza within the CRUI-CARE Agreement.

Declarations

Competing interests The authors have no relevant financial or non-financial interests to disclose.

References

Alagia D (2014) Topografia degli *Horti Lamiani*. Riconsiderazioni di un tema archeologico. Scienze dell'AntichitÃ 20:247–266

Amrhein A (2015) Neo-assyrian gardens: a spectrum of artificiality, sacrality and accessibility. Stud Hist Gard Des Landsc 35:91–114. https://doi.org/10.1080/14601176.2014.945832

Barbera M, Barrano S, de Cola G, Festuccia S, Giovannetti L, Menghi O, Pales M (2010) La villa di Caligola. Un nuovo settore degli *Horti Lamiani* scoperto sotto la sede dell'ENPAM a Roma. FOLD&R FastiOnLine Documents & Research 194:1–59. https://www.fastionline.org/docs/FOLDER-it-2010-194.pdf

Beug HJ (2004) Leitfaden der Pollenbestimmung für mitteleuropa und angrenzende Gebiete. Pfeil, München

Bosi G, Castiglioni E, Rinaldi R, Mazzanti M, Marchesini M, Rottoli M (2020) Archaeobotanical evidence of food plants in Northern Italy during the roman period. Veget Hist Archaeobot 29:681–697. https://doi.org/10.1007/s00334-020-00772-4

Bosi G, Mercuri AM, Bandini Mazzanti M et al (2015) The evolution of roman urban environments through the archaeobotanical remains in Modena - Northern Italy. J Archaeol Sci 53:19–31. https://doi.org/10.1016/j.jas.2014.09.020

Caneva G (2014) Il giardino come espressione del divino nelle rappresentazioni dell'antica Roma. In: Coleman K, Derron P (eds) Le jardin dans l'antiquité: introduction et huit exposés suivis de discussions. Entretiens sur l'antiquite classique, vol 60. Fondation Hardt, Vandœuvres, pp 301–361

Caneva G, Bohuny L (2003) Botanic analysis of Livia's villa painted flora (Prima Porta, Roma). J Cult Herit 4:149–155. https://doi.org/10.1016/S1296-2074(03)00026-8

Caracuta V, Fiorentino G (2017) Plant rituals and fuel in Roman Cemeteries of Apulia (SE Italy). In: Livarda A, Madgwick R, Riera Mora S (eds) The Bioarchaeology of Ritual and Religion. Oxbow Books, Oxford, pp 58–68

Ciarallo A (2006) Elementi Vegetali nell'Iconografia Pompeiana. L'Erma di Bretschneider, Rome

Cima M, La Rocca E (1998) Horti romani: atti del Convegno Internazionale, Roma, 4–6 maggio 1995. (Bullettino della Commissione Archeologica Comunale di Roma, Supplement 6) L'Erma di Bretschneider, Rome

Costantini L, Giorgi J (2001) Charred plant remains of the archaic period from the Forum and Palatine. J Roman Archaeol 14:239–248. https://doi.org/10.1017/S1047759400019905

Dietrich N (2017) Pictorial space as a media phenomenon: the case of 'Landscape' in Romano-Campanian wall-painting. In: Lissarrague F, Valette E, Wyler S (eds) Le spectacle de la nature: regards grecs et romains. (Cahiers des Mondes Anciens 9) Anthropologie et Histoire des Mondes Antiques, Paris, pp 1–27. https://doi.org/10.4000/mondesanciens.1903

Fægri K, Iversen J (1989) In: Fægri K, Kaland PE, Krzywinski K (eds) Textbook of Pollen Analysis, 4th edn. Wiley, Chichester

Ferrandes AF (2014) Circolazione ceramica e approvvigionamento urbano a Roma nel I secolo a.C.: Nuovi dati dall'area degli *Horti Lamiani*. ReiCretActa 43:353–366

Florenzano A, Mercuri AM, Pederzoli A et al (2012) The significance of intestinal parasite remains in pollen samples from medieval pits in the Piazza Garibaldi of Parma, Emilia Romagna, Northern Italy. Geoarchaeology 27:34–47. https://doi.org/10.1002/gea.21390

Florenzano A, Marignani M, Rosati L, Fascetti S, Mercuri AM (2015) Are Cichorieae an indicator of open habitats and pastoralism in current and past vegetation studies? Plant Biosyst 149:154–165. https://doi.org/10.1080/11263504.2014.998311

Giardini M, Calderoni G, Jolivet V, Mari Z, Sadori L, Susanna F, Tresserras Juan J (2006) Indagini archeobotaniche su alcuni materiali degli *Horti Luculliani* (Roma) e di Villa Adriana (Tivoli). In: Morel J-P, Tresserras Juan J, Matamala JC (eds) The archaeology of crop fields and gardens. Proceedings of the 1st Conference on Crop Fields and Gardens Archaeology, Barcelona (Spain), 1–3 June 2006. Edipuglia, Bari, pp 129–144

Giardini M, Sadori L (2015) Il recupero dei vasi da fiori di Via Sistina e i dati provenienti dagli studi archeobotanici. Bollettino di Archeologia on line 6:201–210

Gleason K (2014) Wilhelmina Jashemski and Garden Archaeology at Oplontis. In: Clarke JR, Muntasser NK (eds) Oplontis: Villa A ("of Poppaea") at Torre Annunciata, Italy, vol 1: The Ancient Setting and Modern Rediscovery. American Council of Learned Societies, New York, pp 479–570 (Sects. 929–1095). https://hdl.handle.net/2027/heb90048.0001.001

Greguss P (1955) Identification of living gymnosperms on the basis of xylotomy. Akadémiai Kiadó, Budapest

Helbæk H (1956) Appendix I: vegetables in the Funeral Meals of Pre-Urban Rome. In: Gjerstad E (ed) Early Rome II: the Tombs. Acta Instituti Romani Regni Sueciae, Series in 4°,17, 2. Swedish Institute in Rome, Lund, pp 287–294

Jahren AH, Gabel ML, Amundson R (1998) Biomineralization in seeds: developmental trends in isotopic signatures of hackberry.

Palaeogeogr Palaeoclimatol Palaeoecol 138:259–269. https://doi.org/10.1016/S0031-0182(97)00122-3
Jashemski WF (1979) The Garden of Hercules at Pompeii (II.viii.6): the Discovery of a Commercial Flower Garden. Am J Archaeol 83:403–411
Jashemski WF (1992) The gardens of Pompeii, Herculaneum and the villas destroyed by Vesuvius. J Gard Hist 12:102–125. https://doi.org/10.1080/01445170.1992.10410565
Landgren L (2013) Plantings. In: Gleason KL (ed) A cultural history of gardens in antiquity. Bloomsbury, London, pp 75–98
Larocca F, Celant A (2004) Risultati delle ricerche archeobotaniche. In: Gioia P, Volpe R (eds) Centocelle I: Roma S.D.O. le indagini archeologiche. Rubbettino, Soveria Mannelli, pp 287–290
Macaulay Lewis E (2006) The role of *ollae perforatae* in understanding horticulture, planting techniques, garden design, and plant trade in the Roman World. In: Morel J-P, Tresserras Juan J, Matamala JC (eds) The archaeology of crop fields and gardens. Proceedings of the 1st Conference on Crop Fields and Gardens Archaeology, Barcelona (Spain), 1–3 June 2006. Edipuglia, Bari, pp 207–219
Mariotti Lippi M, Bellini C (2006) Unusual palynological evidence from gardens and crop fields of ancient Pompeii (Italy). In: Morel J-P, Tresserras J, Matamala JC (eds) The archaeology of crop fields and gardens. Proceedings ofthe 1st conference on crop fields and gardens archaeology, Barcelona (Spain), 1–3 June 2006. Edipuglia, Bari, pp 153–159
Marzano A (2014) Roman gardens, military conquests, and elite self-representation. In: Coleman K, Derron P (eds) Le jardin dans l'antiquité: introduction et huit exposés suivis de discussions. Entretiens sur l'antiquite classique, vol 60. Fondation Hardt, Vandœuvres, pp 195–244
Marzano A (2022) Plants, Politics and Empire in Ancient Rome. Cambridge University Press, Cambridge
Massari G (1995) I boschi sacri. In: Cignini B, Massari G, Pignatti S (eds) L'ecosistema Roma, ambiente e territorio: conoscenze attuali e prospettive per il Duemila. Fratelli Palombi Editori, Roma, pp 69–79
Mercuri AM, Allevato E, Arobba D et al (2015) Pollen and macroremains from Holocene archaeological sites: a dataset for the understanding of the bio-cultural diversity of the italian landscape. Rev Palaeobot Palynol 218:250–266. https://doi.org/10.1016/j.revpalbo.2014.05.010
Mercuri AM, Bandini Mazzanti M, Florenzano A, Montecchi MC, Rattighieri E (2013) *Olea*, *Juglans* and *Castanea*: the OJC group as pollen evidence of the development of human-induced environments in the italian peninsula. Quat Int 303:24–42. https://doi.org/10.1016/j.quaint.2013.01.005
Montecchi MC, Mercuri AM (2018) When palynology meets classical archaeology: the roman and medieval landscapes at the *Villa del Casale di Piazza Armerina*, UNESCO site in Sicily. Archaeol Anthropol Sci 10:743–757. https://doi.org/10.1007/s12520-016-0442-9
Moricca C, Nigro L, Masci L, Pasta S, Cappella F, Spagnoli F, Sadori L (2021) Cultural landscape and plant use at the phoenician site of Motya (Western Sicily, Italy) inferred from a disposal pit. Veget Hist Archaeobot 30:815–829. https://doi.org/10.1007/s00334-021-00834-1
Motta L (2002) Planting the seed of Rome. Veget Hist Archaeobot 11:71–78. https://doi.org/10.1007/s003340200008
Murphy C, Thompson G, Fuller DQ (2013) Roman food refuse: urban archaeobotany in Pompeii, Regio VI, Insula 1. Veget Hist Archaeobot 22:409–419. https://doi.org/10.1007/s00334-012-0385-8
Neef R, Cappers RTJ, Bekker RM (2012) Digital Atlas of economic plants in Archaeology, vol Groningen Archaeological Studies 17. Barkhuis, Groningen. https://doi.org/10.2307/j.ctt20p56d7
Pagnoux C, Celant A, Coubray S, Fiorentino G, Zech-Matterne V (2013) The introduction of *Citrus* to Italy, with reference to the identification problems of seed remains. Veget Hist Archaeobot 22:421–438. https://doi.org/10.1007/s00334-012-0389-4
Pignatti S (1995) La vegetazione naturale. In: Cignini B, Massari G, Pignatti S (eds) L'ecosistema Roma, ambiente e territorio: conoscenze attuali e prospettive per il Duemila. Fratelli Palombi Editore, Roma, pp 54–61
Purcell N (1996) The roman garden as domestic building. In: Barton IM (ed) Roman domestic buildings. University of Exeter Press, Exeter, pp 121–151
Reille M (1992–1998) Pollen et spores d'Europe et d'Afrique du Nord. Laboratoire de botanique historique et palynologie, Marseille
Rowan E (2017) Sewers, Archaeobotany, and Diet at Pompeii and Herculaneum. In: Flohr M, Wilson A (eds) The economy of Pompeii. Oxford University Press, Oxford, pp 111–134
Sabato D, Peña-Chocarro L (2021) Maris Nostri Novus Atlas: seeds and fruits from the Mediterranean Basin. Doce Calles Ediciones, Aranjuez
Sadori L, Allevato E, Bosi G et al (2009) The introduction and diffusion of peach in ancient Italy. In: Morel J-P, Mercuri AM (eds) Plants and culture: seeds of the Cultural Heritage of Europe. Edipuglia, Bari, pp 45–61
Sadori L, Giardini M, Masi A (2007) Il paesaggio urbano e suburbano della Roma imperiale. Atti Soc Nat Mat Modena 138:255–272
Sadori L, Mercuri AM, Mariotti Lippi M (2010) Reconstructing past cultural landscape and human impact using pollen and plant macroremains. Plant Biosyst 144:940–951. https://doi.org/10.1080/11263504.2010.491982
Schweingruber FH (1990) Anatomie europäischer Hölzer: ein Atlas zur Bestimmung europäischer Baum-. Strauch- und Zwergstrauchhölzer (anatomy of european woods: an atlas for the identification of european trees, shrups, and dwarf shrups). Forschungsanstalt für Wald, Schnee und Landwirtschaft WSL/FNP. Haupt, Bern
Serlorenzi M (2014) Cave di pozzolana in Urbe. In: Bonetto J, Camporeale S, Pizzo A (eds) Arqueología de la construcción IV. Las canteras en el mundo antiguo: sistemas de explotación y procesos produktivos. Actas del congreso de Padova, 22–24 de noviembre de 2012. Anejos de Archivo Español de Arqueología 69. Instituto de Arqueología de Mérida, Mérida, pp 87–103
Serlorenzi M (2016) Restituire e valorizzare i siti indagati: un dovere o un optional? In: Ferrandes AF, Pardini G (eds) Le regole del gioco. Tracce, archeologi, racconti. Studi in onore di Clementina Panella. Edizioni Quasar, Roma, pp 723–743
Smit A (1973) A scanning electron microscopical study of the pollen morphology in the genus *Quercus*. Acta Bot Neerl 22:655–665
Tally-Schumacher K (2022) Plants as natural ornaments. In: Giesecke A, Mabberley D (eds) A cultural history of plants in antiquity, vol 1. Bloomsbury, London, pp 155–174
Van der Kaars S, Penny D, Tibby J, Fluin J, Dam RAC, Suparan P (2001) Late quaternary paleoecology, palynology and palaeolimnology of a tropical lowland swamp, Rawa Danau, West Java, Indonesia. Palaeogeogr Palaeoclimatol Palaeoecol 171:185–212. https://doi.org/10.1016/S0031-0182(01)00245-0
Vignola C, Bonetto J, Furlan G, Mazza M, Nicosia C, Russo Ermolli E, Sadori L (2022) At the origins of Pompeii: the plant landscape of the Sarno River floodplain from the first millennium BC to the AD 79 eruption. Veget Hist Archaeobot 31:171–186. https://doi.org/10.1007/s00334-021-00847-w
Vignola C, Masi A, Balossi Restelli F et al (2017) δ^{13}C and δ^{15}N from ^{14}C-AMS dated cereal grains reveal agricultural practices during 4300–2000 BC at Arslantepe (Turkey). Rev Palaeobot Palynol 247:164–174. https://doi.org/10.1016/j.revpalbo.2017.09.001
Von Stackelberg KT (2009) The Roman Garden. Space, sense, and Society. Routledge, London