Archaeol Anthropol Sci (2018) 10:743–757
DOI 10.1007/s12520-016-0442-9

ORIGINAL PAPER

When palynology meets classical archaeology: the Roman and medieval landscapes at the *Villa del Casale di Piazza Armerina*, UNESCO site in Sicily

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Received: 30 March 2016 / Accepted: 22 November 2016 / Published online: 3 December 2016

Abstract Palynological researches have been carried out in the framework of cooperative projects with local and national institutions at the Villa Romana del Casale of Piazza Armerina, a small town in central Sicily. The site was studied within a multidisciplinary geo-bio-archaeological set of studies aiming at understanding the economy and environment at a local scale. Analyses allowed us to reconstruct the natural vs cultural landscape dynamics from Roman to medieval periods. On the basis of 85 samples, pollen diagrams show that the site has been built in a low forest cover area, with signs of both natural/semi-natural cover and complex anthropogenic activities. These activities include cereal fields and pastures. There is evidence of ornamental (e.g. *Platanus*, *Buxus*) and fruit trees (above all *Olea*, and also, e.g. *Corylus*, *Prunus* and *Juglans*). The research also includes a detailed study about the finding of *Vitis* pollen grains in the Roman site. In the subsequent phases, pollen shows again an open, fairly treeless, landscape with Mediterranean and hilly vegetation. Anthropogenic signs are evident in the form of groves and orchards. Our data bring evidence and details about the intense land exploitation that had contributed to transform the environment of central Sicily during the Middle and Late Holocene. Data demonstrate that archaeopalynology may be fruitfully regarded as a tool to understand the current landscape structure.

Keywords Archaeopalynology · Sicily · Roman · Medieval · UNESCO site · *Vitis* · Brassicaceae

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Introduction

Villa del Casale is an extraordinary historical settlement located in Sicily, the large island that lies in the central Mediterranean (Fig. 1). Since 1997, the archaeological site has been included in the UNESCO World Heritage List thanks to its inestimable floor mosaics that dated to the Late Roman period (fourth century AD). Thanks to the exceptional richness of architectural and decorative elements, the site represents a unique archaeological inheritance, located in one of the most visited archaeological park of the region with more than 300,000 people every year.[1] In the last decade, it has been subjected to a systematic programme of safeguarding, restoration and valorisation thanks to archaeological and interdisciplinary researches granted by the European Union (Meli 2007).

The historical complex of the site changed architecture and function through approximately 15 centuries. From the end of the first century AD until the fourteenth–sixteenth century AD, this site saw the passing of the Roman world and the developing of medieval cultures. The archaeological research has been carried out involving multidisciplinary analyses over the different chronological phases (Pensabene and Sfameni 2006, 2014; Meli 2007; Pensabene and Bonanno 2008; Pensabene 2010; Gallocchio and Pensabene 2011; Di Bella et al. 2014). Plant macroremains were poorly preserved and rare (Terranova 2007), and therefore, the archaeobotanical research has mainly focused on palynology (Accorsi et al. 2007; Montecchi 2010, 2011; Montecchi and Accorsi 2010; Montecchi et al. 2012). Here, we present new and unpublished archaeopalynological data that enrich the archaeobotanical scenario in Sicily (19 sites, according to Mercuri et al. 2015).

[1] Data from the official Web site: http://www.villaromanadelcasale.it/la-villa-romana-del-casale2/statistica-visitatori-in-villa (accessed 21 March 2016).

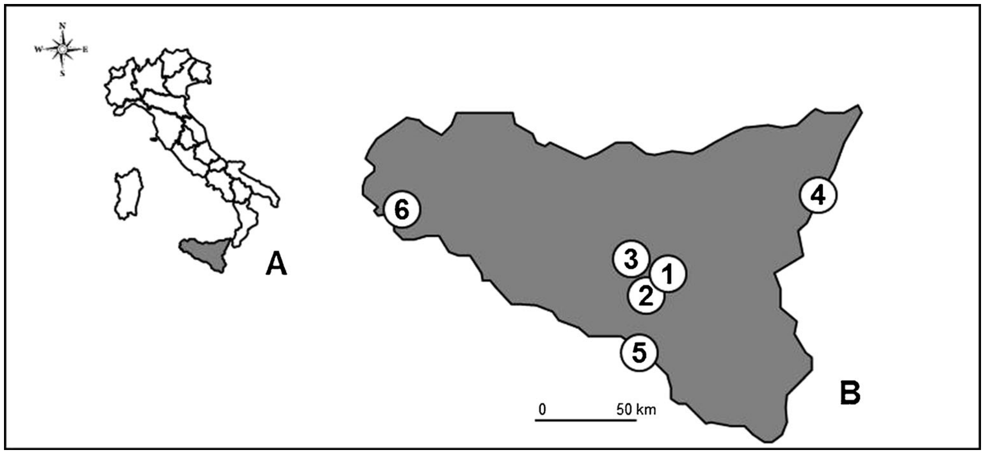

Fig. 1 Maps showing the geographical position of Sicily (**a**) and the locations (**b**) of Villa del Casale (*1*) and other important study sites in comparison: *2*, Philosophiana; *3*, Pergusa lake; *4*, Taormina ancient theatre; *5*, Biviere di Gela lake-lagoon; *6*, Gorgo Basso coastal lake

Plant microremains and macroremains from archaeological sites are direct evidence of the development of cultural landscapes in a given region (Faegri and Iversen 1989; Pearsall 2000; Mercuri 2014). Archaeopalynology has a long-lasting tradition in the Italian peninsula (Mercuri et al. 2015), and on-site pollen analyses have been especially oriented towards the reconstruction of both the plant landscape and the ethnobotanical peculiarities of different cultures. In our study, knowledge of the historical land transformation of this area has been obtained thanks to the biological archives preserved in several points of the site. This added detailed information to the reconstruction provided by archaeology and stratigraphy (Behre and Jacomet 1991). The interpretation of pollen data has taken into account that the natural and anthropogenic plant imprints are intimately mixed in such contexts, as they are part of local and regional events in the Mediterranean area (Mercuri et al. 2011; Mercuri and Sadori 2014).

In Sicily, the high-resolution data obtained from off-site cores (and especially the PG2 core from Lago di Pergusa; Sadori et al. 2013, 2015a) give broad-spectrum information about the regional palaeoenvironment having a strong climate component. According to archaeology, human activity has extensively affected the area of Villa del Casale, just about 20 km from the lake of Pergusa, since the beginning of the Roman imperial age, reaching its acme in the Late Antique period.

This paper reports on the palynological analyses carried out on archaeological layers of the Villa del Casale, giving the diachronic reconstruction of the local landscape transformations from the Roman and medieval/post-medieval contexts. These transformations deal with the land use and agrarian systems that have developed under different cultures in central Sicily. The on-site data obtained from this strategic and specialised settlement improve the resolution of palaeoenvironmental changes and help to detail the anthropic elements that might have been involved in the central Mediterranean landscape transformations. The general results will be followed by a discussion on the landscape reconstruction and significance of the overrepresentation of some taxa in the spectra. In particular, we will focus on the presence and relevance of *Vitis* pollen in the site: this pollen represents a marker of Mediterranean cultures and a remarkable characteristic plant which was depicted in the mosaics of the Roman Villa.

Material and methods

The study site

Geographical setting and vegetation (Fig. 1)

Villa del Casale (37° 21′ N, 14° 20′ E; about 600 m a.s.l.; province of Enna) is located on the edge of an alluvial plain, set on sedimentary Pliocenic soils afferent to the 'Bacino di Caltanissetta'. The site lies near the outlet of a little valley and the hydrographic network where it fits-in is reasonably developed. The construction of the archaeological complex has modified the original hydrographic profile of the area, allowing repeated floodings to cover the site with massive alluvial debris (Graziano and Scalone 2007).

In the area around the site, native arboreal vegetation is poorly preserved. Modern woods are mainly composed of *Pinus* sp. pl. and exotic species (e.g. *Eucalyptus*) introduced by reforestation practises. Near the archaeological park, there are cultivations of *Opuntia ficus-indica* (L.) Mill. and *Corylus avellana* L. The site itself is surrounded and shaded by ornamentals including pine trees, oaks, eucalyptus and cypress trees.

The Enna province is in the heart of Sicily, with no access to the sea but connecting diverse environmental systems. It is known as the 'lakes province', including lakes that are artificial water reservoirs for agricultural purposes. Lago di Pergusa is the only natural lake of central Sicily. This area has a rich natural heritage protected by regional parks. The bioclimate is characterised by the thermo-Mediterranean, meso-Mediterranean and supra-Mediterranean thermotypes at the highest altitude, and from dry to sub-humid ombrotypes (Brullo et al. 1996). The study area lies in the 'agrigentino' phytogeographical district. This territory has an undulating topographical profile, which it is known to have supported agricultural overexploitation since prehistoric times, especially by cereal cultivation and pastures (Brullo et al. 1995). Anthropic activity has rarefied and degraded natural vegetation that survives in limited and less exploitable areas and has caused the spread of shrublands and steppe-like vegetation types. Although dramatically modified by anthropic activity, this area keeps some threaten species included in the regional 'red lists'.[2]

Natural/seminatural vegetation types include mesophilous woods (*Querco-Fagetea*), shrublands and maquis (*Rhamno-Prunetea* in wet sides, and *Oleo-Ceratonion* in warmer sides), garrigue (*Cisto-Micromerietea*, especially in the southern part of the province; Minissale et al. 2008) and steppe (*Ligeo-Stipetea*). The hygrophilous vegetation is featured by shrubs near watercourses (*Nerio-Tamaricetea*) while willows are rare (*Salicetea purpureae*). Furthermore, near little lake basins, there is swamp hygro-hydrophilous vegetation such as *Potametea* and *Phragmito-Magnocaricetea* (Minissale and Sorrentino 2009).

The archaeological contexts (Fig. 2)

The Late Antique Villa was built in the fourth century AD over an earlier countryside villa (*villa rustica*, first–third century AD). There is an open question about the ancient owner (the *dominus*) of the Late Antique Villa: some scholars believe that he was a member of the Roman senatorial aristocracy (a local governor), while others think he was engaged in his role by direct commission of the emperor. However, his high profile is incontestable and celebrated through the iconographic programme of the 3000 m^2 floor mosaics and sumptuous rooms of the site (Pensabene and Bonanno 2008).

From new excavation campaigns, the Villa emerges not only as a Roman residence with public spaces but also as a political and economic centre of administration playing a strategic role for the agrarian hinterland (Pensabene and Gallocchio 2011). *Itinerarium Antonini* (Antonine's Itinerary—fourth century AD) is a document reporting on the local road network and describing an important route that lead from Catania to Agrigento. The road was used to reach the *latifundia* granaries of central Sicily and passed through the great estate of *mansio Philosophiana*. The latter one was only about 6 km as the crow flies from the villa, the alleged centre of the same estate (Pensabene 2010; Vaccaro 2012,

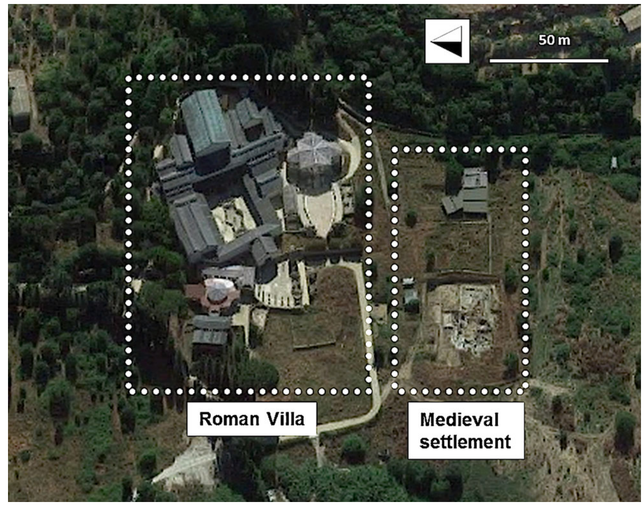

Fig. 2 Aerial photo (from ©Google Map 2016) of the site. *Dots* border the Roman Villa and the excavations of the medieval settlement. On the Roman villa, the new coverings are visible

2013a). According to Vaccaro (2013b) discussing the hinterland of Philosophiana, recent fieldwork data demonstrate an early medieval continuity in the area.

Starting from the Late Antiquity, during the fifth–sixth century AD (including the Byzantine period of the sixth century AD), several functional transformations were carried out and the structures of the residence have been modified for defensive purposes (Vandal invasions occurred during the Byzantine-Gothic war 535–553 AD; Pensabene and Sfameni 2014). A rural settlement rose on pre-existing walls and beyond the previous perimeter, towards the river Nocciara. The medieval settlement, called 'Iblâtasah' or 'Palàtia/Plàtia', was destroyed in the second half of the twelfth century AD (in 1161), during the reign of Guglielmo I of Sicily, and remained abandoned until the fourteenth century. Progressively, after the collapse, the site was repopulated and a '*casale*', i.e. a farmhouse, was built. This gave the current name 'Villa del Casale' to the site.

The site, and especially the ruins of the Roman Villa, experienced frequent floods and were submerged until the nineteenth century, when scholars and antiquities dealers 'rediscovered' the site. Since 2004, annual archaeological excavations in the southern area of the site (under the direction of Patrizio Pensabene, University Sapienza of Rome) unearthed the medieval settlement. The majority of the structures are rooms with irregular disposition facing onto open courtyards, and areas for productive activities. They date to three phases of the Arab/Norman period, from the tenth to the thirteenth century (Pensabene and Sfameni 2006). In the last few years, the interesting finding of an apsidal room, mosaic fragments and some columns have revealed the presence of 'new' Late Antiquity structures under the medieval settlement and nearby the nilla (Pensabene and Sfameni 2014).

[2] Available at: http://www.minambiente.it/sites/default/files/archivio/allegati/biodiversita/lista_rossa_flora_italiana_policy_species.pdf

Chronology

Chronology is based on archaeological data, i.e. architecture (building techniques), stratigraphy and archaeological finds, and on historical data. Sometimes this chronology is very precise thanks to the typology of pottery fragments and presence of coins in the layers. For instance, a coin of emperor Gordiano III (dating to 238–244 AD) was found in the trench 6 cut in the perimeter of the Roman villa, and coins of Guglielmo I (dating to 1160 AD) were found in layers of the Norman phase.

One radiocarbon date was obtained by dried, uncharred, pips found in trench 9, near the ovoid peristyle—*Xystus* (radiocarbon age 1249 ± 45 BP uncal; CEDAD LTL15203A; cal. 670 (95.4%)–890 AD). The date is calibrated with OxCal Ver. 3.10 (Reimer et al. 2013).

On the whole, our samples cover a time span of about 1500 years, from the end of the first century AD until the sixteenth century AD.

Pollen sampling

Pollen sampling was carried out with the help of archaeologists, after cleaning sections and avoiding sediment contamination from modern dust. On the whole, a set of 85 pollen samples was collected from archaeological layers of the Roman villa and the medieval settlement (Table 1; Fig. 3):

- Roman: 45 samples were taken from six small trenches cut into Roman layers, from the countryside villa (*Villa rustica*) to the Late Antique villa, from the end of the first to the fourth century AD.
- Medieval: 40 samples were taken from small trenches, rooms, floors and under walls of houses, pits and spots, and in particular along a vertical sequence in the eastern part of the medieval settlement, dating from fifth/sixth to the sixteenth century AD. The majority of these samples belong to the Norman period, dated to the twelfth century.

Pollen treatment and analyses

About 5–10 g of sediment per sample was subjected to pollen extraction. Sample treatments included heavy liquid separation according to van der Kaars et al. (2001), revised by Florenzano et al. (2012). *Lycopodium* tablets were added for the calculation of concentrations, expressed as pollen per gram (p/g). Residues in glycerol were mounted in permanent slides. Identification was made at ×400 and ×1000 magnification. Pollen taxa nomenclature mainly follows Moore et al. (1991), as well as the Northwest European Pollen Flora (Punt et al. 1976, and followings). Cerealia-type pollen was identified according to Beug (1964) and Fægri and Iversen (1989); some large pollen grains of Cerealia-type were found crumpled and not measurable: they are included in the 'Cerealia undiff'.

The name 'Cichorieae' was preferred to 'Cichorioideae' according to pollen morphology (Florenzano et al. 2015). The family name Chenopodiaceae, largely used in palynological literature, is used instead of Amaranthaceae-Chenopodiaceae (according to the Angiosperm Phylogeny Group III) for brevity.

As a rule, about 500 pollen grains per sample (475 on average) were counted.

According to Turner and Brown (2004), about 1000 pollen grains have been counted in each Roman sample to check the occurrence of *Vitis* pollen that may suggest the presence of plants living inside the perimeter of the villa. The percentage pollen diagrams were calculated on pollen sums including all pollen counted. The pollen diagrams and zonation were drawn with the software TGView (developed and distributed by E. Grimm at the Illinois State Museum, Grimm 2004).

Results and interpretation

Pollen preservation and concentration

Pollen was present in all samples with a variable state of preservation, as usual in samples from archaeological contexts. For example, thinned exine and folded grains were fairly common. Based on the good mean pollen concentration and high taxa diversity (Mercuri et al. 2010), the high values of Cichorieae were interpreted as pastureland indicators (Behre 1986) instead of a result of selective pollen deterioration. High values of these grains are, in fact, fairly common in the archaeological sites from the Italian peninsula and their occurrence has been largely correlated to pastoral economy and animal breeding (Mercuri et al. 2013a; Florenzano et al. 2015).

In Roman samples, pollen concentration varies from a minimum of 430 p/g in sample no. 74 to a maximum of 104,700 p/g in sample no. 53, with a mean value of ca. 7300 p/g. The trench 5 shows the lowest pollen concentration (2800 p/g on average) and was sampled in the southern side of the *Basilica* from layers that dated to the end of the second–third century AD. The trench 1 shows the highest concentration (13,900 p/g) and was taken in the *praefurnium* (South) of the *tepidarium* that dated to the fourth century AD.

Concerning the medieval samples, pollen concentration values range from a minimum of 815 p/g (sample no. 82) to a maximum of 15,200 (sample no. 48), with a mean value of 2830 p/g. The Late Medieval (thirteenth–fifteenth century) period has low pollen concentration (1160 p/g on average), while the highest value (5450 p/g) belongs to the Late Arab/ Early Norman period (tenth–eleventh century).

Table 1 Complete list of samples in chronological order

Sample	Archaeological context	Stratigraphic unit (S.U.)	Chronology
1	East (vertical) sequence		From sixteenth century (modern)
2			
3			
4			
5			
6			From fifteenth century (post-medieval)
7			
8			
9			
10			
11			
12	Bath area	1600	
13	Wall		
14	East (vertical) sequence		Thirteenth–fifteenth century (Late Medieval)
15			
16			
17			Late twelfth–thirteenth century (Late Norman/Early Swabian)
18	Room XVI		
19	Pit S.U. −1567	1566	Twelfth century (Norman period)
20	Grey layer	1575	
21	Near wall 1066	1066	
22			
23	Pit S.U. −1065	1050	
24			
25	Wall 1022	1031	
26			
27	Space XVIII yard		
28	Room XIX–XXV NE corner		
29	Room XI–XXIV S wall		
30			
31			
32	Room XI–XXIV NE corner		
33	Room XI–XXIV N wall		
34	Room VII		
35	Room I		
36	Room XXV		Tenth–eleventh century (Late Arab/Early Norman)
37	Room XIX–XXV N wall		
38	Room XI–XXIV N wall		
39	Room IV		
40	NW	Wall 600	Fifth–sixth century (Late Antiquity)
41	Trench 2	3	First quarter of the fourth century
42			
43			
44			
45			
46	Trench 1	3 (wall)	
47			
48			
49			
50			
51			
52		3 (bottom)	
53			
54			
55			
56			
57	Trench 6	2	Third century
58			
59			
60			
61			
62	Trench 5	12	End of the second–third century
63			
64			
65			
66			
67	Trench 8	1	Second half of the second century
68			
69			
70			
71			
72			
73			
74	Trench 4	4	End of the first–second century
75			
76			
77			
78			
79			
80			
81	Trench 8	10	End of the first century AD
82			
83			
84			
85			

Samples are identified by a progressive numbering from 1 to 85, their archaeological context and stratigraphic unit (Roman numbers refer to the archaeological label of the rooms; negative S.U. refers to cuts of pits) and their chronology

Pollen flora

The site shows a remarkable floristic diversity as the pollen flora consists of 200 taxa (61 woody plants, 139 herbs).

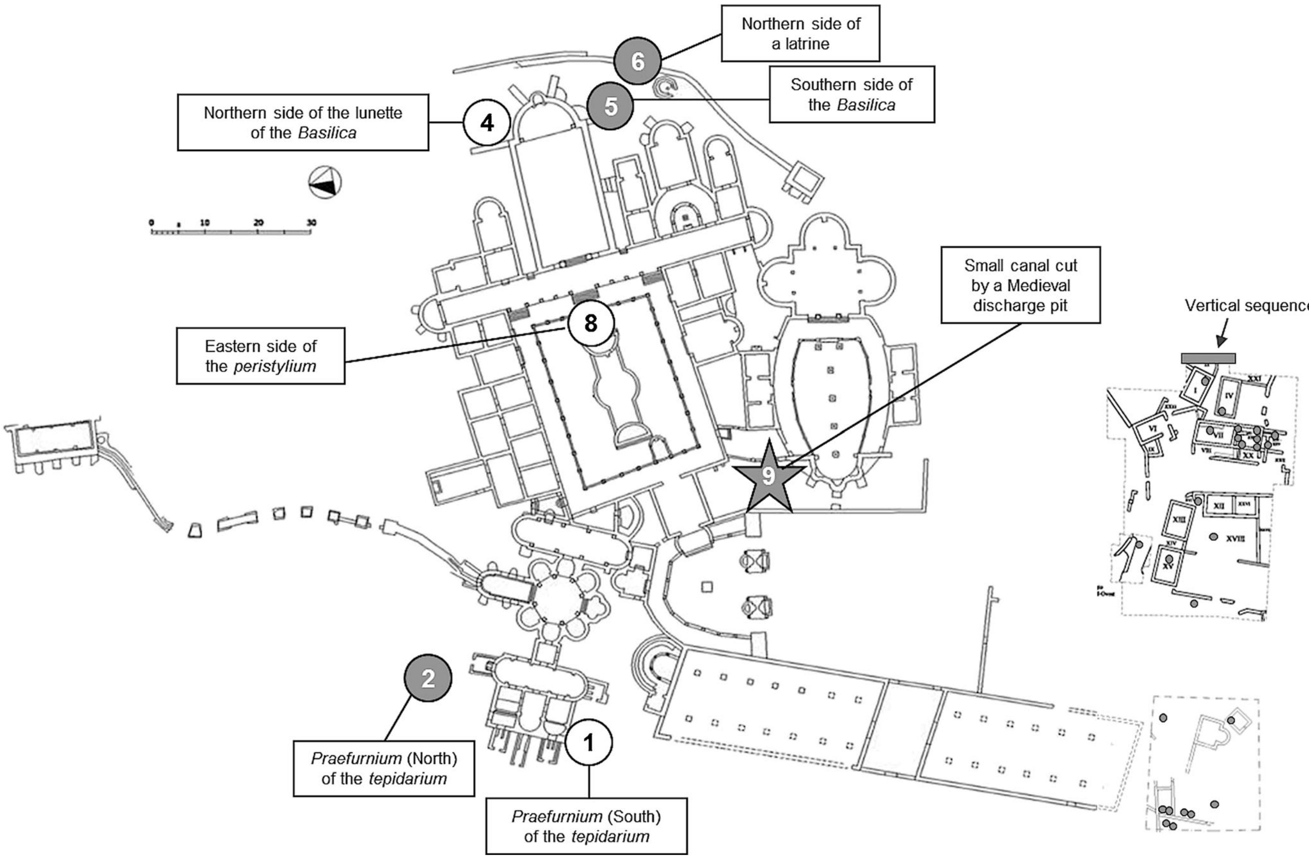

Fig. 3 Map of the archaeological park, with the Roman villa (samples no. 85–41) and the medieval settlement (sample no. 40–1), showing the position of samples collected with grey dots (original drawing by E. Gallocchio, A. Ottati, modified from Pensabene 2010, Pensabene and Sfameni 2014). For the Roman villa, the numbers of the six trenches selected for pollen sampling are indicated. *White spots* identify trenches that recorded *Vitis* pollen grains. The *star* identifies the position of macroremains (*Vitis* seeds) observed and collected at naked eye

Cichorieae have the prevalent values (Roman layers 52%; other phases 50%). Other significant taxa are Poaceae wild group (12%; 13%), Brassicaceae (5%, in both phases), Chenopodiaceae undiff. and *Beta* type (4%; 3.5%), and *Aster* type (2%, in both phases).

Forest cover and wood composition

The average ratio of AP–arboreal/NAP–non-arboreal plants is insignificant (7/93) in the samples from the end of the first century AD; it doubles in the following phase and then decreases again at ca. 10/90 up to the fourth century AD. In the Late Arab/Early Norman period (tenth–eleventh century), the AP/NAP ratio reaches its highest mean value (24/76). Then, it returns to 7/93 in the modern age.

Pinus is the only arboreal pollen that reaches 4% on average in Roman phase and 2.5% in the subsequent phases. It is followed by *Quercus* deciduous (1%), *Quercus ilex* type (1%, present only in post-Roman phases), *Fraxinus* (1%), *Olea* (1%; 3%), *Juniperus* type (2%, in post-Roman phases), *Hedera* (1%, in Roman period) and *Corylus* (0.5%).

The woods are represented by both the Mediterranean shrubs and trees (e.g. *Capparis*, *Myrtus*, *Olea*, *Pinus* cf. *pinea*, *Pistacia*, *Quercus ilex* type, *Tamarix*) and by the mixed oak wood (*Acer campestre* type, *Carpinus*, *Corylus*, *Fraxinus*, *Ostrya carpinifolia/Carpinus orientalis*, *Quercus* deciduous, *Tilia*, *Ulmus*). Conifers mainly include *Pinus* (*P.* cf. *halepensis*, *P.* cf. *pinea* and *P.* undiff.), with mean values ranging from 4% (Roman) to 2% (Medieval), and traces of *Abies*.

In three Roman samples (nos. 77, 42 and 41), the pollen from Mediterranean plants is absent. The minimum values were observed in the first–second century AD (2% on average) and in the third century AD (3%) while the highest values were found in the fourth century AD (3.5% on average; maximum 11% in sample no. 56). In the medieval phases, Mediterranean taxa are more represented and reach 15% on average during the tenth–eleventh century. Then, they halved to 7% in twelfth–fifteenth century and eventually decrease to 5 and 3% in post-medieval and modern age.

Similarly, the pollen from the mixed oak woods has low percentages (4%), with the highest values between the end of the second and the fourth century AD. Then, percentages of the medieval period remains steady (3–4%), with maximum values at around thirteenth–fifteenth century.

Wet environments

The wet environments are represented mainly by *Alnus* and *Salix* (and to a less extent by *Populus*) among trees, and by Cyperaceae, *Nymphaea alba* type and *Typha* types, accompanied by other plants of wetlands in traces (e.g. Alismataceae, *Lemna*, *Myriophyllum*, *Potamogeton*). In Roman phases, these pollen grains are not ubiquitous and their percentages range between 1 and 3% (the highest mean value dated to the fourth century AD). All medieval samples have pollen from wet environments that never exceeds the 2%, and then rises up to 2.5% in modern age.

Fruit trees/shrubs

Trees and shrubs producing edible fruits may be evidence of 'surely or possibly cultivated' plants. They include *Corylus* (on average 0.3–0.5% in Roman and medieval samples), *Prunus*, *Sambucus nigra* type, and also *Arbutus unedo*, *Capparis*, *Morus*, *Myrtus* and *Pistacia*.

The 'OJC' group, representing the trees with key cultural role in Italy (*Olea*, *Juglans* and *Castanea*, according to Mercuri et al. 2013b), is well represented. Noteworthy, OJC shows a clear increase from Roman phases (where it never exceeds 3%; 1% on average) to the subsequent phases (3% on average). The highest value (15% in sample no. 38) is due to *Olea* and occurs during the tenth–eleventh century AD. *Juglans* and *Castanea* are less frequent in Roman than in medieval samples. *Castanea* pollen, however, is present in all the periods covered by our samples, increasing towards to the medieval and post-medieval phases. *Juglans* is rare and present with few records in Roman phases, while in the following periods, it becomes more common.

A special remark deserves the pollen of *Vitis*. It is present in 20% of the Roman samples, with low values (<0.8%) in three trenches: (1) in trench 1 *praefurnium* (South) of the *tepidarium* of the baths complex, five samples dated to the first quarter of the fourth century AD; (2) in trench 4 (North) of the lunette of the *Basilica*, three samples dated to the end of the first–second century AD; (3) in trench 8 (East) of the peristyle, one sample dated to the end of the first century AD.

During the medieval and following phases, *Vitis* pollen is more common, present in 38% of the samples. The highest value belongs to sample no. 40 (Late Antiquity, 1.1%). The evidence of *Vitis* in the site is discussed in more detail further below.

Anthropogenic pollen indicators (API)

The pollen spectra are characterised by 'anthropogenic pollen indicators'. The seven API taxa that are usually found in archaeological sites of Italy (according to Mercuri et al. 2013a) are well represented: *Artemisia*, *Centaurea*, *Plantago*, *Trifolium* type, *Urtica*, Cerealia and Cichorieae. Excluding Cichorieae, they sum up 4–5% on average in Roman layers, with very high values in the second half of the second century AD (42% in sample no. 70) and in the fourth century AD (22% in no. 55). The greatest contribution is provided, respectively, by *Centaurea nigra* type, quite common in disturbed places and a good indicator of pastures (Bottema and Woldring 1990; Court-Picon et al. 2006; Brun et al. 2007), and by *Artemisia* and *Plantago*. *Artemisia* grows in open vegetation as a weed under disturbed conditions. *Plantago* is recurrent in all types of anthropogenic habitats favoured by soil compaction (Noë and Blom 1981; Brun 2011). In the subsequent phases, API group looks to remain steady at 3% on average with the maximum 11% recorded at the tenth–eleventh century (in sample no. 36, mainly *Plantago*).

Cichorieae, as stated above, were interpreted as indicators of pastures. Despite the general high percentages (51% on average), four samples have low values. Only one sample (no. 76, 3%) has probably some taphonomic issue (see below). The others show other taxa prevailing on Cichoriae: the cicory tribe totals 16% in sample no. 56 (where Poaceae wild group is 33%), 5% in no. 38 (*Juniperus* type 35%, and *Olea* 14%), 10% in no. 24 (Caryophyllaceae and Chenopodiaceae 20%, and *Convolvulus* 31%). Among the other ruderal, nitrophilous and synanthropic plants, Chenopodiaceae are frequent, while *Alchemilla* type, *Papaver rhoeas* type and *Ranunculus* type are less common.

Cereals and other cultivated herbs

Pollen spectra show significant, but not high, evidence of cultivated/cultivable herbs, among which cereals are the most interesting records. The average value of cereals (including *Avena*/*Triticum* group and *Hordeum*, to which Cerealia undiff. are added) increases from 0.2 to 1.3% during the Roman phases, from the end of the first century AD to the fourth century AD. A peak of 11% is actually observed in sample no. 55 (fourth century AD) reflecting the importance and spreading of the cereal farming at the acme of the Roman villa.

With regard to the following phases, in the Late Antique period (sample no. 40), cereals reach 2%, following an increasing trend that apparently stops at the tenth–eleventh century phase (0.5% on average). It may reflect the difficult situation created by conflicts between Byzantines and Arabs and the changes that occurred in the agricultural *latifundium* system. Starting from the twelfth century cereal pollen percentage increases again, reaching the maximum value in the post-medieval phase (sample no. 13, 3%).

Other cultivated herbs may be represented by some Apiaceae (including aromatic/vegetable-garden species) and Fabaceae (including *Trifolium* type and *Vicia* type). The legume family was possibly cultivated for fodder and useful to regenerate soils after cereal cultivation as documented in other Mediterranean Roman contexts (Rattighieri et al. 2013; Bowes et al. 2015). Of interest, one record of *Linum* was found at the end of the first century AD (sample no. 82). *Cannabis*, although attested in few samples, is however nearly present in all phases.

Discussion

The significance of overrepresented pollen in archaeological layers

Despite the richness of pollen taxa and complex plant assemblage, including woods and anthropogenic indicators, some pollen grains show randomly very high percentages in spectra (Figs. 5 and 7). The isolated peaks of pollen in archaeological contexts have been interpreted as a model of 'actions by pollen', reflecting human behaviour (Mercuri 2008). In our study, they probably are evidence of some local transport to the site by humans or animals.

Scattered high percentages are found for *Pinus* (23.5% in sample no. 74, dated to the end of the first–second century AD), *Juniperus* type (35% in sample no. 38, tenth–eleventh century), *Centaurea nigra* type (40% in sample no. 70, second half of the second century AD) and Caryophyllaceae (20%, in sample no. 24, twelfth century). The high percentages of these taxa may have a strong masking effect on percentages of other taxa in the relevant samples. The analyses carried out at the archaeological site of Philosophiana did not show comparable accumulation of the same pollen grains (Vaccaro et al. 2015), suggesting that our records have a casual occurrence due to local events.

The most intriguing cases are the scattered high presence of entomophilous Brassicaceae and *Convolvulus*.

Brassicaceae (72% in sample no. 77—trench 4) can mark the presence of excrements in our samples. Abundant pollen in abdominal cavity (Shafer et al. 1989), coprolites (Sobolik 1988) and modern faecal smearts (personal observation by AMM) prove that these pollen grains may be found in high amount in faeces. The very high values of different species of Brassicaceae have been found in drillings carried out in the ancient imperial harbours of Rome (Sadori et al. 2010, 2015b) and of Naples (Russo Ermolli et al. 2014), and interpreted as evidence of crop cultivation of cabbage in Roman times, as attested by classical authors (e.g. Pliny the Elder). High amounts of seeds (*Brassica nigra*) in pits of different ages have been the evidence of the use of these herbs as a spice or oil plants (Robinson 1987; Bandini Mazzanti et al. 2005). Interestingly, the high pollen percentages from off-sites have been also interpreted as environmental markers. In Lake Zeribar, in NW Iran, the *Brassica*-type pollen, together with *Capsella*-type and *Matthiola*, characterised some spectra: they were interpreted as part of the local marsh vegetation in Late Pleistocene samples and as probable weeds occurring in cultivated and fallow fields in surface samples (van Zeist and Bottema 1977). The Brassicaceae pollen that dominated a tundra peat profile from Svalbard was, indeed, considered as a climate indicator in nutrient rich deposits (Rozema et al. 2006).

The high values of *Convolvulus* (20% in sample no. 76, and 30% in no. 24), with well-preserved pollen grains, may have had a different cause than the human interference. The overrepresented values were observed in samples from the northern side of the lunette of the Basilica (no. 76, end of the first–second century AD) and from the filling (US 1050) of a pit (US −1065) (no. 24, twelfth century). Inside the pit was found burned material, mainly consisting of charcoals and ashes. Interestingly, this is the same sample with the high amount of Caryophyllaceae. The genus includes species (as *Convolvulus arvensis* L.) that are persistent weed of cultivated fields, orchards, pastures and gardens. *Convolvulus* also includes very valuable honey species produced during its flowering period lasting from summer to the first frost season. High percentages in spectra are not so common, and their presence in archaeological samples was interpreted as generic evidence of garlands in a Roman site in Parma (Bosi et al. 2011). The custom of making garlands with wildflowers is described by Ovid (Fasti, I), and by Pliny the Elder who lists violets (*Viola*) and knapweeds (*Centaurea*), besides bindweeds (*Convolvulus*) (*Naturalis Historia*, XXI). In our study, the high percentages of *Convolvolus* pollen could reasonably be an effect of a casual accumulation of pollen grains of unknown origin. Considering the good state of preservation, some insect nests present in antiquity cannot be excluded (Davis and Buchmann 1994; this inference was advanced to explain the pollen accumulation of *Malva* found in Mesolithic layers at Terragne, Apulia, Southern Italy; Accorsi et al. 1995).

The palaeoenvironmental reconstruction

Pollen data have been analysed aiming at the reconstruction of the plant cover and palaeoeconomy of this area during the deposition of archaeological layers. Despite the random accumulations, and although cultural variables strongly influenced these spectra, the high number of samples from this multipoint sampling site has allowed realistic palaeoenvironmental inferences (Mercuri 2014). Pollen diagrams show that the site lay in an open area, characterised by insignificant forest cover, and by complex anthropogenic activities.

In these deposits, in accordance with the evidence from many archaeological sites of the Italian peninsula (Mercuri et al. 2013a; Florenzano et al. 2015), Cichorieae testify the presence of pasturelands or animal breeding. This assumption is supported by archaeozoological analyses (Scavone 2014) carried out on animal remains coming from the *frigidarium* of the south baths of the villa, which testify that the economy was largely based on breeding of sheep and goats.

The Roman period (from the first to the fourth century AD) (Figs. 4 and 5)

The most striking element of the diagram is the low percentage of arboreal pollen that never exceeds the 30%. The main curves belong to *Pinus*, *Juniperus* type, *Fraxinus*, *Hedera*, *Olea* and *Quercus* among trees, and to Cichorieae, Brassicaceae, Chenopodiaceae, *Plantago*, Poaceae-wild group among herbs. The anthropogenic signs are evident in the form of groves and orchards with chestnut and walnut trees. In the PG2 core of Lago di Pergusa (Sadori et al. 2015a), *Juglans* pollen was not found in the samples dated to the Roman period while it becomes frequent with chestnut pollen in samples dated to the medieval period. The OJC group (1% on average, and maximum 3%) has values similar to the majority of archaeological sites of Italy (Mercuri et al. 2013b, 2015). Both the ornamental trees and the cereal fields increase and have their maximum values at the beginning of the fourth century, which corresponds to the renovation/expansion of the villa and its estate economy on the territory. *Buxus*, which is present in all Roman phases, has the highest mean value and *Platanus* has the only record (in sample no. 56) in this Roman phase. In Sicily, *Platanus* was recorded also in samples from the Greek-Roman theatre of Taormina (Mercuri et al. 2006). Actually, *Platanus orientalis* L. was an important ornamental tree used by Romans and should be considered an archaeophyte in Italy (Rosati et al. 2015).

Cereal pollen slightly increases during the Roman phases reaching the highest value at the fourth century AD (11% in sample no. 55). Cereal pollen is not easily transported far from the field, so its finding is indicative of the presence of fields near the site (Fyfe 2006). Despite this, its average values are not so high, allowing us to make two assumptions: (a) the sampling points, due to excavation reasons, did not involve areas considered as 'storehouses' by archaeologists; (b) it is likely that cereal fields were located not near the perimeter of the villa, but farther, maybe towards the *mansio* of Philosophiana (Bowes et al. 2011; Vaccaro 2013b), where the land conformation is more suitable for fields. However, it is important to note that the high percentage of cereal pollen of sample no. 55 (fourth century AD, abovementioned) suggests a particular accumulation produced by people, that probably brought to the area, e.g. flowering spikes, or mature spikes with pollen trapped within the glumes, or even pollen trapped on themselves (Robinson and Hubbard 1977; Bottema 1992). Otherwise, this increase of cereals seems to confirm the agrarian specialisation of Sicily as a main producer area for both free commerce and *annona* (grain supplies) reported on textual sources since the Republican period. In ancient sources,[3] we read that under the Romans, Sicily, and especially the area of Enna, became 'the granary of the Empire' and a crossroad of the Mediterranean, Again, in the Late Roman period, the island regained this role. Near the lake of Pergusa, about 20 km from Piazza Armerina, according to the myth, happened the kidnapping of Persephone-Kore (Proserpina), goddess linked to agriculture and wheat.

At Philosophiana (unpublished data), for the period ranging from the first century BC to the first century AD, cereals are well represented, with a peak of ca. 5% and an average value of ca. 3%. This evidence confirms the function of the Villa as an administrative/productive centre of a large agricultural estate (*latifundium*) mostly based on cereal cultivation. The promotion of grain production by senatorial-rank landowners, at this time, had a significant role in the economic revival of the Sicilian countryside and in flourishing of rural sites in the inland (Vaccaro 2013b).

Other important cultivated herbs, found in traces, are *Linum* and *Cannabis*. The record of flax was found at the end of the first century AD (at Pergusa—PG2 core, it is considered, along with other species including *Vitis*, an indicator of cultures starting from 1700 BC; Sadori et al. 2013). Hemp, whose values are not high but common in all phases, it is known to be a species cultivated and processed by Romans in central and northern Italy (Mercuri et al. 2002).

Finally, the finding of *Nymphaea alba* type (max value 2.3%—fourth century AD) deserves to be mentioned. Even if water lily is obviously a plant from wet environments, in this archaeological context its pollen is probably clue of an ornamental use, e.g. in the peristyle tub. A very high percentage of *Nymphaea* (30%) from the Greek-Roman theatre of Taormina was found in samples taken from silt layers and was interpreted as the evidence of the silt used for flooring inside the theatre (Mercuri et al. 2006).

From medieval to modern age phases (from fifth–sixth to the sixteenth century AD) (Figs. 6 and 7)

In the subsequent phases, pollen shows an open, fairly treeless, hilly landscape with Mediterranean vegetation. Elements of 'human-induced habitats' are particularly evident in the spectra, including both cultivation and species indicators of human presence.

As for Roman period, the value of arboreal pollen is low and never exceeds the 35% (except for one sample with *Olea* 14%). It is interesting to note that in Pergusa, *Olea* cultivation is undisputed only after 1600 AD (Sadori et al. 2013), although olive pollen has been present even before in the

[3] Marcus Tullius Cicero (106 BC–43 AD. Orationes, In Verrem 2, 2.5) '*Itaque ille M. Cato Sapiens cellam penariam rei publicae nostrae, nutricem plebis Romanae Siciliam nominabat*', referring to Marcus Porcius Cato 'the Censor' (234–139 BC).

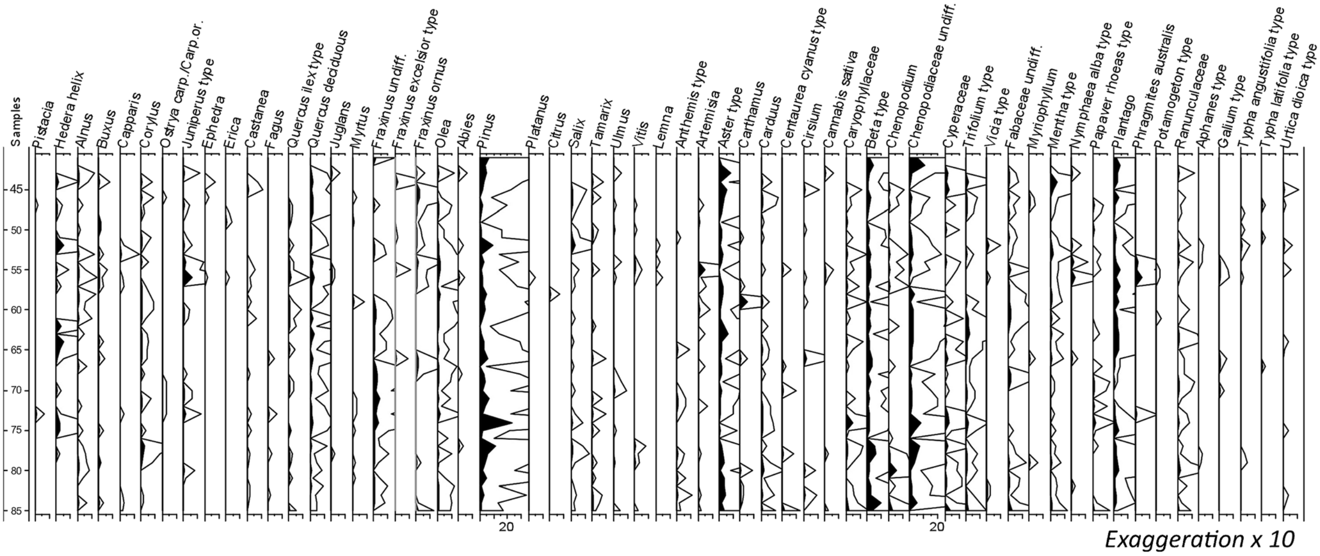

Fig. 4 Pollen data from Roman layers have been summarised in a diagram that shows the percentage of selected taxa (with enhancement curves × 10)

diagram (Sadori et al. 2015a). The on-site data from Villa del Casale, indeed, showing more local data, report that the maximum value of this pollen occurred about five centuries earlier. This suggests a strictly local presence of olive groves as an agrarian feature of the Roman villa during the medieval warm period (MWP ranges ninth–thirteenth century AD).

Another interesting feature is the maximum value of 15% (with a mean value of 4%) that the OJC group reaches during Late Arab/Early Norman phase.

For medieval phases, few macroremains are available (Terranova 2007). They were taken from a pit belonging to 'Room XXVI', dated to the tenth–eleventh century (Late Arab/Early Norman period). Some of them were charred and not identifiable, but the identified seeds/fruits partly confirm the pollen record. Besides one grape pip, there are cereals (*Hordeum vulgare*, *Triticum aestivum* and *Triticum dicoccum*) and pulses (*Vicia faba*, *Pisum sativum*, *Lathyrus sativus*, *Lens culinaris*, *Cicer aretinum*). Among pollen, legumes have not high average values (0.7%; max value 1.5%) accordingly to their entomophilous nature. As a general inference, the crop rotation of legumes/cereals should have probably assured the nitrogen fixation in soils.

Cereal pollen reaches a maximum of 3% in post-medieval phase. This value is lower than that observed in the Late

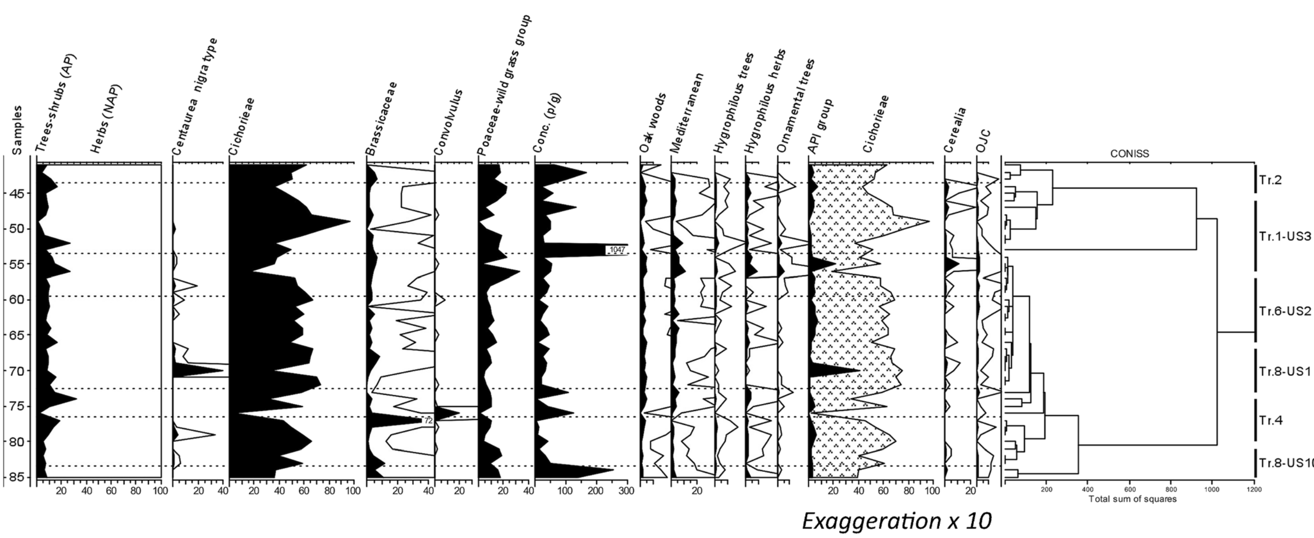

Fig. 5 Pollen diagram of Roman samples showing taxa with high peaks and cumulative curves (with enhancement curves × 10) useful for past reconstructions. Pollen curves follow the alphabetical order of the botanical families. Oakwoods: *Acer campestre* type, *Carpinus*, *Corylus*, *Fraxinus*, *Ostrya carpinifolia/Carpinus orientalis*, *Quercus* deciduous, *Tilia*, *Ulmus*; Mediterranean: *Capparis*, *Citrus*, *Cistus*, *Fraxinus* cf. *ornus*, *Juniperus* type, *Myrtus*, *Nerium oleander*, *Olea*, *Phillyrea*, *Pinus* cf. *halepensis*, *Pinus* cf. *pinea*, *Pistacia*, *Quercus ilex* type, *Tamarix*; Hygrophilous trees: *Alnus*, *Populus*, *Salix*; Hygrophilous herbs: *Alisma* type, Cyperaceae, *Lemna*, *Myriophyllum*, *Nymphaea alba* type, *Potamogeton*, *Typha angustifolia* and *T. latifolia* types; Ornamental tress: *Buxus*, *Celtis*, *Myrtus*, *Platanus*; API group: *Artemisia*, *Centaurea*, Cereals, *Plantago*, *Trifolium* type, *Urtica*; Cerealia: *Avena-Triticum* group, *Hordeum* group, Cerealia undiff.; OJC: *Olea*, *Juglans*, *Castanea*

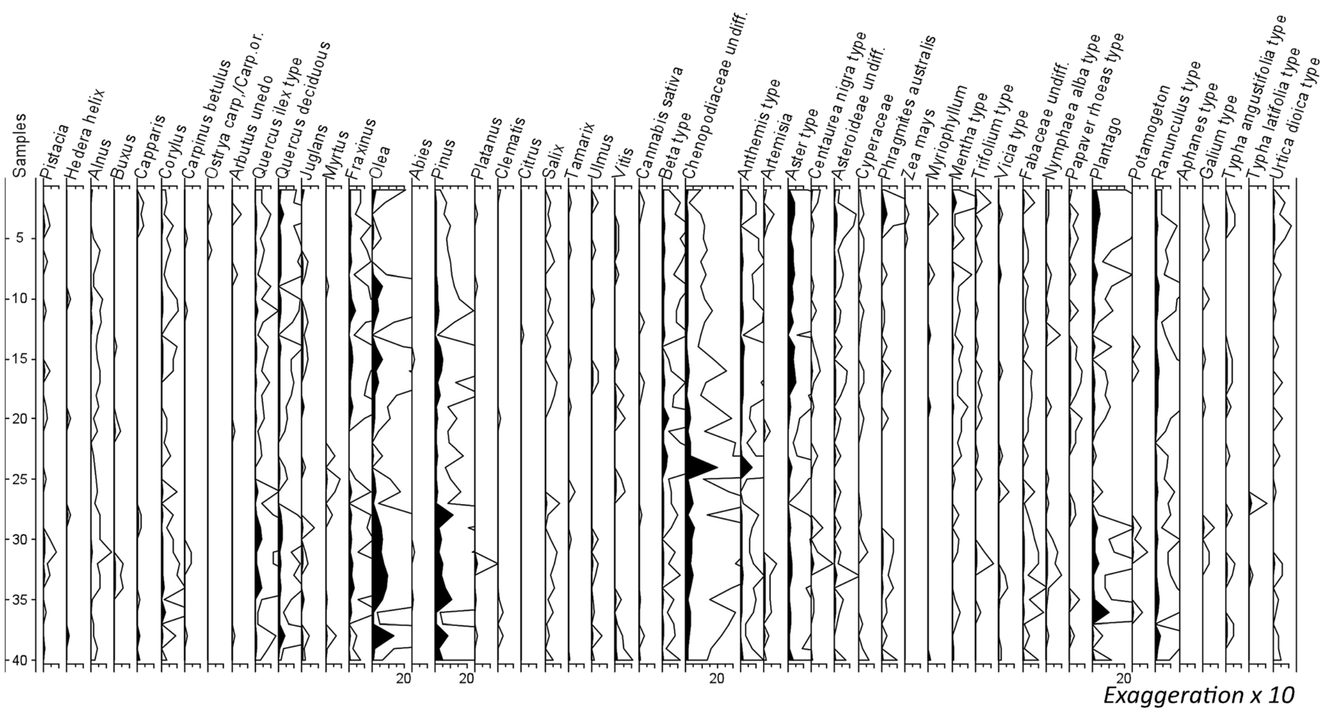

Fig. 6 Pollen data from medieval and subsequent layers have been summarised in a diagram that shows the percentage of selected taxa (with enhancement curves × 10)

Roman samples. Probably, the cereal fields were less wide than pastures. At Philosophiana, for the period seventh–twelfth century AD, the average value of cereals was slightly higher than that observed in the Villa del Casale samples (1.8% against 1%; Vaccaro et al. 2015).

Ornamental plants are still present as in previous phases: *Buxus* and *Myrtus* remain in traces, while *Platanus* slightly increases. The OJC group, cereals and anthropic indicators suggest that the land use of the area has changed. The settlement economy seems to have been more devoted to pasture lands and olive groves than to extensive cereal fields. There is evidence of plants that could have been cultivated in vegetable gardens (some aromatic plants can be included in pollen types of families such as Apiaceae and Fabaceae). Despite changes occurred, pollen shows a continuity of tradition over time. The different cultures that followed one another in the settlement

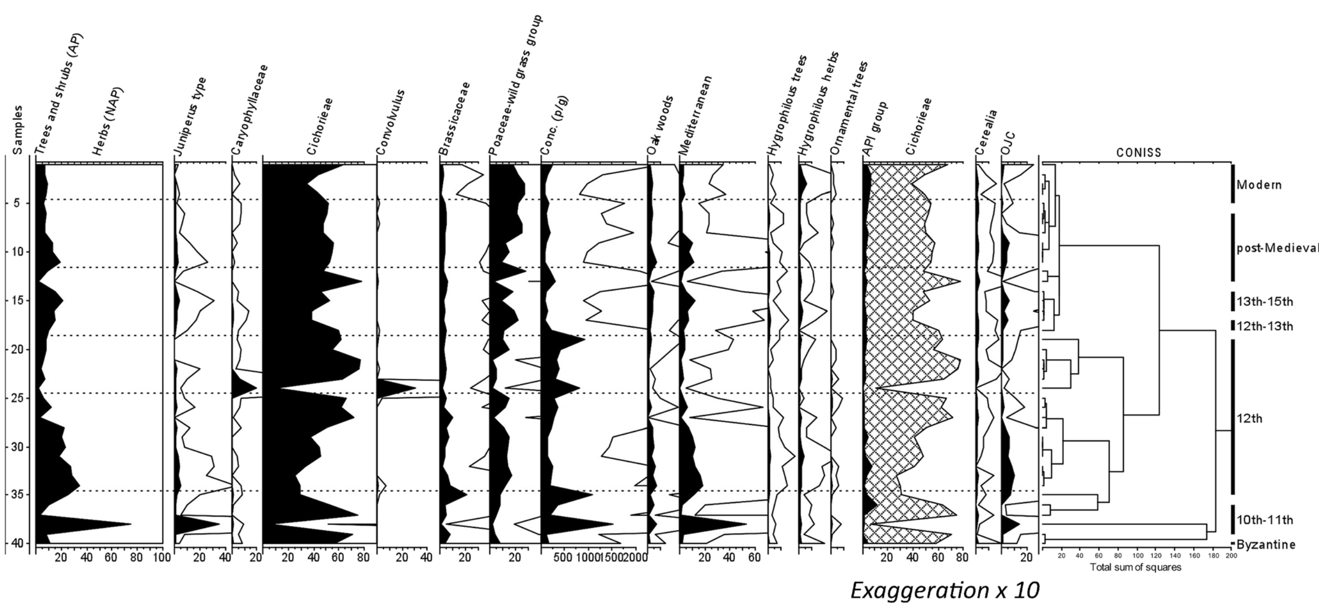

Fig. 7 Pollen diagram of medieval and subsequent samples showing taxa with high peaks and cumulative curves (with enhancement curves × 10) useful for past reconstructions. For categories, see caption of Fig. 4

seem to have progressively intermingled in the practises and uses concerning plants and plant landscape.

The 'cultural' *Vitis*

Vitis has an undisputed importance as a key 'culture plant' in central Sicily, but pollen from wild and cultivated subspecies give different contribution to the pollen rain. The wild, dioecious, species *Vitis vinifera* subsp. *sylvestris* is expected to produce more pollen than the monoecious *V. vinifera* subsp. *vinifera* that has both entomophilous or anemophilous cross-pollination, and self-pollination (Turner and Brown 2004). The very high pollen percentages, possibly also reflecting vine-lopping remnants thrown into the Middle Bronze Age moat of the Terramara Santa Rosa di Poviglio (Northern Italy), have been interpreted as findings from cultivated (not necessarily domesticated) plants easily grown in wet habitats (Cremaschi et al. 2016).

Vitis cultivars may be dramatically underrepresented, or even absent in past pollen spectra of Roman times in central (Bowes et al. 2015) and southern Italy (Florenzano et al. 2013). Therefore, even traces of this pollen may be interpreted as the local presence of viticulture (Bottema and Woldring 1990).

In the Garigliano delta plain, Central Italy, *Vitis* pollen is present with significant amount in pre-Roman periods (Middle Holocene phases, from ca. 3800 to ca. 1100 cal year BC) in the area of the Roman colony of Minturnae (5% in core P2, phase LPAZ Mnt2–2; Bellotti et al. 2016). In the PG2 core of Lago di Pergusa (Sadori et al. 2015a), the presence of *Vitis* during the last two millennia is continuous, suggesting local cultivation. At Philosophiana, on the contrary, *Vitis* pollen grains seem to be virtually absent (Vaccaro et al. 2015), with few exceptions (samples from the end of the first–second century AD, and from the ninth–tenth century AD). Actually, the area of Villa del Casale and Philosophiana is not characterised by the presence of kilns specialised in the production of wine amphorae; the archaeological evidence, therefore, supports that the presence of *Vitis* may be referred to local consumption rather than exportation (Vaccaro 2012).

At Villa del Casale, *Vitis* pollen grains were recorded in few Roman layers, suggesting that probably productive vineyards were not cultivated close to the site. Some plants may have been cultivated for decoration inside the villa, for instance in the *peristylium*—trench 8—as a *pergola*, i.e. a vine training. There are many similar examples from the Roman world, as for instance, the colonnade supporting a vine arbour in the house of *D. Octavius Qartio* (also known as of *Loreio Tiburtino*) in Pompeii (Ciarallo 2002, 2006).

During the transition between the Late Antiquity and the early medieval phases (tenth–eleventh century), the percentage of this plant halves and then totally disappears (at least until the Norman period—twelfth century and following phases), while *Olea* has its peak of concentration. This fact matches the presence of Arab people, whose religious requirements forbid wine consumption, in the medieval settlement. Arabs consider olive tree as a 'blessed tree' (Koran, surah 24—Brosse 2004). It is worth to note what the Italian historian Michele Amari (1854) wrote about grapevine cultivation during the Muslim domination (827–1091): vineyards declined and, at the end of the thirteenth century, Sicily had to import wines from Naples.

Conclusions

Sicily has been continuously occupied and exploited by different cultures during Middle and Late Holocene and its landscape is a result of the long-term shaping that humans and climate made on the environment. Our data bring evidence and details about the intense land exploitation that contributed to transform the natural environment of this island into the cultural landscape, from the Roman to the medieval period, at the origin of the modern agrarian landscape in central Mediterranean. Therefore, archaeobotanical studies are useful not only for 'classical archaeological' purposes but also for the understanding of the current landscape.

The low forest cover that is evident for both the Roman and medieval phases is not simply a local effect due to the archaeological buildings. Actually, this is a feature widespread at a regional level, from inland to coastal areas. At Lago di Pergusa (Sadori et al. 2013), the AP values are comparable with those observed at Villa del Casale. Although the other off-site cores are located in coastal areas (Gorgo Basso, Tinner et al. 2009; Biviere di Gela, Noti et al. 2009), the signs of land use intensification and human impact have been unambiguous in the region since historical times.

Acknowledgements The authors would like to thank several persons who encouraged and support our research: Arch. Rosa Oliva, former director (2013–2016) of the regional office 'Servizio Museo Regionale della Villa Romana del Casale a Piazza Armerina'; Arch. Guido Meli, former director of the regional centre 'Centro Regionale Progettazione e Restauro' of Palermo; Prof. Patrizio Pensabene (Università Sapienza, Rome) and Prof. Paolo Barresi (Università Kore, Enna), directors of the archaeological fieldworks and Dott. Salvatore Roccaforte of the 'Servizio Museo Regionale della Villa Romana del Casale a Piazza Armerina'.

Special thanks go to MCM's PhD tutors Prof. Carla Alberta Accorsi and Prof. Patrizio Pensabene. The project '*Il vino di Polifemo*' (Polyphemus's wine) was supported by the Italian Ministry (Ministero dei beni e delle attività culturali e del turismo, L. 20/02/2006 n.77) and by the Municipality of Piazza Armerina.

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