Antonio Campus*/§, Francesca Anichini*, Gabriele Gattiglia*,
Mauro Buonincontri**, Younes Naime***, Marta Rossi**

* MAPPALab – Department of Civilization and Forms of Knowledge, University of Pisa.
** Department of History and Cultural Heritage, University of Siena.
*** Department of Civilization and Forms of Knowledge, University of Pisa.
§ Corresponding author: antonio.campus@cfs.unipi.it

MULTIPROXY ARCHAEOLOGICAL INVESTIGATION AND GARDEN ARCHAEOLOGY IN THE CHARTERHOUSE OF CALCI (TUSCANY, CENTRAL ITALY) AND ITS TERRITORY: RESULTS AND RESEARCH DATA

LINK AL DATASET: 10.13131/UNIPI/SSHS-3M04

Abstract: A wide-ranging archaeological research programme at the Charterhouse and in the broader area of the Municipality of Calci has been performed since 2018. The archaeological research included the collection of legacy and aerial archaeology data, invasive and non-invasive investigations, as well as natural scientific analysis in the monastic complex. Special attention was paid to the archaeological investigations of three different monks' cells gardens (the Prior's, the Apothecary's, and the Master's), and stratigraphic excavations were combined with archeozoological and archaeobotanical analyses to define the horticultural practices implemented over the centuries of occupation of the Charterhouse. Among the three case studies, the most representative is the Prior's meditation garden, where the excavation explored the phases prior to the construction of the building (14th century), the 18th-century renovation in the current form, and its abandonment at the end of the 20th century. Pollen analysis has allowed to reconstruct the richness of herbal species characterising an ever-blooming garden, with flowers and ornamental plants, such as roses, lilac, and water lilies, and also vegetables. According to charcoal and fruit-remain analyses, the Charterhouse exploited local hilly woods, satisfying the requirements of fuel by maquis and thermophilous deciduous forest. The agricultural practices included the cultivation of fruit trees, such as chestnut, olive, almond, and vine. Finally, archaeozoological analysis attests the domestic cat as the most frequent *taxon* in all contexts, probably common in the monastery as a pet and cell companion. This paper presents an overview and a discussion of the results of the investigations conducted and the complete archaeological dataset.

Keywords: Multiproxy investigations, Garden Archaeology, Monastic Complex, Archaeobotany, Archaeozoology, Entanglement

1. Introduction

Since 2018, the MAPPA Laboratory of the Department of Civilization and Forms of Knowledge of the University of Pisa has been conducting wide-ranging archaeological research at the Charterhouse of Calci, coordinated by Gabriele Gattiglia, Francesca Anichini, and Antonio Campus, under the supervision of Maria Letizia Gualandi. The research started as a development-led assessment of the archaeological interest (VIARCH) as part of the larger project "Preliminary studies and research for the conservation and enhancement of the Certosa of

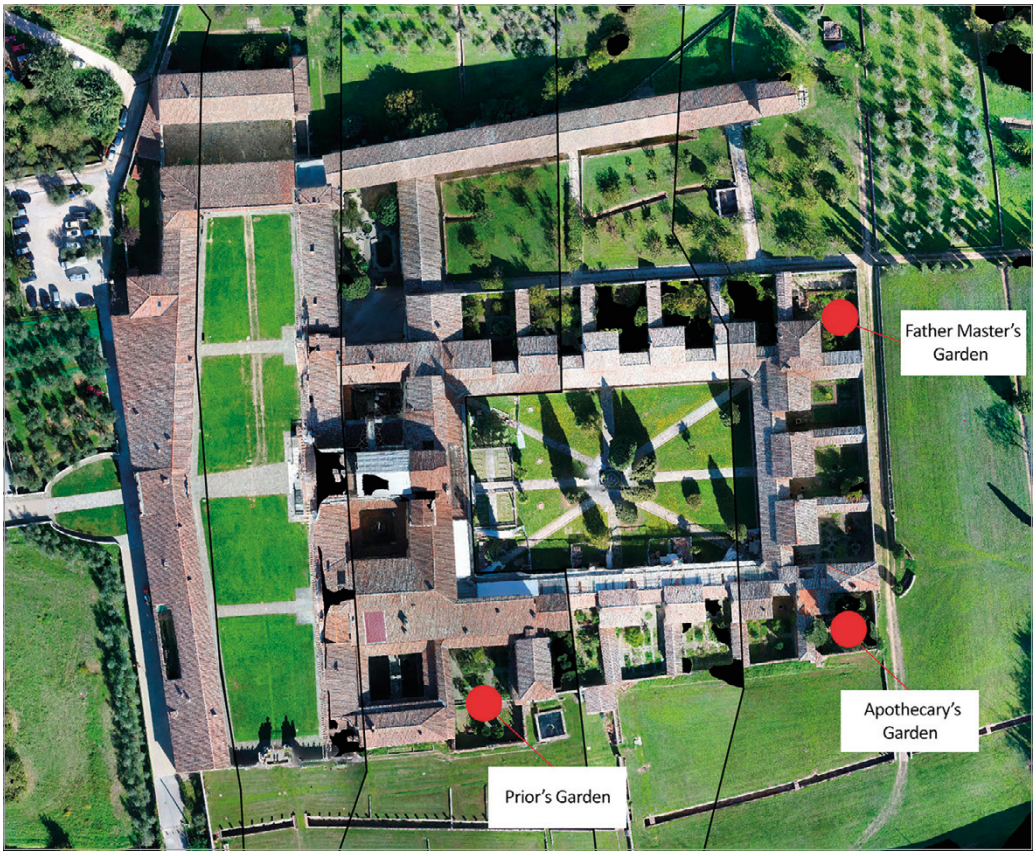

fig. 1. The orthophoto map of the monastic complex with the Prior's, the Apothecary's, and the Father Master's gardens.

Calci Complex and its Museums", led by a multidisciplinary team of the University of Pisa. The overall aim of the project was to produce a detailed analysis of the archaeological potential of the Carthusian Monastery, which had never been investigated before, and the archaeological heritage of its territory, necessary to define a cognitive framework as comprehensive as possible for defining the degree of impact of any works and interventions in the area concerned. From the very beginning, however, the research was designed to achieve the broader scope of analysing the long-lasting transformations of the Charterhouse territory on a landscape scale and the life of the monastic complex in relation to the surrounding environment.

Thus, the first phase concerned the collection and digitisation of known legacy data through archaeological interventions and aerial photointerpretation. A second phase involved the acquisition of new data within the borders of the Charterhouse through non-invasive (aerial archaeology, stratigraphic control of exposed sections, and geophysical survey) and invasive (geognostic coring and excavations) investigations in order to define its construction phases, assess the presence of any buried structure, and acquire stratigraphic data on the topographical layout of the Carthusian Monastery and its functional areas.

Nevertheless, the investigation was not limited to studying the building's architectural and structural aspects and the decorative solutions the monks adopted over time. Instead, the research aimed to investigate the daily life of the Carthusians. For this purpose, a Garden Archaeology project was developed (Anichini et al., 2022). The archaeological investigations focused on three case studies: the gardens of the cells of Father Prior, Father Apothecary and

Father Master (fig. 1). These three gardens were chosen because of the role played within the community by the Fathers who lived there and because they could provide different examples of architectural arrangement and presumably variety of cultivated species. Indeed, the figurative picture of the gardens was not the result of an imposed model, and there was no rule or custom on cultivating them. It was rather an expression of individual monks' intimate relationship with nature (Venturi Ferriolo, 1990, p. 76).

The gardens were approached as strongly anthropic "landscapes" of limited extent, studying their development and relationships with the wider surrounding environment, plant communities, and crops practised inside and outside the monastic building. In this way, the archaeological investigation aimed at the diachronic study of the gardens as an expression of individual monks' feelings and relationships with nature and divinity and, more generally, to investigate the complex interrelationship of human and non-human agencies inside and outside the gardens.

2. Historical overview of the Charterhouse and the cells' gardens of the Father Prior, the Father Master, and the Father Apothecary

The birth of the Carthusian order was part of the 11th-century reform movement in the Catholic Church that led to the founding of new religious orders combining manual labour with solitude and contemplation, so-called monastic hermitism. The first Charterhouse was founded by Bruno of Cologne in 1084 CE in an uninhabited mountainous place called Chartreuse in the lower Alps near Grenoble. In the following centuries, the Order spread widely, and from the founding of the Grande Chartreuse in 1084 until 1783 CE, 261 Charterhouses were built in Europe. Since the early 14th century, the Carthusian order was also present in Tuscany, and Carthusian monasteries were built in the territory of Florence, Lucca, and Siena (Giusti & Lazzarini, 1993, pp. 30-31; Manghi, 1911, pp. 5-6).

The construction of the Charterhouse of Calci was determined by the testamentary will and bequest of goods of a wealthy Pisan merchant, Pietro di Mirante della Vergine, executed by the priest Nino di Puccetto. The foundation was authorised in May 1366 by the Archbishop of Pisa Francesco Moricotti in a secluded place called *Vallis Gratiosa*, chosen to encourage the isolation imposed by the Rule of the Order, and the monastery was dedicated to the Virgin Mary and St. John the Evangelist. The first nucleus was built by the end of the 14th century. In the second half of the 15th century, the complex was enlarged with the construction of new monks' cells and green spaces were prepared for vegetable gardens. Between the 17th and 18th centuries, extensive renovation led to its appearance. During WWI, the Charterhouse was partially converted into barracks and a military hospital. In 1969, the Order decreed the closure of the monastic community, and in 1972 the monks left the Charterhouse. The Italian Ministry of Cultural Heritage directly took over its management, establishing the National Museum of the Monumental Charterhouse of Calci. Finally, in 1979, the complex was partially entrusted to the University of Pisa, housing the Museum of Natural History (Gioli, 2015, p. 12; Giusti & Lazzarini, 1993, p. 53; Manghi, 1911, pp. 1-5).

During the first phase of the construction of the monastery, the perimeter of the cloistered wall was defined to contain the Fathers' cells. Although, the cloister developed in a modular way through the serial addition of each monk's cell with its portico (Giusti, 1990, p. 165). Among the earliest ones built is the Prior's cell, the first nucleus of which dates to 1375. The structure was enlarged in 1483 with the construction of an internal loggia and again renovated in the first decades of the 17th century, finally taking on its present appearance during renovations in the late 18th century. In its current state, the Prior's Garden is organised into two levels connected by a staircase. The upper terrace facing the loggia to the north is marked by orthogonal paths divided by four small flowerbeds. The original symmetrical articulation of paths and flowerbeds was partially compromised in 1825 by the enlargement of the building necessary

to consolidate the adjacent library. The lower terrace to the south is characterised by two side flowerbeds and an octagonal basin with a fountain placed in the centre. The fountain is aligned with a grotesque backdrop decorated with encrustations, depicting a seated monk reading in solitude within an illusory architecture, topped by a pediment (Giusti, 1991, pp. 34-36; Giusti & Lazzarini, 1993, pp. 107-108).

The presence of the pharmacy and the apothecary 18th-century inventories attest to the specialised cultivation of medicinal plants. It is not known where these cultivations were conducted, although it is likely that they were practised in defined spaces within the outdoor vegetable gardens. In fact, the cell of the Father Apothecary, located at the southeast corner of the monastic building, is the only one with direct access to the outdoor gardens (Giusti, 1991, p. 32; Giusti & Lazzarini, 1993, pp. 107-108).

Finally, the garden of the Father Master's cell, as it looks today, has an "L"-shaped layout, subdivided into an area dedicated to the well and the actual *hortulus*. The *hortulus* is arranged in geometric flowerbeds: a square one in the centre and four "L"-shaped ones around it. A loggia to the south, and a terrace with flowerbeds, to the north are added (Giusti, 1991, pp. 36-37).

3. Archaeological legacy data on the Charterhouse and the Municipality of Calci

During pre-field work, all available archaeological data on the Charterhouse and Municipality of Calci was collected, including both published (Alberti, 2014; Amante Simoni et al., 1986; Codagnone, 1992; Fascetti, 1997; Grifoni Cremonesi & Tozzi, 1994; Nannipietri & Redi, 1982; Taddei, 1997) and unpublished materials, such as Master's degree theses (Bandinelli, 2014-2015; Niccoli, 2013-2014) and archival documents preserved by the Superintendence offices (ex-SBATOS and SABAP-PILI). All legacy data were acquired, digitised, and geolocated following the workflow developed by the MAPPA project (Anichini et al., 2012; 2013). This way, 19 archaeological interventions and 18 historical sites were catalogued, covering a large time span from Prehistory to the Contemporary Age (fig. 2).

The most ancient archaeological evidence is testified by out-of-context finds of prehistoric flints in the excavation at "Podere San Vito" (Amante Simoni et al., 1986; Nannipietri & Redi, 1982), and of Final Bronze Age pottery in the excavation at "Lo Spuntone", near "Campaccio" (Taddei, 1997), whereas a hoard of Ancient Bronze Age axes was found inside an ancient quarry near the "Rocca della Verruca" (Grifoni Cremonesi & Tozzi, 1994).

Archaeological evidence of the Archaic and Classical Etruscan periods is limited to pottery sherds and traces of a 5th-century BCE settlement, including some wall structures, a ballast, and a water channelling system, at "Lo Spuntone". The strategic position of the site on a hill ridge attests to its defensive function, controlling the coastal plain and the urban centre of Pisa with its landings and waterways. Isolated finds, such as a stone slab with an Etruscan inscription at the "abbey of Calci" (Codagnone, 1992, p. 54, n. 155.1), some Etruscan pottery sherds on a hill near "Monte della Verruca", or some Etruscan and Hellenistic sherds at the foot of the Bianco and Focetta mountains, in the locality known as "I Grugoli", are attributable to a not-better-specified frequentation of the territory.

Similarly, little evidence of the Roman age is known. A Black-glazed Ware fragment is reported in "Podere San Vito", and Terra Sigillata and amphorae are testified nearby the village of Montemagno (Fascetti, 1997, p. 29 and note 3). More relevant would be the uncertain identification of a Roman villa in the locality "Buca di Nerone" at the "Abbey of Calci" (Codagnone, 1992, p. 54, n. 155.2). Although the information is too vague to be considered reliable, human presence in the Roman age seems probable based on the identification of centurial axes through aerial archaeology and the discovery of Roman imperial water or storage tanks for productive purposes below the Pieve of Caprona, close to the boundaries of the Municipality of Calci.

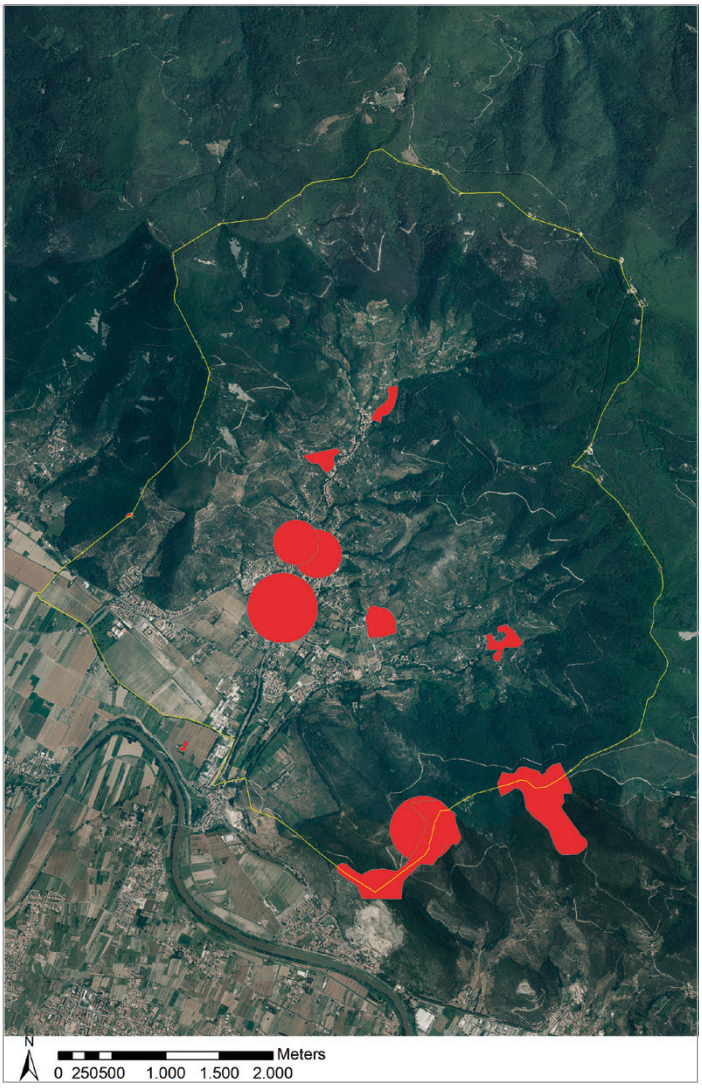

fig. 2. The archaeological interventions in the Municipality of Calci described as polygons in GIS.

Even archaeological data on the Middle Ages is poor. The excavation in "Podere San Vito" reported the early medieval church of San Vito, consisting of a modest rectangular room divided into two bays. The most relevant phases of the ecclesial building date back to the late Middle Ages. Between the 10th and 12th centuries, a larger hall with a semi-circular apse was built next to the pre-existing building, creating a two-nave complex. In the same period, a square bell tower was added, and the building was extended and enriched with a portico on the facade. A cemetery area with at least three phases of deposition, dating between the 11th-12th and mid-15th centuries, was found inside the ecclesiastical building and all around it. A mass grave pertains to the last phase of deposition.

After a prolonged period of abandonment, in the late Middle Ages, a fortified complex consisting of a tower and trapezoidal-shaped walls was established at the aforementioned site of "Lo Spuntone". A series of wall structures have been reported in the locality known as "Gangalandi", perhaps belonging to the "Castle of Ripabrunoli", then "*de Vicecomes*", documented since 1046 CE (Fascetti, 1997, pp. 113-115). Some stone structures visible on the road

leading to Monte Serra (Castelmaggiore) could testify to the presence of a medieval village coeval with the castle (Alberti, 2014).

In addition to random ceramic finds, some abandoned and cultivated areas in San Vito and in "Lo Spuntone" are dated to the Modern Age. During renovation work of a house in the town of Calci, 36 silver coins with the effigies of the Grand Dukes Ferdinando (1794-1800), Leopoldo (1769-1806), and Francesco III (year unreadable) were also found.

As for the Contemporary Age, some machine gun casings dated back to 1943 in "Lo Spuntone" refer to the presence of a military post during WWII.

Although never systematically investigated, the territory proved to be inhabited from Prehistory to the contemporary age. Despite this evidence, the archaeological knowledge of the Charterhouse and the nearest area appeared insufficient, and the only archaeological finds pertaining to the monastic complex were "ceramic fragments and other materials" collected in a well in 1986. No pre-existing structures were known, nor had the construction phases of the monastery been stratigraphically investigated.

4. Methods

The systematic examination of the archaeological legacy data revealed a fragmentary knowledge of the Charterhouse and the entire Municipality of Calci. Side by side with the analysis of the data acquired, a dual strategy consisting of non-invasive and invasive investigations was chosen for acquiring new data. Non-invasive investigations focused on aerial archaeology, stratigraphic control of exposed sections, and geophysical survey. Invasive investigations included geognostic coring and excavations.

Aerophotographic interpretation was conducted by observing all the aerial images available on the GEOscopio of the Tuscany Region (1954-2012)[1] and the Marcello Cosci Archive held by the Department of Civilization and Forms of Knowledge.

The lack of archaeological interventions within the boundaries of the Charterhouse recommended the acquisition of new stratigraphic data for a better definition of the archaeological potential. Therefore, a stratigraphic control of nine samplings (long approx. 1.5 m for a height varying between 0.6 and 0.9 m) was conducted along the earthen banks of the water channels (figs. 3 and 4).

Three geophysical surveys were carried out to verify the presence of any buried feature in the Cortile d'Onore, the large courtyard at the entrance of the monastery. The Ground Penetrating Radar surveys were led by the team of Adriano Ribolini of the Department of Earth Sciences of the University of Pisa. Two different sectors were investigated: the first in the northern part of the Cortile d'Onore; the second in the southern one. A single-channel GPR with a 200 MHz antenna and a line distance of 40 cm (variable) was adopted in the first campaign. The second campaign focused exclusively on the northern portion of the Cortile d'Onore, in an area of 27×20 m, partially investigated in the first campaign. In this case, a Hi Mode GPR with two antennas (200 and 600 MHz) was used, keeping a line distance of 40 cm (variable).

Geognostic surveys made it possible to explore the archaeological deposit of the green spaces around the building to great depths, allowing the acquisition of stratigraphic data on the Carthusian monastery's previous and contemporary anthropic frequentations.

The archaeological investigation has focused on the structural transformations of the gardens of the Prior's, the Apothecary's, and the Father Master's cells, paying special attention to pedological variations, horticultural works, and biological alterations (roots, animals, microorganisms, etc.) to obtain a detailed picture of the cultivation practices, planting/explanting, fertilisation, etc. (Anichini et al., 2022).

[1] https://www.regione.toscana.it/-/geoscopio

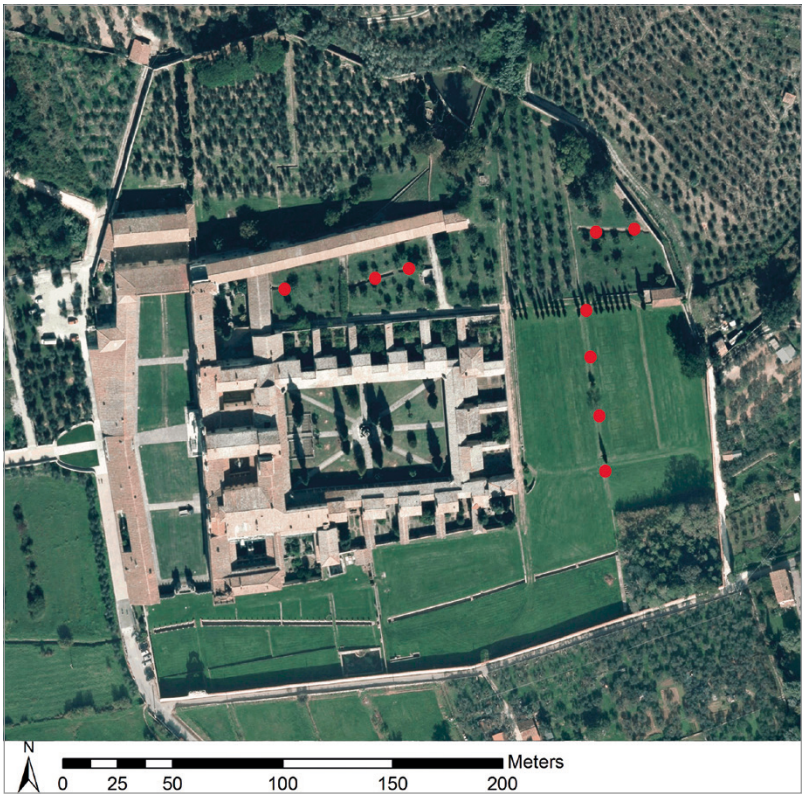

fig. 3. The location of the nine samplings chosen for the stratigraphic control of the exposed sections.

fig. 4. The stratigraphic control of one of the exposed sections shows a succession of horticultural layers.

Two areas were excavated in the Prior's Garden: a larger one on the lower terrace (sector I) and one of limited extension on the upper terrace (sector II) (fig. 5). In the lower terrace, the excavation extended from the octagonal flowerbed located in the eastern half of the garden to the central fountain and the southern back wall. In the upper terrace, the excavation area included part of the hexagonal flowerbed located in the western half.

fig. 5. Excavation in progress in the flowerbed of the Prior's garden.

In the Apothecary's Garden, one of the flowerbeds near the southern back wall was investigated, while in the Master's Garden, the archaeological investigations focused on the *hortulus*, within the central flowerbed (sector IV), in the flowerbed bordering the eastern perimetral wall (sector V), and, finally, within the north-eastern side flowerbed (sector VI).

During the investigation, a Structure-from-Motion-based field documentation workflow was employed to obtain a high-resolution 3D spatial reconstruction of the archaeological stratigraphy. SfM is a multi-image photogrammetric technique for extracting three-dimensional data from overlapping sets of two-dimensional photos, which is increasingly being adopted in archaeology to digitise surfaces, landscapes, and objects (see, e.g., Jones & Church, 2020).

The investigation in the Fathers' gardens can be ascribed to the field of Garden Archaeology and included pollen analysis, carried out by the research group directed by Anna Maria Mercuri of the Palynology and Paleobotany Laboratory of the Department of Life Sciences of the University of Modena and Reggio Emilia, anthracological and carpological analysis, performed by Mauro Buonincontri of the University of Siena, and the study of animal bones executed by Younes Naime, PhD student at the University of Pisa.

Samples from highly informative Stratigraphic Units were chosen for pollen analysis: 4 from the Prior's, 3 from the Apothecary's, and 5 from the Master's Gardens. After the extraction treatment (Florenzano et al., 2012), pollen analysis was performed at 400x and 1000x magnifications under oil immersion. Pollen determination was carried out using dichotomous keys, photo atlases (Moore et al., 1991; Reille, 1999), and the comparison pollen collection of the University of Modena Laboratory. Undetermined pollen grains were included in the pollen sum. Non-pollen palynomorphs (NPPs) were identified according to van Geel's methodology (Van Geel, 1986).

Plant macroremains were analysed on 10 SUs from the Prior's, 8 SUs from the Apothecary's, and 7 SUs of the Father Master's Gardens. Plant remains were obtained by water sieving, taking a variable percentage of the total sediment ranging from 10-25% for the larger SU to 100% for those of limited extent (e.g., ash lenses, small hole fills). Anthracological analysis concerned charcoal larger than 2 mm, observed under a reflected light optical microscope at magnifications of 100x, 200x and 500x. Wood anatomy atlases were used as references (Abbate Edlmann et al., 1994; Schweingruber, 1990; Vernet et al., 2001). Charcoal remains were quantified, and percentual frequency was calculated on the sum of SUs grouped by the chronological interval. Charcoal has been identified to species or genus level (botanical nomenclature follows Pignatti, 1982) or according to taxonomic nomenclature. In a limited number of cases, poor conservation or vitrification of the finds allowed identification to the family level or none. Carpological analysis was performed under a stereomicroscope using magnifications from 0.5x to 20x. Undamaged seeds were separated from fragmentary seeds,

quantifying both groups, and each category was identified and subdivided by carpological type based on morphological characteristics. Each type was subjected to optical microscope observation for taxonomic recognition at the level of species, genus, or taxon (Neef et al., 2012. Again, the taxonomic nomenclature refers to Pignatti (1982).

The faunal sample was studied by direct comparison with the reference collection of the Laboratory of Archaeozoology, University of Pisa, while the fish remains were identified thanks to Vito Giuseppe Prillo (University of Padua).

5. Results

The results of the investigations make it possible to gain more specific knowledge of the monastic complex and the entire territory of the municipality of Calci.

The already known persistence of the main axes and the *limites intercisivi* of the Roman centuriation has been verified through aerial archaeology. A *cardo* is recognisable along the current Via Oberdan Brogiotti and along Via del Paduletto in the neighbouring Municipality of Caprona. Uncertain seem to be the centurial traces of a *decumanus* in a road section of Via della Propositura and a *cardo* in a section of the provincial road Vicarese/Arnaccio Calci (Niccoli, 2013-2014, pp. 91-94; Vaggioli, 1990, p. 129). Within the boundaries of the Charterhouse, a series of sub-rectangular traces arranged in two rows has been identified in the eastern garden (fig. 6). The collection of oral sources allows us to establish that these marks must be traced to contemporary agricultural practices, as reported by the gardeners employed after the Carthusians left the monastery.

fig. 6. Sub-rectangular anomalies distributed in two rows in the eastern garden of the Charterhouse.

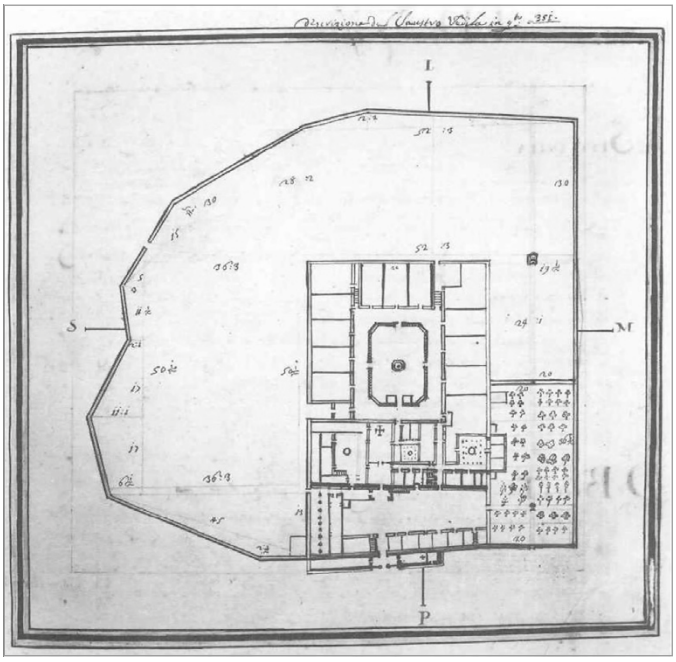

fig. 7. Map of the Charterhouse in 1688 (ASPi, Inventory n. 14, 209; Giusti & Lazzarini, 1993, p. 52, fig. 20).

fig. 8. The overlay of the 1688 and 20th-century maps, achieved in a GIS environment, enlightens the transformations of the Cortile d'Onore happened in the late 18th century.

Stratigraphic control of the exposed sections and geognostic surveys confirmed the horticultural destination of the land surrounding the monastic building, documenting an overlapping of horticultural layers. Ceramic materials and metal slags were recovered in the exposed sections: the pottery is dated to the 14th-15th century (Maiolica Arcaica monocroma), the 16th-17th century (Maiolica su ingobbio, Ingobbiata Monocroma e dipinta), and the 18th-19th century (Taches Noires, Ingobbiata dipinta, scaldini invetriati, mezzine invetriate in verde, maiolica di Capraia, etc.). Similarly, in geognostic investigations, ceramic materials refer to chronological horizons from the late Middle Ages to the Modern and Contemporary ages.

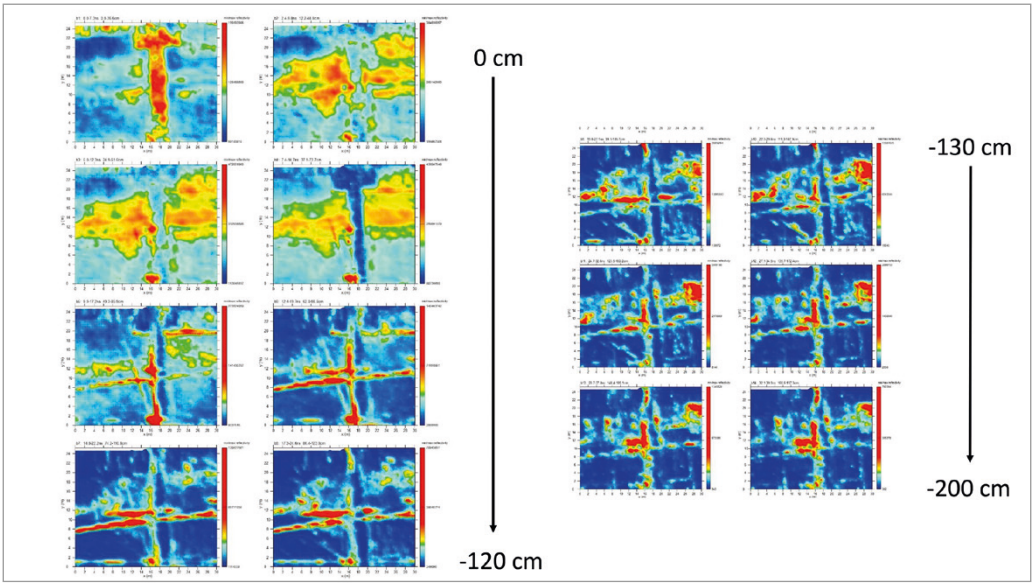

fig. 9. The outcomes of the investigation of the first sector of the Cortile d'Onore realised with a Hi Mode GPR.

Archival research has contributed to the definition of areas suitable for archaeological investigation within the Charterhouse complex: a map of the plumbing systems of the Cortile d'Onore, drafted during unspecified works in the contemporary age and preserved in the Charterhouse Archives, indicated the presence of "ancient walls" and "foundations". These features, geolocated and overlapped to a 1688 map of the Charterhouse (ASPi, Inventory n.14, 209), seem to define the original perimeter of the Cortile d'Onore, which was then enlarged at the end of the 18th century (figs. 7 and 8). In the northern portion of the Cortile d'Onore (fig. 9), superficial linear features between -0.50 and -0.60 m and again between -0.90 and -1.20 cm are attributable to underground services, such as the water system. From about -1 m and down to -1.50 m, complex-oriented features, among which a sub-quadrangular one is noteworthy, could be referred to buried structures, such as walls and – perhaps – paved rooms. The "ancient walls" indicated in the above-mentioned map are not recognisable. Perhaps they fall under the paved driveway that crosses the courtyard from east to west. In the southern sector, superficial features are identifiable as underground services, but starting from a depth of -0.70 m, a quadrangular-shaped feature is constantly present down to the maximum depth of -2 m. This anomaly is probably the so-called "foundation" reported in the map. From the depth of about -1 m and down to about -1.3 m, rectilinear anomalies are visible, even diverging from the main orientation of the monastic complex (fig. 10).

5.1 Stratigraphic investigations in the cells' gardens of the Carthusian Fathers

5.1.1 The garden of the Prior

The earliest human activities in the area of the Prior's Garden have been identified on the upper terrace: between the end of the 14th and the mid/second half of the 15th century, the gossan bank was levelled for the construction of the garden. Its interface became a trampling surface, and a small sub-circular hole was dug for a pole, possibly related to horticultural activities. Between the second half of the 15th and the beginning of the 16th century, the pole was removed, and the small hole was filled in.

In the lower terrace, the excavation has identified a large, stepped cut made in the gossan bank during the 17th century. A brick wall, preserved for just a single row and probably forming

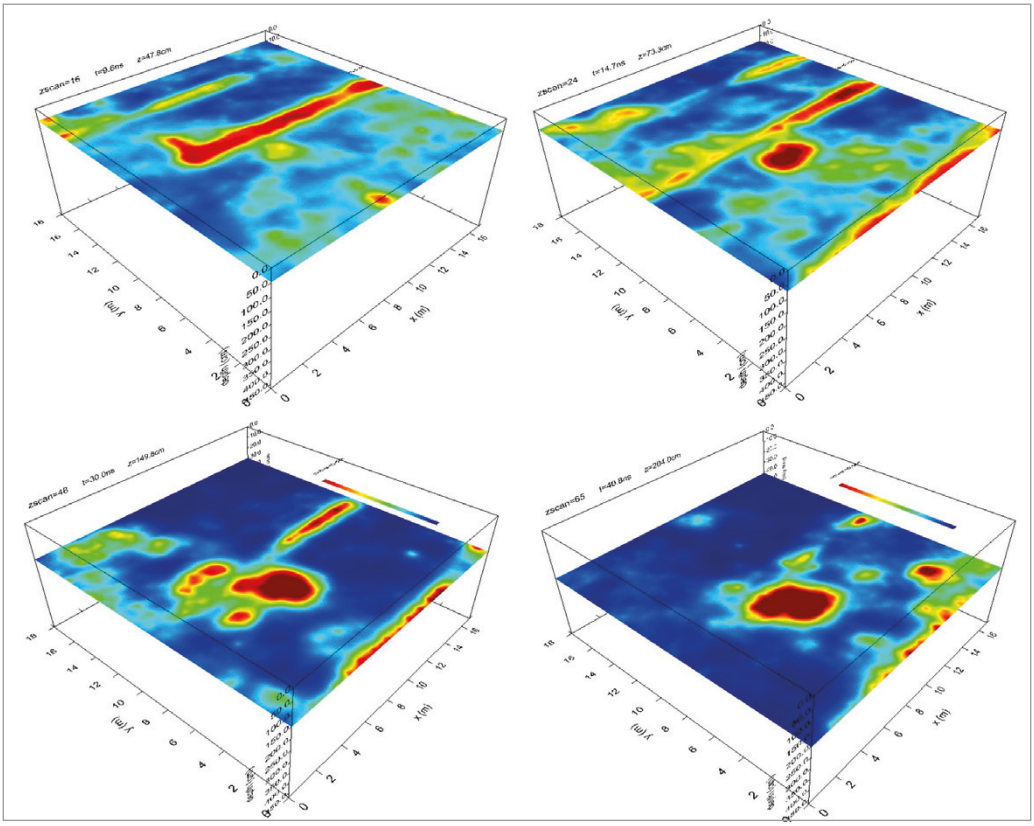

fig. 10. The outcomes of the investigation of the second sector of the Cortile d'Onore achieved with a single-channel GPR.

fig. 11. Sfm-based 3D model of the eastern basin and the octagonal fountain.

fig. 12. Skeletal remains of a cat during excavation.

the original boundary of the garden, was built on its edge, while the cut was filled with debris and agricultural layers.

Around the mid/second half of the 18th century, the garden was reorganised, and this border wall was demolished and obliterated by a layer of debris. On the lower terrace, the fountain and the octagonal flowerbeds were built. In this phase, the fountain consisted of an octagonal basin flanked by two rectangular basins on the east and west sides. The eastern rectangular basin, the only one investigated, consisted of two parallel brick shoulders, a perpendicular partition wall, and a sloping floor probably used for cleaning operations (fig. 11). This water-collecting system was undoubtedly ornamental, as evidenced by pollen of water lilies – *Nymphaea* and *Nuphar* – other aquatic plants and traces of hygrophilous wood widespread in pollen diagrams; but it could also have functioned as a fishpond. A layer of mortar with ceramic fragments disposed on its trampled surface dates this construction activity to the late 18th century, a date consistent with the grotesque built between 1756 and 1767 by Angiolo Somazzi. These building interventions were aimed at realising a "meditation garden" with a water feature and floral decorations that converged scenically in the grotesque backdrop. During the same renovation works, the ground was raised with earth and debris on the upper terrace, and the flowerbed was built with a brick-stone foundation and a stone curb.

In a later phase, the basins were partially transformed, demolished and obliterated. The octagonal basin in the centre of the garden became a stand-alone ornamental fountain with a pile of stones at the centre, creating a fake 'island' as decoration. At the same time, a flowerbed was probably created along the southern boundary wall, with sandstone curbs set above the demolished southern parapets of the pre-existing side basins. Garden paths were redesigned by laying a layer of gravel around the fountain and the flowerbeds.

Gardening practices inside the flowerbeds range from the late 18th to the second half of the 20th century, testifying to prolonged and continuous use. To the last use of the flowerbed belong the skeletal remains of a domestic cat (*Felis catus*), intentionally buried in the octagonal flowerbed inside a wooden box, as suggested by the presence of charcoals and eight small nails (fig. 12). Afterwards, the flowerbed was used as an occasional dump site during some minor garden wall restoration activities and for sporadic horticultural purposes in the present time.

In the upper terrace, on the interface of the first fill layer of the flowerbed, produced by the continuous gardening activities, the planting hole and subsequent explant (datable to the 19th century) of an arboreal species, perhaps an *Acer* (maple) according to the pollen analysis, was found. The following layers attest the horticultural works that took place between the 19th and 20th centuries, consisting of the cultivation of aromatic plants such as *Allium* (garlic), *Daucus* cf. *carota* (carrot), *Raphanus* (horseradish), and *Mentha* (mint). On the upper interface of these levels, a series of small holes probably testifies the presence of poles supporting plants, subsequently explanted and obliterated by the current humus layer.

fig. 13. Sfm-based 3D model of the simultaneous dumping of mortar and charcoals inside the flowerbed of the Apothecary's garden.

5.1.2 The garden of the Apothecary

In the 15th century, a series of layers of debris levelled the sloping surface of the gossan bank. Three small and shallow holes cut on the most recent layers attest to agricultural practices such as removing trees. In addition, a series of levelling layers with charcoals and burned sediment was deposited, resulting from throwing materials from one or more fires. In the 17th century, the first phase of gardening ended with a progressive growth layer.

Between the 17th and 18th centuries, the garden reached its present appearance. The flowerbed was built by cutting a ditch in the previous layers and laying a masonry foundation completed with a sandstone curb which also served as a support for a pergola that crossed the garden. Once filled in, the flowerbed was subjected to continuous gardening practices evidenced by a succession of planting and removal of vegetable species, such as a circular re-cut made to remove an arboreal species in the southwestern corner of the sector, two cuts filled with drainage material, and an ovoid-shaped hole attributable to the planting of (probably) a *Syringa vulgaris* (Lilac).

The last phase is represented by the simultaneous dumping of mortar and charcoals (fig. 13) and a progressive natural growth deposit, followed by a grey-whitish layer resulting from the decomposition of the roots of the existing cypress tree.

5.1.3 The garden of the Father Master

The flat interface of the gossan bank in sectors IV and VI of the Master's Garden probably testifies to an extended cutting action for levelling the original morphology of the hill, still visible in the sloping profile within sector V (fig. 14).

The first phase of the garden predates the 19th-century renovation and has been identified by removal cuts of previous trees (probably *Quercus*, *Fraxinus*, *Pinus*, and *Acer*, according to palynological analyses) and two post holes, possibly installed to support one or more trees. The eastern boundary wall and the parallel espalier flowerbed were probably built in the same phase. An artesian well, identified in the northern section of sector VI and only partially excavated, could also have been part of the same spatial organisation.

During the 19th century, the garden was remodelled to assume its still visible appearance by constructing the flowerbeds and laying the brick paving. In the centre of the *hortulus* (Sector IV), the foundation cut for the square flowerbed was excavated, and a masonry foundation was laid, completed with a curb consisting of vertical bricks and quadrangular concrete

fig. 14. Sfm-based 3D model of the three archeological sectors in the Father Master's garden.

corner elements with pyramid cusps. The flowerbed was then filled with a draining layer of gravel and a subsequent garden level. As in the previous phase, a small sub-circular shallow hole was made to plant an arboreal species located in the centre of the *hortulus*. Two further layers related to horticultural works close the stratigraphic sequence. In sector VI, during the garden renovation, the well was filled with debris and, once the flowerbed was completed, covered with a sandy silt layer like the entire flower bed. The same construction technique used for the central flowerbed was observed here. On the surface, a small sub-circular hole testifies to the horticultural activities of planting and explanting arboreal species. Two layers related to the abandonment and humification phase closed the sequence.

In the flowerbed along the eastern boundary wall (sector V), the oldest activity is a series of three holes referable to gardening practices. This activity was followed by a series of garden layers on which two small holes were dug, testifying to the planting and removal of small trees. Two gardening layers closed the stratigraphic sequence.

5.2 Results of archaeobotanical analysis

5.2.1 Pollen analysis

In the garden of the Prior, the pollen diagrams reveal a wide variety of botanical species, consisting mainly of herbaceous plants (87-91%). In addition to the aquatic, such as the aforementioned *Nymphaea* and *Nuphar*, granules of cultivated vegetable plants were observed, such as *Allium* (garlic), *Daucus* cf. *Carota* (carrot), *Raphanus* (horseradish), and *Mentha* (mint) (about 3% on average). Traces of ornamental plants were also found, including Rosaceae: *Aphanes*/*Alchemilla* (parsley-piert/lady's mantle), *Filipendula*, *Potentilla* (cinquefoils), and *Rosa* (rose), often planted as hedges; "pseudo-climbing plants", such as *Solanum*; or species probably chosen for different seasonal blooms, for example, *Adonis*, *Anagallis* (pimpernel), *Oxalis*, *Geranium*, *Papaver*, *Polygala* (milkworts) in summer; *Primula* (primrose) and *Liliaceae* s.l. (lily) in spring; *Helleborus* (hellebores) in winter; *Herniaria* (rupturewort), *Saxifraga* (saxifrages), and *Sedum* (stonecrops), graceful blooming evergreens. The few local trees might have included field maples and hazels, while ivy and evergreens covered the perimeter walls. The context of the area must have included cereal cultivation of the *Hordeum* group (barley) and *Avena*/*Triticum* (oats/wheat), as well as tree crops (such as walnut, olive, hazel, and perhaps grape vine).

The three pollen samples in the Apothecary's Garden returned high floristic diversity (from 43 to 58 taxa), with 78-84% herbaceous plant pollen. However, the presence of woody plants

is significant, such as *Quercus* (oak) (6.3%), *Fraxinus ornus* (manna ash) (4.0%), *Juniperus*/*Cupressus* (juniper/cypress), and *Ulmus* (elm) (> 2%). Well represented are also *Hedera* (ivy) (up to 3.0%) and *Erica* (heather), among ornamentals, *Corylus avellana* (European hazel) and *Vitis vinifera* (grape vine) (1% each), among woody plants. The presence of chestnut-*Castanea sativa* is rare (4% in a single sample) and could be related to acid soil transport from a forest rather than local planting. Among the woody species, in addition to oak, hazelnut and alder, present in all samples, *Syringa vulgaris* (1% on average), Lilac, a shrub appreciated for its fragrant flowers, is of particular interest. Wetlands are hardly found in this garden, although the presence of water buttercups and willows is evident. Cereals (1.4%) suggest that straws were used in horticultural practices. High values of ornamental-medicinal-aromatic plants have been identified, such as lamb's lettuce, a variety of salads, and *Cirsium*, sometimes used in cooking as an artichoke. A very widespread find is *Apium*, which could be cultivated based on the high percentage of attestations. Celeriac (*Apium graveolens* var. *Rapaceum*) can be easily preserved even for 4-5 months and is used for medicinal purposes, cooking, and preparing infusions. *Peucedanum* can also testify to the production of medicines and the preparation of some liqueurs. Other herbaceous plants such as *Salvia* and Mallow, *Hypericum*, and *Papaver* are food- and medicinal-related and can be cultivated or grow spontaneously.

In the Master's Garden, the diversity of pollen taxa is variable (from 25 to 49) and testifies to less species-rich sectors, perhaps poorly cared for (many herbaceous, especially Poaceae), and others characterised by a wide variety of cultivated woody and herbaceous plants. The different state of preservation of pollen grains in the same sample suggests that some grains could have arrived with soil brought from elsewhere for cultivation practices; this may have been the case, for example, of coniferous pollen (*Pinus*, pine; *Abies*, Fir), as well as it could explain the frequent presence of chestnut pollen (up to 11%). High values of *Alnus* (alder) (up to 3.7%), *Corylus* (hazel) and *Castanea sativa* (chestnut), as well as traces of *Olea* (olive tree) and *Vitis* (grape vine), were observed in the different sectors. Among shrubs, *Syringa vulgaris* (Lilac) is quite common. Some Mediterranean shrubs produce lovely and long-lasting flowers in summer: *Cistus*, *Helianthemum* (rock rose), and *Erica arborea* (heather) were found in good quantities in all samples. Finally, *Hedera helix* (ivy) and *Jasminum* (the fragrant jasmine) are climbing plants usually present in gardens. Wetland plants are more significant than elsewhere, such as aquatic buttercups, sometimes not well discriminable from other types of buttercups; Ranunculaceae (buttercups) are 5.5% on average (*Ranunculus* type, *Ranunculus parviflorum* and *Thalictrum*); Cyperaceae, especially *Scirpus* (club-rush), are also common (about 2% on average). Many ornamental-medicinal-aromatic plants have been identified: in addition to the same species already reported in the Apothecary's Garden, *Mentha* and *Cannabis* are added. Hemp was used both for fibres and textile, rope and paper products, and for its medicinal and psychoactive properties useful in medicine; oil can also be extracted from the seeds, and the leaves can be used as animal feed. Finally, *Primula vulgaris* (primrose) and *Anagallis* (pimpernel) have graceful flowers that could adorn a flowerbed, together with *Cyclamen* (cyclamen), *Filipendula* and *Rosa*, which are present in all pollen samples.

5.2.2 Anthracological analysis

In the Garden of the Prior, anthracological analysis reveals the predominance of non-cultivated plants (67,5% of the determined charcoals) attributable to woodlands and semi-natural areas. Woodlands are mainly represented by sclerophyllous evergreen taxa (22%) and by mesophilous and thermophilous deciduous broad-leaved trees (22,4%), as well as conifer (16,4%). Cultivated taxa (32,5%) have been dominated by *Castanea sativa* (chestnut, 19,8%) since the second half of the 15th century. Deciduous vegetation is represented by arboreal plants such as *Quercus* cf. *cerris* (Turkey oak), *Fraxinus* cf. *ornus* (manna ash), *Fagus sylvatica* (European beech), *Ostrya carpinifolia* (European hop-hornbeam). Sclerophyllous evergreen formations are represented by shrubs, such as *Rhamnus*/*Phillyrea* (buckthorns/phillyrea), *Erica* (heather), *Arbutus unedo* (strawberry tree), *Smilax* (sarsaparilla), and *Viburnum* (viburnum), and

by arboreal plants such as *Quercus* cf. *ilex* (holm oak). The high percentage of *Pinus halepensis*/*pinaster*, almost certainly *P. pinaster* (maritime pine), may be related to one of the largest hillside concentrations of this conifer in all of Tuscany, on nearby Mt. Pisano. Lowland, plain, and riparian environments are represented by *Fraxinus* cf. *oxycarpa* (Narrow-leaved ash) and *Alnus* (alder). Species of agricultural interest, in addition to chestnut, are *Olea europaea* (olive tree*), Juglans regia* (walnut), *Prunus* cf. *dulcis* (almond tree), and *Vitis vinifera* (vine).

In the Apothecary's Garden, the anthracological study involves 751 charcoals (680 determined) with 24 taxa. Uncultivated plants (20) are prevalent, and 95,3% can be attributed to woodlands and semi-natural areas. The woodlands are mainly represented by mesophilous and thermophilous deciduous broad-leaved trees (11 taxa, 47.2%), sclerophyllous evergreen formation (6 taxa, 17.8%), and conifer (16.6%). The percentage of cultivated taxa (4-4,7%) is dominated by *Olea europaea* (olive tree, 3.5%). Deciduous vegetation is represented by arboreal plants, such as *Q.* cf. *cerris* (Turkey oak), *F. cf. ornus* (manna ash), *Ulmus* (elm), *O. carpinifolia* (European hop-hornbeam) and *F. sylvatica* (European beech). Undergrowth shrubs, such as cf. *Crataegus* (hawthorn) and *Cornus* (Cornelian cherry/common dogwood), are also attested. Riparian environments are represented by *Alnus* (alder). Sclerophyllous evergreen vegetation includes shrubs such as *Erica* (heather), *Rhamnus*/*Phillyrea* (buckthorns/phillyrea), *Smilax* (sarsaparilla), *A. unedo* (strawberry tree) and *Viburnum* (viburnum), and finally arboreal plants such as *Q. cf. ilex* (holm oak). The percentage of *P. halepensis*/*pinaster* (maritime pine) is par with sclerophyllous evergreen taxa. Among species of agricultural interest, olive and *C. sativa* (chestnut) appear throughout the chronological range, *J. regia* (walnut) between the 15th and 17th centuries, and *Prunus cf. avium* (cherry) in the 17th century. Hawthorn may have been planted for hedges, and dogwood may have found its space in cultivated areas.

In the Master's Garden, the record concerns 462 charcoals (379 determined), returning 21 taxa. The data highlight the predominance of 18 non-cultivated plants (93,7% of the determined charcoals), attributable to woodlands and semi-natural areas. Woodlands are represented by mesophilous and thermophilous deciduous broad-leaved trees (10 taxa, 32,5%), evergreen sclerophyllous vegetation (5 taxa, 26,1%), and conifer (14,8%). The percentage of the 3 cultivated tree taxa, compared to the Prior's Garden, is quite low in this context (6.3%) but slightly higher than the one of the Apothecary's Garden. Deciduous woodlands are represented by *Q.* cf. *cerris* (Turkey oak), *F.* cf. *ornus* (manna ash), *Fagus sylvatica* (European beech), *Acer* (maple), *Cornus* (Cornelian cherry/common dogwood), *O. carpinifolia* (European hop-hornbeam), *Ulmus* (elm). Shrubby evergreen sclerophyllous vegetation includes *Rhamnus*/*Phillyrea* (buckthorns/phillyrea), *Erica* (heather), *Smilax* (sarsaparilla) and *A. unedo* (strawberry tree), then arboreal plants such as *Q.* cf. *ilex* (holm oak). Coniferous forests are always represented by *P. halepensis*/*pinaster* (maritime pine). Riparian environments are represented by *Alnus* (alder). Species of agricultural interest are the same as in other contexts: *O. europaea* (olive tree), *C. sativa* (chestnut) and, sporadically, *J. regia* (walnut).

In all three gardens, Maloideae and Prunoideae, two subfamilies of Rosaceae, were not included among the cultivated taxa. The anatomical characteristics of these species do not allow a determination between wild and cultivated plants but considering their constant presence since the 16th century, and the quantitative consistency of the Maloideae*,* at least some of the charcoal could derive from local ornamental or fruit-bearing individuals. The presence of charred wood fragments may be justified by the addition of ash from firewood, traditionally used as fertiliser and related to the daily activities of the monastery. The cultivation of chestnut trees (since the 15th century) refers to external habitats, while olive, walnut, almond, and vine could be cultivated both in external and internal gardens.

5.2.3 Carpological analysis

In Prior's Garden, the carpological analysis identified cultivated fruit plants (3 taxa). A single endocarp of *Corylus avellana* (European hazel) and a grape seed of *V. vinifera* (common grape vine) are dated to the late 19th century. The endocarp of *Prunus persica* (peach tree) is dated

at the end of the 20th century. The record, as well as suggesting information on the diet of the occupants of the Charterhouse, could represent a sample of the garden plants, such as hazel attested also by the pollen rain.

In the Apothecary's Garden, the analysis identified 5 taxa: an endocarp of *Prunus* cf. *persica* (peach) is dated to the 15th century, a grape seed of *Vitis vinifera* (common grape vine) and five cones of *Alnus* (alder) to the 17th century, and an endocarp of olive, peach and two grains of *Triticum sp.* (wheat) between the 19th and 20th centuries. It is possible that these fruits supplemented the diet of the inhabitants of the Charterhouse. Cereals extend information to arable crops. Because of the association with the anthracological record, carpological material seems to have flowed into the sediment with firewood residues or burnt waste. Once dried, woody alder fruits, particularly the tiny pinecones, persist on the plant for many months, sometimes years, so they could still burn attached to the branches.

In the garden of the Master, 18 finds are attributed to cultivated fruit plants, almost all from the same SU and dated to the second half of the 20th century. Six taxa have been identified: including arboreal, *Corylus avellana* (European hazelnut), *Malus*/*Pyrus* (apple/pear), *Prunus* cf. *avium* (cherry) and *V. vinifera* (common grape vine), and herbaceous, *Triticum aestivum*/*durum* (bread/macaroni wheat) and *Vicia sp.* (vetch). Wheat and vetch also extend the information to arable crops. Again, carpological material appears to have flowed into the sediment with firewood residues.

5.2 Results of archaeozoological analysis

In Prior's Garden, the sample consists of 349 optimally preserved bone remains, so taxa identification was possible for 340 of them. The most frequent species are mammals (42,4%), followed by marine molluscs (29,4%), land molluscs (15%), reptiles (10%), birds (1,5%), and fish (0,2%). The most frequent taxa are *Felis catus* (domestic cat), represented by one adult and two young individuals. The first young cat is testified by a right femur and a left humerus; the second by a right femur (probably a sub-adult). The skeleton of the adult cat was almost complete (including many costae and vertebrae). In addition, two young individuals of other domestic mammals are attested: *Bos taurus* (cattle) and *Oryctolagus cuniculus* (rabbit). Wild mammal species include six bone remains (mandibles and teeth) of *Castor fiber* (beaver) and a femur of an unidentified *Mustelidae*. Marine molluscs are mainly represented by the *Chamalea gallina* (common clam), with at least 40 individuals attested. A few shells testify to other species, such as the *Cerastoderma edule* (common cockle), *Glycymeris glycymeris* (dog cockle), *Ostrea edulis* (oyster), and *Hexaplex trunculus* (banded-dye murex). Land snails are referable to invasive species, namely – ordered by number – *Pomatias elegans* (round-mouthed snail), *Helix lucorum* (common snail), and *Cochlicella acuta* (pointed snail). Bird remains refer to only two taxa: *Gallus gallus* (domestic fowl) – represented by three long bone remains – and *Fulica atra* (Eurasian coot), attested by a complete tibiotarsus. The presence of reptiles is attested by 37 plastron and carapace remains belonging to the *Testudo hermanni* (Hermann's tortoise). Only two remains can be attributed to fish: a vertebra of an individual from the *Sparidae* family and a skull fragment – a preopercular – of *Dicentrarchus labrax* (European seabass).

A total of 59 bone remains were collected from the Apothecary's Garden. More than 80% of the sample refers to a single taxon, the domestic cat, attested by limb elements belonging to a young individual and two scapulae and one metatarsus of a sub-adult/adult individual, as well as some vertebrae probably referable to the same species. Land molluscs follow, with 10 shell fragments of a common snail and one of a round-mouthed snail. The same bird species observed in Prior's Garden are attested: limb elements belonging to domestic fowl and Eurasian coot. Only one fish bone was recovered in this area: a vertebra of *Mustelus mustelus* (common smoothhound).

Only 9 bone remains were collected in the Master's Garden, consisting of a metatarsus of *Vulpes vulpes* (fox), a Eurasian coot tibio-tarsus, a Hermann's tortoise plastron fragment, and four poorly preserved shell fragments, including only one identified as *Donax trunculus* (coquina clam).

6. Discussion

The project started as a development-led evaluation of the archaeological potential of the Charterhouse, integrating different methods to obtain a more precise archaeological knowledge of the monastic complex and its territory. Despite this, the research was not limited to the investigation of the Carthusian monastery's construction phases and the analysis of its foundation structures. From the very beginning, the research aimed to investigate the long-lasting transformations of the Charterhouse territory on a landscape scale, as well as the life of the monastic complex in relation to its surrounding environment.

Up to this point, archaeological interventions have been carried out occasionally with different investigation methods for different purposes, ranging from generic information from random finds to stratigraphic sequences. The systematic collection and digitisation of legacy data and the study of aerial anomalies have proved the extent of the settlement network in the *Vallis Gratiosa* and the neighbouring mountains, as well as the long-lasting human presence from Prehistory to the Contemporary Age. Despite poor knowledge, the two stratigraphically excavated sites testify to a long continuity of settlement that, in both cases, also involves traces of prehistoric and protohistoric frequentations. Evidence of the Etruscan-Roman period, often limited to the discovery of out-of-context pottery, may conceal a consistent and pervasive settlement pattern, also attested by centurial axes indicating extensive agricultural exploitation. More conspicuous traces refer to the medieval age, such as partially preserved structures of small settlements, fortified buildings, and a church.

The Charterhouse, built in a secluded location away from the city to ensure the solitude and silence sought by the Carthusian order, was, in any case, close to small human settlements. It is still uncertain whether the same site chosen for the foundation had been previously occupied: in the Cortile d'Onore, GPR surveys have identified rectilinear anomalies, perhaps belonging to the original layout of the courtyard and the buildings facing it. However, divergent anomalies from the main orientation of the monastic complex are also present, and their actual entity can be better investigated in future targeted investigations.

Stratigraphic control of the exposed sections and geognostic surveys confirm the agricultural vocation of the green spaces surrounding the monastic building since its foundation. Here, a series of overlapping horticultural layers with pottery materials dating from the late Middle Ages to the Modern and Contemporary ages is attested.

Inside the monastic building, archaeological investigations of the Father's Gardens, combined with archaeobotanical and archaeozoological analysis, provide an opportunity to read the gardens as an expression of individual monks' feelings and relationships with nature and to analyse the complex interrelation of human and non-human agencies in and outside the monastery walls. Thus, an attempt was made to use archaeological, archaeobotanical and archaeozoological records as a means for a not necessarily anthropocentric reconstruction of the gardens, their appearance and their transformations over time. Nevertheless, it was an opportunity to broaden the horizon to the surrounding area and its woodland composition in a continuous dialogue between the interior and exterior of the building (Anichini et al., 2022).

Especially in the Prior's Garden, it has thus been possible to identify different construction phases prior to the visible one, with planimetric differences or complex water systems. However, primarily the integration of archaeobotanical data has made it possible to outline its changing appearance over time due to both seasonal variations and the different species cultivated over the centuries.

Pollen analysis has reconstructed a rich diversity of plants attributable to the anthropogenic origin of the vegetation cover. The most representative is Prior's meditation garden, characterised as an ever-blooming garden with flowers and ornamental plants, such as roses, lilac, and water lilies. Pollen records also attest to daily horticultural activities evidenced by food and medicinal plants, such as in the Apothecary's and Master's Gardens, where even woody plants seem more frequent.

The anthracological study attests to clear ethnographic information on the use of wood as fuel and offers geobotanical data on the composition and state of the woods of the Charterhouse territory. The presence of charred wood attributable to wooded areas and semi-natural forest cover suggests the recovery of timber from the woodlands of Mt. Pisano for about five centuries. Between the 15th and 19th centuries, the use of firewood from these areas is predominant, with percentage values between 90.5 and 97.3%. Over time, there is a slight quantitative decrease that becomes evident and tangible in the early (37.6%) and late (72.2%) 19th century, then in the transition to the 20th century (77.1%). The use of wood from forests and semi-natural areas becomes predominant again in the second half of the 20th century (92.4%). Consequently, the anthracological material can be related to the supply of wood used as fuel for the Charterhouse's daily household and craft activities. The presence of charcoal in the flower beds could then be explained by the addition of firewood ash, considered a fertiliser in the peasant tradition.

Similarly, carpological material is associated with firewood residues and may represent an index of the scraps or waste burned and subsequently thrown with the ashes into the garden. In this case, the results suggest which fruits were present in the diet of the inhabitants of the Carthusian monastery and may represent traces of the plants grown in the garden, especially the hazelnut, also attested by pollen.

Among the species attested for timber supply, the prolonged use of maritime pine wood is particularly interesting, suggesting a constant presence in the territory, perhaps regulated by forms of renewal of the resource. Such a strong presence may predate the hilly concentration of *Pinus pinaster Aiton* on Mt. Pisano, one of the largest in all of Tuscany, supporting the hypothesis of its local origin (Bertacchi et al., 2004; Pierini et al., 2009).

However, the record is not limited to wooded areas; cultivated areas have been present since the 15th century with long-used species, such as olive and chestnut. The olive tree and especially its secondary product, oil, obviously play an essential role in the life of religious communities, while the archaeobotanical data available for medieval Tuscany show a very low presence of the olive tree in the landscape and oil in the diet of the populations at least until the late Middle Ages (Buonincontri et al., 2017). On Mt. Pisano, the cultivation of chestnut trees is attested since the 9th and 10th centuries, as evidenced by a notarial document dated 933 CE, and chestnut trees are among the most widespread forest coenose today (Bertacchi et al., 2004). Its presence in the 15th-century contexts is a probable consequence of the great expansion of chestnut fruit cultivation that characterised the hilly and mountainous areas of the Italic peninsula between the 10th and 14th centuries, an event of such magnitude that historians coined the term "chestnut civilisation" (Cherubini, 1981; Buonincontri et al., 2015).

Pictures of the daily life of the Carthusian Fathers also emerge from the archaeozoological analyses. The most frequent *taxon* in all contexts is the domestic cat, probably common in the monastery as a pet and cell companion. The adult individual in the Prior's Garden, intentionally buried, proved the care reserved for these animals, leading us to believe in the close relationship between the animal and the Father Prior.

The archaeozoological analysis also returns data on the diet of the inhabitants of the Charterhouse, although the Carthusian role, similarly to other monastic Orders, does not allow the consumption of animal meat except on very rare occasions (Lorenzi, 1990, p. 40). Meat could be replaced by dairy products, eggs, and fish; furthermore, other animal species living in the water, such as marine molluscs, tortoises and otters, could be consumed (De Grossi Mazzorin & Minniti, 1999, pp. 34-44; 2009, pp. 282-288).

The archaeozoological record of the Fathers' Gardens attests to the presence of young cattle. Their premature age of death is striking since these animals are usually killed at later stages of life, after having been largely employed as a labour force in the fields. Therefore, their consumption as meat cannot be excluded, although no butchery marks appeared on any skeletal remains. The domestic fowl had a dual food importance for its meat and eggs. The presence of marine shells could be related both to decorative purposes, as in the grotesque

encrustations (Giusti, 1991, pp. 34-35), and to food consumption. Marine shells, beavers, fish, and tortoises could represent species consumed in monastic contexts, similar to what is attested in the garbage dump of the Monastery of "Minimi di San Francesco di Paola" in Rome, dated to the 16th century (De Grossi Mazzorin & Minniti, 2009). The presence of the beaver in the faunal record of these gardens may also hint at its food consumption: according to scientific treatises of the Middle Ages, this species falls in the category of *Aquatilia* (Delaunay, 1997; De Grossi Mazzorin & Minniti, 1999, p. 36), thus an animal that monks could consume; the otter (*Lutra lutra*) also falls into this category and otter remains with butchery marks have been found in the Monastery of "Minimi" (De Grossi Mazzorin & Minniti, 2009).

7. Dataset

The dataset includes the digital archaeological documentation realised during the project. The documentation (graphic, photographic, and written) is organised into three macro groups: (I) stratigraphic control of exposed sections (II) archaeological excavations, and (III) geognostic surveys.

Written documentation of the interventions consists of the stratigraphic diagrams in .dxf format; the lists of SUs in .xlsx format; tables of material in .xlsx format; the SU sheets organised in the relational database (RDBMS) developed during the MAPPA Project and released in .accdb format (Fabiani & Gattiglia, 2012).

In addition, the complete photographic documentation (JPG format) of the geognostic surveys, the controlled sections, and the archaeological excavation in the Fathers' Gardens, and all the graphic documentation in vector format (.dxf) of the cores and the controlled sections are released. Likewise, the dataset includes all the context vector plans and the SfM-based 3D models (in .obj format) of the surfaces of the Stratigraphic Units.

8. Conclusion

The research, aimed at evaluating the archaeological potential of the Charterhouse of Calci, has confirmed the richness of the archaeological deposits pertaining to the monastic complex and, more generally, the Municipality of Calci. The surrounding territory is characterised by diachronic presences, covering a chronological range from prehistoric to contemporary times. No collected data indicate a presence in the area near the Charterhouse before the 14th century. Therefore, the monastic complex may have been established in a previously unsettled area.

However, the presence of buried structures in the Cortile d'Onore is noteworthy. Planning an excavation in this area would make it possible to investigate the early life of the Charterhouse, understand the evolution of the complex and verify the presence, so far unprovable, of any pre-existing building.

The data collected in the gardens of the Father Prior, the Apothecary and the Master illustrates the extreme detail of information that archaeology can provide to reconstruct the monks' gardens, their diachronic evolution and, more generally, the environment and vegetation surrounding the Charterhouse.

The informative potential of the archaeological investigation of monks' gardens is of great importance, especially considering how characteristic and fundamental these spaces are for understanding daily monastic life. The investigation has allowed us to read the architectural evolution together with the floristic composition of the gardens. Living spaces are thus defined not only by the architecture of the complex *per se* but also by the relationship between natural elements, such as water, animals, and ornamental-medicinal-aromatic plants. The ever-blooming flower garden of the Father Prior, populated by domestic and wild animals, with its articulated system of pools, probably decorated with water lilies, is the perfect image of the extraordinary care provided over time by the monks to this space of meditation and spirituality.

Authors' contributions

Conceptualization: Gabriele Gattiglia, Francesca Anichini, & Antonio Campus; Methodology: Francesca Anichini, Antonio Campus, & Gabriele Gattiglia (Archaeology), Mauro Buonincontri & Marta Rossi (Archaeobotany), Younes Naime (Archaeozoology); Archaeological investigation: Francesca Anichini, Antonio Campus, & Gabriele Gattiglia; Writing – original draft preparation: Antonio Campus & Gabriele Gattiglia; Writing – review and editing: Antonio Campus, Gabriele Gattiglia, & Francesca Anichini, Archaeobotanical contribution: Mauro Buonincontri & Marta Rossi, Archaeozoological contribution: Younes Naime.

References

Abbate Edlmann M.L., De Luca L., & Lazzeri S. (1994). *Atlante anatomico degli alberi e arbusti della macchia mediterranea.* Istituto agronomico per l'Oltremare.

Alberti, A. (2014). Monasteri e castelli sul Monte Pisano. Insediamenti medievali in un'area di confine (X-XII secolo). In E. Salvatori (Ed.), *Studi di Storia degli Insediamenti in onore di Gabriella Garzella* (pp. 149-163). Pacini editore.

Amante Simoni, C., Amici, S., Redi, F., & Vanni, F.M. (1986). San Vito di Calci (PI): una fossa cimiteriale comune; primi risultati archeologici e cronologici di uno scavo stratigrafico. *Archeologia Medievale, XIII*, 239-256.

Anichini, F., Buonincontri, M., Campus, A., Gattiglia, G., Mercuri, A.M., Rattighieri, E., & Rossi, M. (2022). I giardini dei padri. Garden Archaeology alla Certosa di Calci (Pisa). *FOLD&R FastiOnLine documents & research*, 543, 1-24.

Anichini, F., Dubbini, N., Fabiani, F., Gattiglia, G., & Gualandi, M.L. (Eds.). (2013). *Mappa. Methodologies applied to archaeological potential predictivity. Vol. 2*. Edizioni Nuova Cultura.

Anichini, F., Fabiani, F., Gattiglia, G., & Gualandi, M.L. (Eds.). (2012), *Mappa. Methodologies applied to archaeological potential predictivity. Vol. I*. Edizioni Nuova Cultura.

Bandinelli, A. (2014-2015). *La Certosa di Calci: analisi storica, rilievo e proposte di recupero strutturale* [Unpublished Master's degree thesis]. Università di Pisa.

Bertacchi, A., Sani, A., & Tomei, P.E. (2004). *La vegetazione del Monte Pisano*. Felici Editore.

Buonincontri M.P., Saracino A., Di Pasquale G. (2015). The transition of chestnut (Castanea sativa Miller) from timber to fruit tree: Cultural and economic inferences in the Italian peninsula. *The Holocene*, *25*, 1111-1123.

Buonincontri, M.P., Pecci, A., Di Pasquale, G., Ricci, P., Lubritto, C. (2017). Multiproxy approach to the study of Medieval food habits in Tuscany (central Italy). *Archaeological and Anthropological Science*, *9*, 653-671.

Cherubini G. (1981). La «civiltà» del castagno in Italia alla fine del Medioevo. *Archeologia Medievale*, *8*, 247-280.

Codagnone, A. (1992). Foglio 104 Pisa. In M. Torelli, C. Masseria, M. Menichetti, & M. Fabbri (Eds.), *Atlante dei siti archeologici della Toscana* (Vol. 1, pp. 37-53). L'Erma di Bretschneider.

De Grossi Mazzorin, J., & Miniti, C. (1999). Diet and Religious Practices: The Example of two Monastic Orders in Rome between the XVIth and XVIIIth Centuries. *Anthropozoologica*, *30*, 33-50.

De Grossi Mazzorin, J., & Minniti, C. (2009). L'analisi dei resti faunistici: alcune osservazioni sull'alimentazione dei Minimi di San Francesco di Paola. In H. Broise & V. Jolivet (Eds.), *Pincio. I. La Villa Médicis et le couvent de la Trinité-des-Monts à Rome. Réinvestir un site antique* (pp. 277-291). École Française de Rome.

Delaunay, P. (1977). *La zoologie au seizième siècle*. Hermann.

Fabiani, F., & Gattiglia, G. (2012). The digital archiving structure. In F. Anichini, F. Fabiani, G. Gattiglia, & M. L. Gualandi (Eds.), *Mappa. Methodologies applied to archaeological potential predictivity. Vol. I* (pp. 43-72). Edizioni Nuova Cultura.

Fascetti, G. R. (1997). *Il Monte Pisano: storia del territorio*. Edizioni ETS.

Florenzano A., Torri P., Rattighieri E., Massamba N"siala I., & Mercuri A.M. (2012). Cichorioideae-Cichorieae as pastureland indicator in pollen spectra from southern Italy. In G. Vezzalini & P. Zannini, *Atti del VII Convegno Nazionale di Archeometria (AIAr),. 22-24 febbraio 2012* (pp. 342-353). Pàtron.

Gioli A. (2015). Il soprintendente, i politici, i certosini, i calcesani e i soldati: cronaca di un riuso (e di una guerra). In A. Gioli (Ed.), *La Certosa di Calci nella grande guerra: riuso e tutela tra Pisa e l'Italia* (pp. 11-66). Edifir.

Giusti M.A. (1990). Itinerari di illusione e artifici nella Certosa di Pisa. In C*ertose e Certosini in Europa. Atti del Convegno alla Certosa di San Lorenzo, Padula 22, 23, 24 settembre 1988* (Vol. 1, pp. 165-179). Sergio Civita Editore.

Giusti M.A., & Lazzarini M.T. (1993). *La Certosa di Pisa a Calci*. Pacini Editore.

Grifoni Cremonesi, R., & Tozzi, C. (1994). Gli insediamenti dal Paleolitico all'età del Bronzo. In R. Mazzanti (Ed.), *La pianura di Pisa e i rilievi contermini. La natura e la storia* (pp. 153-182). Società geografica italiana.

Jones, C. A., & Church, E. (2020). Photogrammetry is for everyone: Structure-from-motion software user experiences in archaeology. *Journal of Archaeological Science: Reports*, *30*, 102261. https://doi.org/10.1016/j.jasrep.2020.102261.

Lorenzi, Dom. G. M. (1990). Finalità e vita quotidiana dei Certosini. In C*ertose e Certosini in Europa. Atti del Convegno alla Certosa di San Lorenzo, Padula 22, 23, 24 settembre 1988* (Vol. 1, pp. 29-46). Sergio Civita Editore.

Manghi, A. (1911). *La Certosa di Pisa. Storia (1366-1866) e descrizione*. Tip. Editrice del Cav. F. Mariotti.

Moore P.D., Webb J.A., & Collinson M.E. (1991). *Pollen analysis*. Blackwell.

Nannipietri, S., & Redi, F. (1982). Area di S. Vito a Calci (Pisa): risultati parziali dello scavo. *Archeologia Medievale*, *IX*, 411-415.

Neef R., Cappers R.T.J., Bekker R1.M., & Boulos L. (2012). *Digital atlas of economic plants in archaeology.* Barkhuis.

Niccoli, F. (2013-2014). *Forme del popolamento e dinamiche insediative nei territori di Calci e Vicopisano tra Età imperiale e Medioevo* [Unpublished Master's degree thesis]. Università di Pisa.

Pierini B., Garbari F., & Peruzzi F. (2009). Flora vascolare del Monte Pisano (Toscana nord-occidentale). *Informatore Botanico Italiano*, *41*, 147-213.

Pignatti S. (1982). *Flora d'Italia. II*. Edagricole.

Reille, M. (1999). *Pollen et spores d'Europe et d'Afrique du Nord, Supplement II*. Laboratoire de Botanique historique et Palynologie CNRS.

Schweingruber F.H. (1990). *Anatomy of European Woods*. Paul Haupt.

Taddei, N. (1997). Scavi in località Campaccio (Calci, Pisa): notizie preliminari. *Contributi della Scuola di Specializzazione in Archeologia dell'Università degli Studi di Pisa, I*, 87-98.

Vaggioli, M. A. (1990). Il territorio di San Giuliano in età romana. In Aa.Vv., *San Giuliano Terme. La storia, il territorio* (Vol. 1, pp. 125-164). Giardini editore.

Van Geel, B. (1986). Application of fungal and algal remains and other microfossils in palynological analyses. In B.E. Berglund (Ed.), *Handbook of Holocene palaeoecology and palaeohydrology* (pp. 497-505). New Publisher.

Venturi Ferriolo, M. (1990). Simbologia dei giardini nella tradizione monastica. Note per una lettura veterotestamentaria. In C*ertose e Certosini in Europa. Atti del Convegno alla Certosa di San Lorenzo, Padula 22, 23, 24 settembre 1988* (Vol. 1, pp. 75-81). Sergio Civita Editore.

Vernet, J-L., Ogereau P., Figueiral I., Machado Yanes C., & Uzquiano Ollero P. (2001). *Guide d'identification des charbons de bois préhistoriques et récents: Sud-Ouest de l'Europe, France, péninsule ibérique et îles Canaries*. CNRS Editions.