REVIEW



Olive growing in Puglia (southeastern Italy): a review of the evidence from the Mesolithic to the Middle Ages

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Abstract

This paper presents a comprehensive review of the history of the olive in Puglia, southern Italy, from prehistory to the Middle Ages, including evidence from various sources. The primary source of information is from archaeological sites, where the remains have been found of olive pollen, stones and wood charcoal, olive presses and pottery kilns for making amphorae for transporting olives or their oil. The survey also includes data from pollen sequences from natural sites and from written documents referring to olive groves. Our study shows that olives have been cultivated since the Early Neolithic, but it is only during the Middle Bronze Age that the domestic type appeared in the region, a consequence of selective cultivation of the wild type. The domestication of the olive had been completed by the first half of the 1st millennium BC, during the Iron Age–Archaic period, when remains of olives appear outside their area of natural distribution. The increasing exchanges with the Greeks during the Hellenistic period favoured the spread of olive cultivation and led to the construction of olive presses for oil extraction. The Roman conquest promoted the production of olive oil, which was successfully traded during the Republican and Early Imperial periods. After the Roman period ended, economic developments and political turmoil led to a decrease in olive growing, which did not fully recover until the Norman period in the 12th century AD. Later, under the Swabians, olives became a key crop and a major asset for the economy of Puglia.

Keywords Olive growing · Puglia · Archaeobotany · Pollen · Olive press

Introduction

The olive tree is the symbol of the Mediterranean landscape, where it has been cultivated for its fruits and wood since the prehistoric period (Carrión et al. 2010; Kaniewski et al. 2012).

Archaeological excavations have identified olive remains from as early as the Palaeolithic in Greece, where fossilized

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² Laboratory of Archaeobotany and Palaeoecology, University of Salento, Via Birago 64, 73100 Lecce, Italy leaves and charcoal were dated to 60–50,000 years ago (Friedrich 1978; Kuhn et al. 2010).

The domestication of the olive began much later, during the Copper Age (Chalcolithic) in the Levant region, but it is during the Bronze Age that olives became a staple crop in many areas of the eastern Mediterranean (Zohary and Spiegel-Roy 1975; Salavert 2008). Olive cultivation is seen as a turning point in the development of complex societies because it requires long term commitment and a centralized power to bring marginal areas into cultivation (Renfrew 1972; Margaritis 2013). Furthermore, the production of olive oil is considered to be related to the rise of elite groups who used it in ointments for ritual and cosmetic purposes (Archi 1991; Hamilakis 1996; Valamoti et al. 2017). Documentary evidence indicates intensive trade of scented olive oil among different political entities around the Aegean, the Levant and North Africa during the Bronze Age (Kelder 2009; Bushnell 2012; Fappas 2012). It is possible that demand for such products favoured the cultivation of olive in areas where it grew naturally.

Over the course of the Iron Age, olive cultivation became established in many areas of the western Mediterranean as a result of the contacts between Phoenicians, Etruscans and Greeks with the indigenous communities living in the Iberian Peninsula, Liguria, Provence and Tunisia (Garcia 1992; Brun et al. 1998; Leveau 2003; Buxó 2008; Laporte 2013).

By the time the Romans had extended their influence into other parts of Europe, the olive was intensively cultivated in southern Greece and Italy (Florenzano et al. 2013; Valamoti et al. 2017) and olives were being traded as far as Bulgaria and Britain (Lodwick 2013; Valamoti et al. 2018).

Studies in the Italian peninsula show an increase in the presence of olive since the 2nd millennium BC, which indicates that it began to be cultivated there in the Bronze Age (Di Rita and Magri 2009; D'Auria et al. 2016). Archaeological evidence from this period suggests that olive oil was being produced locally, because residues of the liquid have been detected in storage jars made in Sicily, Calabria and Puglia (Peroni 1994; Evans and Recchia 2005; Tanasi et al. 2018).

By the 5th century BC, Greek colonies had spread olive growing to Sicily, according to Diodurus Siculus of Sicily, a Greek historian writing in the 1st century BC (Diod. Sic. *Bibl. Hist.* 13.81.4–5, Oldfather 1950; Stika et al. 2008); the Etruscans had already established olive groves in Toscana (Tuscany) and Lazio in central Italy (Ciacci and Zifferero 2010).

Olive cultivation has been a pillar of Italian culture and economy since antiquity and olive growing continues to thrive even today in many regions. Puglia alone has 32% of all the olive groves in Italy, and is among the leading regions for olive production (Istat 2019).

A comprehensive history of olive cultivation in Puglia has never been compiled, and while evidence has been gathered by historians for the Middle Ages (Camposeo 2013; Stranieri 2019), archaeological discoveries suggest that a much longer tradition exists (Volpe 1990, 1996; Fiorentino et al. 2013; Primavera et al. 2017).

Here we present the first complete review of the history of the olive in Puglia, based on the integration of archaeobotanical, archaeological, palynological and written information. We analyse the evidence of the early use of the wild olive in the Neolithic and investigate the cultural processes that led to the cultivation of domestic olives by the Bronze Age. We evaluate the influence of contact with the Aegean world on the development of olive cultivation in Italy and examine the circumstances under which olives became cultivated outside the range of their natural distribution. The results of this study show that olive growing probably began during the Middle or Late Bronze Age in Puglia, but only in those areas that had direct contact with the people of the Aegean, as shown by pottery and building style. The transition from management of wild olives to cultivation on a large scale happened much later, during the Iron Age–Archaic period, coinciding with the time when the Greeks extended their influence over a large part of southern Italy through their colonies. The rise of olive cultivation in Puglia happened at the same time as in other parts of the western Mediterranean, where Greeks, Etruscans and Phoenicians improved the growing techniques in areas where olives had only occasionally been cultivated before.

The first recorded agronomic writings that refer to the olive in Puglia are dated to the Roman period, and archaeological evidence shows that the expansion and prosperity of the Early Roman Empire was instrumental in the spread of olive groves and oil processing facilities in Puglia.

The end of the Roman Empire and the political upheavals that followed led to the collapse of agriculture and the decline of olive cultivation in Puglia in the 5th–10th century AD. The continuous state of war between Goths, Byzantines, Lombards and Saracens caused instability in the region and left much land abandoned or belonging to the Church. Until the 10th century, olives were grown as a small-scale enterprise carried out by monastic orders which settled in the north of Puglia and by the Byzantine villagers who lived in the south.

After the Norman conquest in the 11th century AD there was a period of relative stability during which the calcareous hills of central Puglia were turned into olive groves in the 12th century and olive growing became a leading part of the economy of the region. In 1194, Puglia, as part of the Kingdom of Sicily, joined the Swabian realm through the marriage of the Holy Roman Emperor Heinrich VI to the Norman heiress of Sicily. Under Swabian rule, Puglia became a leading region for the production of olive oil, a status it retains to the present day.

The origin of the olive, its use, cultivation and domestication, an open issue

Olea europaea L. (olive) is the domesticated form of *O. europaea* ssp. *sylvestris* (Mill.) Rouy ex Hegi (wild olive, oleaster), which is an evergreen sclerophyllous tree or shrub. *Olea* is considered to have been part of the middle Tertiary flora, and it managed to survive during the Quaternary glaciations to become a major element of Holocene thermophilous Mediterranean vegetation (Carrión et al. 2010; Suc et al. 2018).

Scholars have long debated the origin and natural distribution of wild olives, as well as the nature and timing of domestication (Trujillo et al. 1990; Terral et al. 2004; Baldoni et al. 2006; Carrión et al. 2010; Besnard et al. 2013; Valamoti et al. 2017).

Pollen evidence shows that *Olea* has been present in the Mediterranean region since the Miocene, but its pollen

becomes more abundant from the Middle Pleistocene (Suc et al. 2018). Olive charcoal from the Acheulian site of Gesher Benot Ya'aqov, Israel, which is dated to ~800,000 years ago, proves that in western Asia its wood was used in the Lower and Middle Palaeolithic period (Goren-Inbar et al. 2004). Later evidence from the Palaeolithic includes olive charcoal from the Klissoura Cave in Greece, dated to 60,000 years ago (Carrión et al. 2010; Kuhn et al. 2010) and the leaf prints identified in the ashy layers from the Santorini Volcano, dated to the Weichselian High Glacial (Friedrich 1978). A few millennia later, olive appeared in Spain, at the Cave Higueral de Valleja (Jennings et al. 2009).

Secure finds for the Epipalaeolithic come from Israel, from the site of Ohalo II (Kislev et al. 1992) and Turkey, from the Öküzini Cave (Emery-Barbier and Thiébault 2005). The use of the wild olive continued in the Near East in the Early Neolithic period, as shown by the remains of olive stones found at Nahal Oren (Noy et al. 1973) and Horvat Galil, both in Israel (Liphschitz 1997).

Increasing evidence of olive in the Mediterranean Basin during the final stage of the Pleistocene

Olea is well recorded on the Island of Cyprus since the 9th millennium BC, having being found at Shillourokambos and later, from the 8th millennium at Khirokitia (Thiébault 2003). In the central Aegean area, finds of *Olea* are limited to the caves of the Cyclops-Youra, Alepotrypa and Drakaina, Greece, where charcoal was found in layers dated to the Late or Final Neolithic period (4th millennium BC) (Ntinou 2011; Ntinou and Stratouli 2012; Ntinou and Tsartsidou 2017); however, no secure finds of olive have occurred from the Early and Middle Neolithic in Greece (Valamoti et al. 2017).

In the western and central Mediterranean, olive finds are abundant south of the parallel 40°N, a latitude that marks the northernmost limit of the thermo-Mediterranean Climatic Belt suitable for it (Thiébault 2001; Carrión et al. 2013). In the Iberian Peninsula and in Morocco, olive has been found in a few Epipalaeolithic/Mesolithic sites, such as Cueva de Nerja and Cova de Santa Maira, Cova de l'Esperit and later in Abrido da Pena d'Água and Río Palmones (Carrión et al. 2010) and Ifri Oudane (Morales et al. 2013). The northernmost presence of *Olea* in the meso-Mediterranean climatic area is from Portugal, at Buraca Grande, and dates from the 7th millennium BC (Figueiral and Terral 2002).

Olive finds are reported from Italy, at Grotta dell'Uzzo, Sicily, where *Olea* charcoal was identified in the Mesolithic levels dated to the 7th millennium BC (Costantini 1989). Later finds include the olive charcoal remains in Arene Candide Cave, Liguria, dated to the 6th millennium BC (Nisbet 1997). The presence of olive in the archaeological deposits of the western Mediterranean region increases exponentially since the start of the Holocene, and studies suggest that it became more intensively used since the Neolithic (Terral 1997, 2000; Carrión et al. 2013).

The timing of the domestication of the olive is controversial and genetic analyses of modern olive trees provide varied results, suggesting that domestication did not occur as a single event, but rather as a long and gradual process that might have developed in different places at different times in the wider region of the Mediterranean (Besnard et al. 2001; Breton et al. 2009; Belaj et al. 2012; Diez et al. 2015). It remains unclear whether the diversity of modern olive varieties arises from the diversification of genetic traits among isolated groups of domesticated olives, or from multiple independent processes of primary domestication.

Archaeobotanical finds from the Levant, in the eastern Mediterranean region, suggest that the local wild olive stands began to be systematically used since the Chalcolithic, possibly paving the way towards an early form of domestication there in the Copper Age (Zohary and Spiegel-Roy 1975). Remains of structures probably used for the extraction of olive oil dated to ~ 5600 to 5000 cal BC were discovered in the submerged Neolithic Site of Kfar Samir, south of the Haifa Bay, Israel (Galili et al. 1997). The study of the archaeobotanical remains associated with these structures suggested that wild oleasters were used for the extraction of their oil. The domestication of the olive might have begun as early as 4400-4000 cal BC, when it started to be used outside its area of natural distribution (Kaniewski et al. 2012). Chalcolithic sites in the Jordan valley such as Teleilat Ghassul and el-Khawari provide abundant finds of olive stones and structures for the extraction of olive oil (Bourke et al. 2004; Lovell et al. 2010; Dighton et al. 2017), but uncertainties persist about the nature of the olives found at these sites. Scholars debate whether they were harvested from local stands of domesticated trees, or rather imported from areas where wild olives were abundant (Salavert 2008). The number of finds increases throughout the Levant around 3300–2100 cal BC, when olives became widely used at sites such as Ebla-Tell Mardikh, Syria (Caracuta and Fiorentino 2014), Qatna-Tell Mishrifsh, Syria (Peña-Chocarro and Rottoli 2007) and Mersin, Turkey (Fiorentino et al. 2015). Textual evidence shows that olive oil was a precious commodity that was traded in exchange for silver, wool and textiles, and used as an ointment in various ceremonies, including coronations of kings (Archi 1991).

The timing of the appearance of intensive olive cultivation in other areas of the Mediterranean is a matter of debate. In the Aegean area, structures connected with olive oil extraction are known from the 3rd millennium BC (Blitzer 1993), but archaeobotanical evidence indicates that olive cultivation might have started there as early as the 4th millennium (Valamoti et al. 2017). It has been suggested that the intensification of contacts between Crete and the Levant favoured the spread of olive cultivation into the Aegean region to satisfy the increasing demand for ointments (Blitzer 2014). Other authors support the idea of a local development that happened earlier than the Bronze Age and was independent of the Levant (Margaritis 2013). Regardless of the timing, by the 2nd millennium BC, olive was systematically being grown to extract its oil, which was used by the Minoan palaces as a system of payment and as a way of making alliances (Kelder 2009; Fappas 2012).

The evidence from the western Mediterranean shows that the wild olive has been consistently used since the Mesolithic, but it is only during the Bronze Age that new ways of managing it were developed. Selective pruning was applied to increase flowering and fruit production (Terral 1997, 2000; Terral et al. 2004), but evidence of real cultivation does not appear until the Iron Age. The timing and geographical distribution of olive cultivation differs between regions; in the southern Iberian Peninsula, cultivated olive was introduced by the 9th century BC by the Phoenicians, while in southern France it was introduced in the 6th century by the Greeks of Massalia (now Marseille) (Buxó 1999, 2008; Marinval 2000). Finds of olive oil presses are dated a few centuries later, to the 5th century BC in the Iberian Peninsula and to the 3rd century BC in southern France (Brun et al. 1998; Quixal Santos et al. 2016).

The olive in the Italian peninsula: a review of the evidence

Comprehensive studies of the presence of olive on the Italian peninsula show records of it there since the Early Holocene. The earliest evidence (ca. 6700–5700 вс) comes from Sicily, where *Olea* pollen is recorded in the pollen sequences from Lago di Pergusa and Gorgo Basso (Sadori and Narcisi 2001; Tinner et al. 2009) and olive charcoal has been found in the Mesolithic layers of Grotta dell'Uzzo (ca. 6600–6100 вс) (Costantini 1989).

During the mid Holocene, olive appears in Liguria, in the charcoal assemblage of Arene Candide Cave (Nisbet 1997). Pollen records from Puglia and Toscana show that *Olea* was present there from the 5th millennium BC (Caroli and Caldara 2007; Di Rita and Magri 2009; Di Rita et al. 2011).

Reviews of the pollen analyses available for the Italian peninsula show an increase in the percentage of *Olea* pollen in the 2nd millennium (Magri et al. 2015), with a peak at the end of the 1st (Mercuri et al. 2013), suggesting that olive cultivation became widespread between the 2nd and 1st millennia BC. These data match those of another study, based on a review of the charcoal records available for southern Italy, which dates the earliest evidence of olive to the 21st–18th

centuries BC (D'Auria et al. 2016). Olives were grown in several areas of southern Italy, probably to produce olive oil; residues of the precious liquid were found in a large container discovered in a hut at the Site of Castelluccio, Sicily, that was radiocarbon dated to the 10th century BC. The container was locally manufactured and the find reinforced the hypothesis that the olive oil which had been stored inside was locally produced, rather than imported from other areas of the Mediterranean (Tanasi et al. 2018). The discovery of other containers for liquid in Calabria and Puglia, showing traces of olive oil and dating to the 12th–11th century BC, confirm that olive oil was extracted in various places during the Late Bronze Age, probably encouraged by contact with the Aegean people (Peroni 1994; Evans and Recchia 2005; Guglielmino et al. 2015). Despite the importance of olive oil for the Bronze Age communities in Italy, there are no archaeological remains of structures for pressing olives from before the Iron Age-Archaic period.

The earliest evidence of structures associated with olives is dated to the 6th century BC and consists of the oil cellar discovered in the Villa dell'Auditorium, Rome (D'Alessio and Di Giuseppe 2004). The area which was then under Etruscan influence, which included Lazio, Toscana and northern Campania, has yielded other evidence that indicates the importance of olive oil production at this time. This includes the bronze containers full of olive stones discovered in the 'Olive Tomb' in Caere, 'Vulci's Krater', a large vase with scenes of shaking down olives with poles, and an *aryballos* (flask for perfume or oil) with the Etruscan name of olive, 'Eleiva', engraved on it (Ciacci and Zifferero 2010).

In other regions, the cultivation of olive was started by the presence of Greek colonies, such as at Agrigento and Selinunte in Sicily and Metapontum in Basilicata, southern Italy, according to Diodorus (Costantini 1983; Diod. Sic. *Bibl. Hist.* 13.81.4–5, Oldfather 1950; Stika et al. 2008). It is possible that the foundation of the Greek colony of Taras (now Taranto) also promoted olive cultivation in Puglia; the sharp increase of *Olea* pollen in the pollen record of Lago Alimini around the 8th–7th century BC supports this hypothesis (Di Rita and Magri 2009).

It was during the Roman period that a series of technological improvements led to the spread of olive cultivation (Brun 2004). Oil production peaked in the early part of the Roman Empire, mostly in Campania, Lazio and Puglia, where oil facilities were connected to *latifundia*, great estates owned by the aristocracy (Falsone 1976; Wilson 1982; Gualandi 1985; Volpe 1990; Brun 2004). Later, the expansion of the Roman Empire during the 2nd and 3rd century AD opened the Italian market to imports of olive oil from Spain and North Africa which led to a decrease in the demand for the local product (Mattingly 1988a, b). The analysis of the documentary records suggests that the large estates were converted into cereal farms by the 3rd century AD. Puglia appears to have followed this trend and became the "bread basket" of Rome (Pani 1979). After this, the disruption that followed the end of the Roman Empire and the lack of a stable political system may have been a deterrent to olive growing in many parts of the Italian peninsula during Late Antiquity and the Early Medieval period (5th-6th century AD), for olive groves take many years to become productive. Secure evidence for an economic recovery starts to appear from around the 11th century, after the Normans had conquered southern Italy and the cultivation of olives could finally be restored (Lizier 1907). Olive growing began again in Puglia in the 12th century AD, where large areas were devoted to the production of olive oil meant for international markets. A century later Campania and Calabria followed this lead, while it took another two centuries for the regions in central Italy to start producing olive oil for exports once more (Cortonesi 2005).

From this brief review of the evidence for the presence of olives and their cultivation, it emerges that Puglia is among the regions with the longest tradition of olive cultivation in Italy, which has played a key role in the development of an 'olive culture' there as an important part of life in the Mediterranean region since the prehistoric period. The importance of olive growing there has led historians to carry out extensive research on the Medieval and modern historical records of it (Licinio 1983; Iorio 2005; Dalena 2010; Camposeo 2013; Rivera Magos 2013), but exhaustive studies for the prehistoric and early historical periods have not been published and there has not been any comprehensive analysis of the origin and development of olive cultivation in Puglia, up to now.

The context of the study

Geographical setting

The Puglia region is mostly flat, with two major plains, the Tavoliere and the Salento, which account for about half of its area. Higher terrain is concentrated in the northern and central parts of the region. The northern part, which corresponds to the Province of Foggia, includes the Monti Dauni, a hilly complex which forms a natural boundary between Puglia and Campania, and the Gargano, a promontory on the Adriatic coast.

In the centre of the region stands the Murge Plateau, which gradually descends eastwards towards the coast (Fig. 1).

The diverse geomorphology of the region is responsible for local variations in rainfall and temperature, which in turn lead to significant differences between the climate of the hilly areas and that of the plains. Average rainfall ranges



Fig. 1 a Location of Puglia, **b** administrative division of the region, **c** average annual rainfall map and **d** topography, showing hilly areas, also olive growing areas in green

from 500 mm on the plains and low hills to 1,000 mm in the higher ranges of hills (Fig. 1). Average summer temperatures range from 15 to 40 °C, while winter temperatures range from 10 to 5 °C and rarely drop below zero. Puglia is characterized by a Mediterranean climate, with cool winters and springs and hot dry summers (Caliandro and Stelluti 2005).

Geomorphology, soil and climate create a variety of habitats. Of these, the most favourable for growing olives are those with calcareous soils, 600–800 mm annual rainfall and winter temperatures between 15 and 5 °C, such as the Murge Plateaus and the Salento Peninsula (Macchia et al. 2000).

Materials and methods

The primary source of information for our study is from archaeological sites, where remains of olive stones, charcoal and pollen grains can be preserved. Unfortunately, the numbers of archaeological sites excavated for each period varies widely, and not all sites have yielded archaeobotanical material.

In order to assess how representative the data are of the region, the number of sites with olive remains was compared to the total number of sites for which there were archaeobotanical investigations. In the sites where charcoal and olive stones were found, archaeobotanical remains were recovered using a range of methods, such as flotation or wet sieving of sediments or sampling visible burnt patches. The total number of charcoal pieces and seeds was recorded, and the percentage of olive remains compared to other taxa was calculated. Since different methods were used to recover the remains, the density of olive remains per litre of sediment could not be compared between sites.

The type of data collected includes the presence of olive charcoal, olive stones and pollen. The type and quantity of remains and the percentage of the archaeobotanical assemblage associated with olive remains was recorded for each site (Table 1).

The technique used to date the olive remains represents a further source of uncertainty; radiocarbon dating is used in prehistoric contexts to date the olive remains or the layer they were found in, but it is rarely applied to historical contexts, where the chronology usually relies solely on the cultural material.

Given that archaeobotanical investigation was not done at all the excavated sites and that where it was, the botanical material was sometimes randomly collected and not always securely dated, it was assumed that a survey based solely on the archaeobotanical evidence would be biased. In order to obtain a more accurate picture of the presence of olives in Puglia through the last 9 millennia, other sources of information were needed to be included in the survey. Archaeological remains, such as ancient installations for the extraction of olive oil and kilns for making oil amphorae for export, provide information on the economic system associated with the use of olives during the historical period.

The survey also includes documentary sources, such as administrative texts that refer to the cultivation of olives in Puglia and the trading of olives and their oil from this region around the Mediterranean during the Middle Ages. The data considered in the present study were not derived from a direct analysis of the documents, but rather were taken from reviews compiled by historians, such as Lizier (1907), Touber (1981), Martin and Noyé (1989) and Cherubini (1987).

The cartularies (administrative document collections) of medieval churches and monasteries are the primary textual sources of information and the most important documents are gathered together in three major collections, known as *Codici diplomatici Barese, Brindisino* and *Pugliese*.

These collections include 20 volumes of documents dating from the period from the 8th to the 14th centuries AD, but the ones mentioning donations of olive groves to local churches and tax collections in the form of olives and olive oil mostly date from the 11th–13th centuries (Carabellese 1899, 1912; Coniglio 1975).

Lastly, the survey examined the pollen records obtained from natural deposits. The entire corpus of published offsite pollen records for the area under study consists of three lake cores, from Lagi Battaglia, Salso and Alimini (Caroli and Caldara 2007; Di Rita and Magri 2009; Di Rita et al. 2011) and one marine core (MD 90–917) (Combourieu-Nebout et al. 2013). The four sequences are geographically distributed along the eastern coast of Puglia and are mostly representative of its ecological conditions, but no set of data is available for the inland part of Puglia or the western coast.

Following the work by Florenzano et al. (2017), who observed that the deposition of olive pollen decreases exponentially with distance from the olive trees, it was estimated that values above 7% total pollen indicate that olives grew close to the coring sites (\leq 500 m). Using this value as a reference, the *Olea* pollen curves from the four cores were plotted together and the variations in the percentages were used as a direct indication of the closeness of olive trees to the pollen coring sites. For details of the sites included in the survey, see the ESM.

The database was compiled including all the types of finds identified for each site, archaeobotanical remains, written documents, archaeological structures and pollen data. Each find represents a distinct entry, so if a site yielded archaeobotanical remains and also archaeological structures, it was counted as two entries. That was the case of the Site Terragne-Cisternino (BR), which had both archaeological and pollen records. If the same type of find occurred in two different chronological phases, as in the Site

Table 1 List of archaeological sites where olive remains were found

Elevation (m a.s.l.)	0-85				85-170			170-280			280-370			370-700						
Remains	Wood Stones		es	Wood Stones			Wood Stones			Wood Stones			es	Wood Stones						
No. and percentage	N	%	N	%	N	%	Ν	%	Ν	%	N	%	N	%	N	%	N	%	N	%
7th-3rd millennium BC																				
Scamuso*	Р	Р	Р	Р	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Terragne*	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carpignano salentino	-	-	-	-	23	48	+	N/A	-	-	-	-	-	-	-	-	-	-	-	-
Pulo di Molfetta	-	-	-	-	10	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macchia don Cesare	74	28.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21st-13th century BC																				
Coppa Nevigata	404	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scoglio di Apani	16	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Castello Angioino	13	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piazza San Salvatore	21	13.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Domenico	10	14.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scalo di Furno	39	15.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Masseria Chiancudda	47	25.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piazza Palmieri	64	63.4	30	N/A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roca	220	57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oth 2nd contumy DC																				
Via Damalla	2	4	2	5																
Via Perfeita	2	4	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Castelluccio	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	170	44	-	-
Cavallino	8/ D	29 D	- D	- D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arpi"	Р 7	P 12	Р	Р	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	/	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L'Amastuola	-	-	-	-	-	-	-	-	1,008	39	10	0.08	-	-	-	-	-	-	-	-
Fondo Casino	40	12	48	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fondo Melliche	-	-	-	-	160	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Castello D'Alceste	-	-	-	-	350	52	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monte Papalucio	-	-	-	-	352	12	81	0.9	-	-	-	-	-	-	-	-	-	-	-	-
Monte Calvello	-	-	-	-	-	-	-	-	728	88	-	-	-	-	-	-	-	-	-	-
Piazzetta Cervi	7	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caserma Roasio	62	26	22	82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piazzetta Epulione	214	34	9	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piazza Dante	-	-	-	-	60	55.5	86	10	-	-	-	-	-	-	-	-	-	-	-	-
Saturo	16	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Muro Tenente	-	-	-	-	216	3	32	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Località Torre Montello	-	-	>100	N/A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Palazzo Vernazza	196	41			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cattedrale di Monopoli			>100	N/A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Egnathia	614	52	61	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Località Capanne	-	-	-	-	413	45	1	50	-	-	-	-	-	-	-	-	-	-	-	-
Herdonia*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Р	Р	Р	Р
1st cent. BC-6th cent. AD																				
Faragola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	132	3	65	2
Via Ciotta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	112	32	-	-
Chiesa Sant'Irene	90	40	26	80	-	-	-	-	-	-	-	_	-	-	-	-	_	_	-	-
Masseria d'Amendola	-	-	-	-	-	-	-	-	-	-	-	-	776	72	1	50	-	-	-	-
Egnathia	65	4	3519	55	-	-	-	-	-	-	-	-	-	_	_	-	-	-	-	-
Giarnera Grande*	-	-	-	_	-	-	-	-					-	-	-	-	Р	Р	Р	Р
Località.Perazzone	-	-	-	-	-	-	-	-	+	N/A	6	80	-	-	-	-				
Muro Rotto	-	-	-	_	-	-	-	-	152	84	_	_	-	-	-	-				
Piazzetta Epulione	18	10	3	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piazzetta Castromediano	243	50	4	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caserma Roasio	24	3	2	3	-	-	-	-	-	_	-	_	-	_	-	-	-	-	-	-
	2.	5	-	5																
7th-14th century AD					•															
Località Scorpo	-	-	-	-	30	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apigliano	-	-	-	-	220	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paretone	-	-	-	-	153	22.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Montecorvino	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	5	1	0.3
Quattro Macine	210	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Castello Carlo V	100	27.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
San Lorenzo in Carminiano	112	22.7	40	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vico dei Sotterranei	58	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caserma Roasio	300	30	1	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Località Capanne	-	-	-	-	17	29.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Borgo Terra	6	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Capanne-Castro, where archaeobotanical remains of olive were found in the Hellenistic period and also in the Medieval, it was counted as two different entries in the database. As a result, the number of entries is higher than the number of sites.

Results

The survey of pollen, archaeobotanical macrofossil, archaeological structures and documentary evidence has enabled us to identify 166 records of olive, distributed over 127 sites and spanning a period from the Mesolithic to the Middle Ages (Fig. 2; for details, see ESM).

The records may be grouped into five major chronological phases: the first includes the Neolithic and Aeneolithic (Chalcolithic) periods (7th–3rd millennia BC), the second the Bronze Age (21st–13th centuries BC), the third the Iron Age, together with the Archaic/Classical and Hellenistic periods (8th–2nd centuries BC), the fourth the Roman period (1st century BC to 6th century AD), while the fifth, the Medieval period, lasts until the beginning of the Post-Medieval period (8th–14th centuries AD).



Fig. 2 Total entries considered in the survey. The first number (before the comma) represents the total number of entries per type of find (archaeobotanical remains, written documents, archaeological structures etc.). The number after the comma is the percentage that the type of finds represents. In brackets the number of sites where that particular class of finds was found

Archaeobotanical data

Fifty-nine archaeobotanical entries from 56 sites were included in the survey, representing 35% of the total entries (Fig. 2).

The largest group (23) is dated to the period from the 8th to the 2nd centuries BC, while the rest are unevenly distributed, with just 5 records for the 7th–3rd millennia BC, 9 for the 21st–13th centuries BC, 11 for the 2nd century BC–6th century AD and 11 for the 7th–14th centuries AD (Fig. 3).

When the presence of olives is evaluated against the number of sites with archaeobotanical analyses, it becomes clear that the presence of olives increases over the course of time, as a consequence of cultural and environmental factors (Fig. 4).

For the Neolithic and Aeneolithic periods, olive remains are found in 13% of the sites investigated. The finds are limited to low-lying and coastal sites, although human occupation reached far inland and high altitudes.

For the Bronze Age, olives are recorded at 50% of the sites investigated, but these continue to be limited to the coastal areas. A significant gap exists for the 12th to the 9th centuries due to the lack of major archaeological excavations for this period (Fig. 4b).

The Iron Age and the Archaic/Classical and Hellenistic periods are characterized by an increase in the number of finds of olives. The period from the 8th to the 2nd centuries BC sees the definitive rise of the olive, which becomes ubiquitous and is found outside its previous distribution range.

During the Roman and Medieval periods, olives are recorded at all sites, including those above 400 m (Fig. 4d), where the ecological conditions are not optimal for Mediterranean maquis scrub vegetation or for olive growing.

Archaeological evidence

While the archaeobotanical record is widely distributed in area and period, the archaeological evidence for olive presses and pottery kilns for making olive oil containers is almost exclusively limited to the Roman period (Fig. 3). Overall there are 25 entries, distributed over 21 sites, accounting for 15% of the data surveyed.

The highest concentration of archaeological evidence is recorded in the Tavoliere and Monti Dauni areas, where an extensive archaeological survey was carried out by Volpe (1990, 1996). Other evidence was discovered in the course of archaeological excavations in the Salento Peninsula (Pagliara 1968; Manacorda 1990; Palazzo 1994a; Alessio 2001; Andreassi 2006) and on the Murge Plateau (Ciancio and Small 1990; Casucci 2007).

The lack of evidence of olive oil extraction and storage during the prehistoric period might reflect the absence or the limited use of the oil, but it may also depend on the



Fig. 3 Chronology of the evidence considered in the study. For each phase, the data are divided into columns representing a type of evidence. With the exception of 'pollen from natural deposits', for which a chronology based on cultural affiliation cannot be accurate, the columns are sub-divided according to the number of finds or records from a specific cultural period. In the case of 'written documents', the number of entries is higher (66) than the number of sites (47), because the same site is mentioned in more than 1 period. Similarly,

low visibility of the evidence itself. If the installations were made of perishable material, as they were in the Chalcolithic site of Kfar Samir-Israel (Galili and Weinstein-Evron 1985), or located far from major settlements, they would be hard to detect and difficult to date.

Information on olive presses in the Medieval period in Puglia is difficult to obtain due to the continuous use of traditional installations throughout the period. Underground installations for the extraction of olive oil are believed to have been in use since the Middle Ages, but none of the 174 remaining examples can be certainly dated to a time before the 16th century AD (Monte 1995; De Marco and Sannicola 2001; Manghisi 2004).

Documentary sources

With the exception of an engraved stele (stone slab) found in Herdonia which mentions the activities of a group of olive oil refiners active in the 2nd century AD (Mommsen 1883), the corpus of written documents is made up exclusively of clerical and administrative records dated to the 8th–14th centuries AD (Fig. 3).

Since these data come from reviews by historians, the exact number of references to olives in the documents cannot

archaeological sites that yielded archaeobotanical remains from n cultural periods were counted n times. *Mes* Mesolithic, *EN* Early Neolithic, *MD* Middle Neolithic, *FN* Final Neolithic, *Aen* Aeneolithic, *EBA* Early Bronze Age, *MBA* Middle Bronze Age, *IA* Iron Age, *Arc* Archaic, *Hel* Hellenistic, *Rep* Republican, *EI* Early Imperial, *Imp* Imperial, *LA* Late Antique, *Byz* Byzantine, *Nor* Norman, *Swa* Swabian, *Unc* Uncertain

be precisely assessed, nor can we estimate the frequency of mentions of olives compared to other important crops, such as grapes or cereals.

Based on the survey of these historical reviews, olives are recorded at 46 sites, of which 18 are in central Puglia, 16 in the north and 13 in the south. Olives are mentioned 106 times in total, 67 times in central Puglia, 22 in the north and 17 in the south (Table 2).

The number of entries is 66, and it is calculated as the sum of sites mentioned in each cultural period (for details, see Table 3).

The few records dated to the 8th and 9th centuries located olive groves on the calcareous plateau lying behind the City of Bari, around Canosa (AD 792 and 852), Trani (AD 845) and Barletta (AD 845). There are other mentions for the Capitanata region where olives were cultivated around Lucera (AD 846) and Lesina (AD 893) (see ESM for references).

By the 10th century, records of olive trees multiply in central Puglia, at Genna (AD 944), Monopoli (AD 944 and 963), Bari and Balsignano (AD 962), Conversano (AD 976) and Polignano (AD 977), while there are only two records outside this area, the first from Lesina (AD 944), the second from Massafra (AD 970), in the south (see ESM for references).



◄Fig. 4 Maps of the distribution of olive finds (black dots) from archaeological sites that yielded archaeobotanical remains. The crosses represent sites where no remains of olive were found in the archaeobotanical assemblage. The letters refer to the various chronological periods; a 7th–3rd millennium BC, b 21st–13th century BC, c 8th–3rd century BC, d 2nd century BC–6th century AD and e 7th–14th century AD

By the 11th century the mentions of olive double in central Puglia, going from 9 to 17 (Table 2). It is during the 11th century that for the first time olive groves were planted above 750 m, around Sant'Agata (AD 1086) (Martin 1993), well beyond the natural range of distribution. From the 12th century onwards, records of olive groves multiply everywhere in Puglia, but the central part of the region remains the most active of all, with several documents referring to the presence of olive presses around Bari and its surroundings (Table 2; Nitti de Vito 1900, doc 20, 1902, docs 3 and 17).

Pollen records from natural deposits

Four pollen cores extracted from natural deposits provide a continuous record of *Olea* in Puglia. Of the four cores, three provide a record from the 5th millennium BC until the first half of the 2nd millennium AD, while the fourth, from Salso, only provides a record for the first 2,000 years of this period, as shown in Fig. 5. Thus, we obtain four entries for the first and second chronological phases, and three entries for the 3rd–5th phases for which the Salso sequence provides no data. A total of 17 entries were counted corresponding to 10% of the total considered in the survey.

The earliest trace of olives was found in MD 90–917, the marine core located about 20 km east of Bari, where *Olea* pollen appears around 8500–8000 BC (Combourieu-Nebout et al. 2013; data not shown in Fig. 5). Given that the data come from an offshore core, the record does not prove that the olives grew in Puglia during the Epipalaeolithic, but rather that at the end of the Younger Dryas (YD), the environmental conditions in the lower Adriatic region became suitable for the olive.

The earliest traces of *Olea* pollen in the lake cores are found from Battaglia and Salso and date to the recent Neolithic, the second half of the 5th millennium BC (Fig. 5; Caroli and Caldara 2007; Di Rita et al. 2011). Despite some intra-core variability, the percentage of olive pollen remains relatively high up ($\geq 10\%$ total sum) to the Final Neolithic and Aeneolithic periods.

The transition from the Aeneolithic to the Bronze Age marks the beginning of a drastic reduction in the percentage of olive pollen in the lake cores, which reaches its lowest point between the 24th and 22nd centuries BC, when the values drop below 5% (Fig. 5). Unlike the lake cores, the marine core MD 90–970 shows an increase in olive pollen

that might indicate favourable conditions for olives along the lower Adriatic coast.

The end of the Bronze Age marks a change toward a diversification in the spatial distribution of olives. In the Lago Alimini results, the percentage of olive pollen increases constantly from the 21st to the 11th centuries BC, with values reaching up to 15%, while in Battaglia the percentage is below or close to 5%.

The first half of the 1st millennium BC is characterized by a drop in the percentage of olive pollen in the Battaglia core in which, between the ~ 8th and 6/5th centuries BC, values are close to zero. The Alimini core shows a slight decrease around the 9th/8th centuries BC, but the values remain above 10% for the rest of the millennium.

The downward trend does not seem to have lasted more than a few centuries, and a new increase is recorded towards the end of the Roman period. The last part of the millennium is characterized by a constant increase in values in Alimini, while Battaglia shows a more fluctuating pattern, with values close to 5% between the 1st and 4th centuries AD, in the 8/9th centuries and in the 10/11th centuries AD. The period between the 5th and 12th centuries sees an increase in olive pollen in MD 90–970, which indicates more olives growing along the lower Adriatic coast.

Discussion

The olive in Puglia through the ages

Earliest records: Neolithic and Aeneolithic periods

The first appearance of the olive in Puglia remains debatable, and the few records available for the Palaeolithic and Epipalaeolithic periods suggest open landscapes, characterized by various species of *Prunus* and *Pinus*, and no trace of olives (Follieri 1968; Maspero 2004; Fiorentino 2012; Fiorentino and Parra 2015). Offshore data from core MD 90–917 show that at the end of the YD period, the environmental conditions in the lower Adriatic region became suitable for the olive (Fig. 5, pollen zone 917-IV), but the earliest evidence of olives in Puglia is dated much later.

For the Mesolithic and Neolithic periods, the evidence is very scarce and just 5 out of 38 sites with archaeobotanical data yielded olive remains (Fig. 6; Fiorentino et al. 2013).

The earliest evidence of olives in Puglia are the pollen and charcoal found in the Mesolithic levels of Terragne, where *Olea* appears to be associated with mesophilous woodland taxa such as *Ostrya carpinifolia*, *Prunus* spp. and deciduous type *Quercus* (Accorsi et al. 1995; Fiorentino 1995a).

Other early records include the *Olea* pollen found at the Early Neolithic Site of Scamuso, in layers characterized by impressed pottery dated to the first half of the 6th Table 2Total number of
mentions of olives per area
per century or cultural period
in the administrative records
(for references and details, see
ESM)

.

Cultural period	Lomba	rd/Byza	ntine	Norma	n	Swabia	n	Total mentions		
Century AD	8th	9th	10th	11th	12th	13th	14th	per site		
Central Puglia										
Canosa	1	1					1	3		
Trani		1		3				4		
Barletta		1			1	1		3		
Balsignano			1					1		
Genna			1					1		
Polignano			1					1		
Conversano			1	2	1			4		
Bari			3	7	9	5		24		
Monopoli			2	1	1	1		5		
Canne				1	1			2		
Terlizzi				1	2	1		4		
Corato				1	1	1	1	4		
Andria				1			1	2		
Bitonto					1	1	1	3		
Rutigliano					1			1		
Molfetta					1	1		2		
Giovinazzo					1			1		
Sub total	1	3	9	17	20	11	4	65		
Southern Puglia										
Massafra			1					1		
Misicuno				1				1		
Pulsano				1				1		
Taranto				2	1			3		
Nardò				1				1		
Fasano					1			1		
Castellaneta					1			1		
Mesagne					1			1		
Mottola					1			1		
Ostuni					1	1		2		
Brindisi					2	1		3		
Otranto							1	1		
Gallipoli							1	1		
Sub total	0	0	1	5	8	2	1	17		
Northern Puglia										
Lucera		1						1		
Lesina		1	1				1	3		
Sant'Agata				1				1		
Troia				1	1			2		
Foggia				1	1	1		3		
Dragonara					1			1		
Peschici					1			1		
Vieste					1		1	2		
Salpi					1	1		2		
Casalnuovo						1		1		
Castel Fiorentino						1		1		
Montecorvino						1		1		
San Severo						1		1		
San Paolo di Civitate						1	1	2		
Manfredonia							1	1		
Ascoli Satriano							1	1		
Sub total	0	2	1	3	6	7	5	22		
Total of mentions per cent.	1	5	11	25	34	20	10	106		

millennium BC. The tree pollen there is below 5%, which indicates a rather open landscape, and it can be assumed

that the olives were not growing close to the site (Renault-Miskovsky and Bui-Thi-Mai 1997).

Table 3 Total entries for the area in the various cultural periods. Each entry corresponds to the mention of olive in the administrative documents dated to the period, Lombard/Byzantine (8th–10th century AD), Norman (11th–12th century AD) and Swabian (13th–14th century AD)

	Lombard/ Byzantine	Norman	Swabian	Total entries for area
Central Puglia	9	13	9	33
Southern Puglia	1	10	4	15
Northern Puglia	2	7	11	18
Total entries for period	12	30	24	66

The plant macrofossil analysis confirms that various staple crops such as barley, wheat and legumes had been grown since the Early Neolithic (Fiorentino et al. 2013), while remains of olive stones are absent from sites dated to this period, which indicates that olive was merely used for its wood. Charcoal studies in Spain and France show that the use of wild olive wood increased during the Neolithic, and the whole tree began to be used and not just the small branches, as in the Mesolithic (Terral 2000; Piqué 2009).

The earliest remains of olive stones date to the Middle Neolithic and were found in Carpignano Salentino, where they were found in funerary contexts (Primavera 2008; Ingravallo and Tiberi 2009). In the Final Neolithic olive wood was still being used at Pulo di Molfetta (Primavera and Fiorentino 2011). Olive wood continued to be appreciated by the Aeneolithic communities, who used it in funerary rituals, such as those performed at the stone tumulus in Macchia Don Cesare (Aprile and Fiorentino 2018).

The data available from charcoal for the three sites show that *Olea* was associated with mesophilous trees such as deciduous *Quercus*, *Carpinus betulus*, *Corylus avellana*, *Fraxinus* sp., *Prunus* sp., as well as members of the Mediterranean maquis, such as evergreen *Quercus*, *Pistacia lentiscus*, *Cistus* sp., *Erica* sp. and *Rhamnus/Phillyrea*.

A continuous set of evidence comes from the pollen records of Battaglia and Salso, where olive pollen appears in the mid 5th millennium in percentages that indicate that the trees grew near the lakes (Fig. 5). Around this period, the pollen spectrum of Battaglia (pollen zone BAT5) is characterized by high arboreal pollen (AP) values (72-95%) with high percentages of evergreen Quercus type (9-42%), deciduous Quercus type (16–39%) and Ostrya/Carpinus (4–11%), which are indicative of mesophilous conditions around the lake (Caroli and Caldara 2006, p. 321). Compared to Battaglia, which is closer to the wooded hills of Gargano, Salso shows a higher input from thermophilous vegetation typical of coastal environments. In this record (beginning of pollen zone CN3-1), evergreen taxa such as evergreen Quercus (33%), Pistacia (11%), Phillyrea (7%) and Olea (10%) are abundant (Di Rita et al. 2011, p. 144). The tree pollen values



Fig. 5 Comparison of olive pollen values recorded in the MD 90–970 marine core and the Battaglia, Salso and Alimini Lake cores. Data from Caroli and Caldara (2007), Di Rita and Magri (2009), Di Rita et al. (2011), and Combourieu-Nebout et al. (2013). The pollen percentages are based on AP+NAP pollen sums

in this zone range from 60 to 80%, a clear indication of good woodland cover around Lago di Salso. Despite their ecological differences, Battaglia and Salso reflect similar situations with wild olive trees growing among dense woodland.

When the archaeobotanical and off-site pollen data are combined, the records of olives are concentrated within a few kilometres of the modern coastline at an altitude of 0 to 130 m. Given that the inner parts of the region had been inhabited since the Early Neolithic (Fig. 4a), and since no evidence of the presence of olives is recorded inland, one can assume that stands of wild olives only grew close to the coastline where the climate was of a Mediterranean type. The abundance of mesophilous taxa in the evergreen woodland indicates wetter environmental conditions than at present.

The lack of archaeobotanical data for the 4th and 3rd millennia BC prevents speculation on the local farming economy and leaves unresolved questions about the role of olives in Puglia during the Copper Age. Data on the local environment can be inferred from pollen cores, where changes in the composition of the vegetation were driven more by climate than by human activities.

Variations in vegetation cover along the southeast coast are recorded in Alimini, which shows increasing woodland, with tree pollen increasing from 22 to 94% between the 37th and 24th centuries BC (pollen zones ALI-1, ALI-2). During this period, *Olea* values are modest ($\leq 6\%$), and the landscape appears to have been dominated by *Quercus* mostly of the evergreen type (Di Rita and Magri 2009). A sudden change occurs between the ~ 24th and 21/20th centuries (ALI-3), when the AP drops from 94 to 70% and the values of *Olea* and evergreen *Quercus* decrease. In this period, the increase in herbs and Mediterranean shrubs indicate a more open landscape.

The second half of the 3rd millennium BC is generally associated with a warming period in the eastern Mediterranean (the 4.2 kyr event) and is related to the end of the Early Bronze Age in western Asia (Fiorentino et al. 2008; Roberts et al. 2011; Kaniewski et al. 2018). It is probable that the changes recorded in the Alimini and Battaglia pollen results were driven by this major climatic event.

From use of wild olives to cultivation: the Bronze Age

The beginning of the 2nd millennium, which corresponds to the start of the Bronze Age in southern Italy, is characterized by a sudden increase in *Olea* pollen in Alimini, which remains high until the beginning of the 1st millennium. Higher values for evergreen trees and higher AP (80%) indicate the recovery of woodlands around the lake (Di Rita and Magri 2009, pp. 298–300).

Data from northern Puglia, such as those from Lagi di Battaglia and Salso, show an increase in trees in the first half of the 4th millennium (AP 80–90%), indicating favourable conditions for olives and evergreen oaks (pollen zones BAT4, CN3-1) (Caroli and Caldara 2007, p. 322; Di Rita et al. 2011, p. 144). In the second half of the 4th millennium, the values of herbs begin to increase (CN3-2 and beginning of BAT3). Tree and shrub pollen reaches its lowest point around the 24th century BC, when evergreen *Quercus* and *Olea* values drop below 20% and 5% respectively at the beginning of BAT3 (Caroli and Caldara 2007, p. 322). No information is available for Salso for the 2nd millennium and Battaglia shows low *Olea* values (\leq 5%) in spite of a general increase in trees in the second part of BAT3.

The earliest archaeological olive remains date to the 2nd millennium and are found at sites of the Apennine culture. This cultural complex, typical of central and southern Italy, lasted from the 21st to the 11th centuries and corresponds to the Bronze Age. Fundamental features of this culture in Puglia include a mixed economy based on agriculture and pastoralism, and exchanges with the people around the Aegean (Guglielmino et al. 2010; Cazzella and Recchia 2013). Evidence of the use of olives comes exclusively from coastal sites, where their wood was used; none of the inland sites with archaeobotanical analyses has ever yielded olive finds (Fig. 4b). Olea is among the most frequently identified woody taxa (Table 1), and is associated with deciduous and evergreen Quercus, Pistacia ssp. and Prunoideae (Primavera et al. 2017). The only remains of olive stones so far discovered come from the Middle Bronze Age burial in Piazza Palmieri. These were subject to image analysis and the results have provided insights into the cultivation of the olive in Puglia during the Middle Bronze Age (Fiorentino 1995b). Based on the morphology of the stones, they showed similarities with both wild and domesticated olive varieties that were widespread in the western Mediterranean (Terral et al. 2004).

The presence of domestic and wild olive types of western origin in the same assemblage suggests that local stands had been subject to some form of management that led to the selection of domesticated traits in the olive trees and therefore their stones.

Archaeologists tend to think that systematic cultivation of the olive in Puglia started in the Middle Bronze Age, as a consequence of the intensification of the interaction between the Aegean people, who used olive oil as a commodity and traded it across the Mediterranean, and the indigenous population (Cazzella et al. 2003; Evans and Recchia 2005). This hypothesis is strengthened by the findings of traces of olive oil on locally manufactured Bronze Age pottery (Guglielmino et al. 2015).

The find of olives in Piazza Palmieri could be interpreted as early evidence of systematic cultivation, but not necessarily as conclusive evidence of olive domestication. The domestication of a plant such as the olive is considered to have occurred over a long period and to have involved successive stages (Margaritis 2013). Managing wild stands by techniques such as pruning would certainly have improved productivity, promoting the selection of useful genetic traits, but it is through asexual propagation, which fixes genetic traits, that the process of domestication is completed.

During the Middle Bronze Age, the wild olive was a common component of the Mediterranean maquis scrub that spread along the coast of Puglia. Systematic use by the local population would have favoured the selection of useful traits, as evidence from Piazza Palmieri suggests, but the process of domestication had only just begun. There is no evidence that people were able to propagate the plants, which would also have allowed them to grow olives inland, where part of the population lived. In contrast, the evidence suggests that the indigenous populations of Puglia were able to manage the olives only where there were wild stands. Increased contacts with the Aegean people, who had already mastered the art of olive oil extraction by the 17th century (Blitzer 1993;



Fig. 6 Distribution of olive finds or written records in Puglia over the

last 7 millennia BC. The distribution of modern olive groves is based

on the data available at Puglia.con (2019). Loc. Località, M.te Monte,

Mass., Masseria, P.tta Piazzetta, P.zzo Palazzo. The letters refer to the

various chronological periods; **a** 7–3rd millennium BC, **b** 21st–13th century BC, **c** 8th–3rd century BC, **d** 2nd century BC–6th century AD and **e** 7th–14th century AD

104. Rutiglaiano, 105. Salpi, 106. Salso Lake, 107. San Domenico, 108. San Lorenzo in Carminiano, 109. San Paolo di Civitate, 110. San Severo, 111. Sant'Agata, 112. Santa Maria di Merino, 113. Saturo, 114. Scalo di Furno, 115. Scamuso, 116. Scoglio di Apani, 117. Siponto, 118. Taranto, 119. Ternzano, 120. Terlizzi, 121. Terragne, 122. Trani, 123. Troia,

24. Via Ciotta, 125. Via Perrella, 126. Vico dei sotterranei, 127. Vieste.

Fappas 2008; Valamoti et al. 2017), might have led to the adoption of new techniques that paved the way towards the cultivation of the plant in Puglia.

Detection of olive oil residues on locally made pottery containers from Sicily, Calabria and Puglia shows that olive oil had become a traded commodity during the Bronze Age (Peroni 1994; Evans and Recchia 2005; Guglielmino et al. 2015), but no archaeological remains of structures for olive presses that pre-date the Iron Age–Archaic period have ever been found. The lack of such structures raises questions about the extent of olive growing during the Bronze Age and suggests that this was a short-term achievement, which was begun through contact with the Aegean people and ended with the disruption of the Minoan world (ca. 1450–1100 вс).

The rise of the olive culture: the Iron Age and the Archaic, Classical and Hellenistic periods

Towards the end of the Bronze Age, Illyrian people arrived in Puglia from the Eastern Coast of the Adriatic (Lomas 2000), as also reported by classical authors living much later, in the 1st century AD by Pliny the Elder (Pliny, *Nat. Hist.* 3.102, Rackham 1942) and Strabo (Strabo, *Geography*, 6, 1, 3 C277, Jones 1924). The newcomers, merging with the indigenous populations and perhaps some Aegean groups, led to the development of Early Iron Age cultures (Herring et al. 2007).

The 12th to the 9th centuries BC, which mark the transition from the Bronze Age to the Iron Age, must have been crucial for the success of the domestication of the olive, but no archaeobotanical data are available for the period, while those from the pollen cores suggests the transformation of the natural landscape into farmed land.

In Battaglia, the 1st centuries of the 1st millennium are characterized by low pollen deposition and high values for grassland taxa and micro-charcoal, showing that fire was used to open up areas for farming at the end of BAT3. Given the low *Olea* values ($\leq 5\%$), it is unlikely that olives were extensively cultivated around the lake (Caroli and Caldara 2007, p. 322).

In the second half of the 1st millennium, the landscape around Battaglia continued to be open and greatly affected by human activities, as shown by the high frequency of micro-charcoal and the high sedimentation rate. Unlike the previous phase, when olives played a marginal role, the last five centuries of the 1st millennium are characterized by increasing values of both *Olea* and cereals in BAT2 (Caroli and Caldara 2007, p. 322).

The Alimini record shows a similar pattern, with a marked decrease in the values of *Olea* and other trees and shrubs at the beginning of the 1st millennium BC (ALI-4). The trend is quickly reversed around the 8th–7th centuries, when the area was intensively occupied, as shown by the

continuous presence of cereal and olive pollen at the end of ALI-4 and in ALI-5 (Di Rita and Magri 2009, p. 300).

The archaeobotanical record shows that the olive had spread outside its natural range by the 8th century. Olive wood was found at Castelluccio, an Iron Age/Archaic site located at 380 m, where it dominates the charcoal assemblage in association with evergreen and deciduous taxa (Fig. 4; D'Oronzo 2012).

In the 8th–6th centuries, small groups of Greek seafarers settled along the coast of southern Italy and established colonies. In Sicily, the cultivation of olive was begun by the Greek colonists of Agrigento and Selinunte, while the colony of *Metapontum* grew it in the Basilicata region according to Diodorus (Costantini 1983; Diod. Sic. *Bibl. Hist.* 13.81.4–5, Oldfather 1950; Stika et al. 2008). It is likely that the foundation of *Taras* (modern Taranto) in southern Puglia intensified contact between the Greeks and the local communities (D'Andria 1983) and favoured the spread of olive cultivation there. Olive remains were found in all sites dated to the Archaic period such as Via Perrella, Cavallino, Fondo Mbrufico, Fondo Casino and L'Amastuola (Colaianni 2008a, b; Lentjes 2011).

The political crisis that struck the region at the end of the Archaic phase (5th century BC) led to a reorganization of the territory, with fewer larger sites ruling over groups of smaller rural settlements (D'Andria 1999; Semeraro 2009). This hierarchical system may also have favoured the spread of specialized crops such as olives and perhaps grapes. Data become more abundant from the 5th to 4th centuries, when olives became a staple for the indigenous population in Castello d'Alceste and Monte Papalucio (Ciaraldi 1997; D'Oronzo 2012). The first structure for the extraction of olive oil, found at Oliovitolo, is dated to this period (Alessio 2001).

A similar trend might have developed in northern Puglia, where the natural pollen records, such as that from Battaglia, show a constant increase in olive pollen during the second half of the 1st millennium BC. Unfortunately, the lack of on-site archaeobotanical studies for the period limits our understanding of the local events in this part of the region.

Archaeological evidence from southern Puglia suggests the reorganization of rural areas around major settlements during the Early Hellenistic period in the second half of the 4th century (D'Andria 1989; Burgers 2009). Under the direction of elite groups, a large number of rural sites were established in marginal areas to promote agricultural development, an action that was mainly driven by the Messapians, a local Illyrian tribe (Semeraro 2009). Some archaeologists have linked this increase in urban and rural settlements with agricultural specialization, which, in their opinion, was based on large-scale vine and olive cultivation (Yntema 1993, 2008). The archaeobotanical evidence is consistent with this hypothesis. Indeed, olive remains are abundant in all 16 sites dated to the 4th–3rd/2nd centuries BC, but it is difficult to estimate the extent of olive cultivation and the role it played in the rural economy.

In the Hellenistic period, olive growing became widespread in southern Italy (Mercuri et al. 2013), and archaeobotanical, archaeological and pollen evidence confirms its importance in the farming economy of Puglia in that period (Fig. 6).

The independent development of the Hellenistic city states in Puglia was ended by the Roman conquest, which began in the early 3rd century BC, when the Romans won the Pyrrhic War, defeating the Greek City of Taranto and its allies in 275 BC (D'Andria 1991). The foundation of Latin colonies opened up the Roman market, encouraging the production of a food surplus for trade. In order to satisfy the demand of the urban markets, new farms appeared in the countryside and archaeological and aerial surveys show that olive groves and vineyards grew in number (Goffredo and Ficco 2009).

Agricultural specialization and exports across the Mediterranean in the Roman period

The end of the second Punic War between Rome and Carthage (201 BC) brought about a substantial reorganization of the territory of Puglia with the inclusion of vast areas within the *ager publicus* or public land, often that which had been seized from enemies of Rome. Under the land reforms of the Gracchus brothers, who were tribunes of the Roman republic, the *ager publicus* was divided into *centuriae*, and large portions of the Tavoliere and Salento Peninsula were devoted to olive growing (Jones 1980; Chiocci and Pompilio 1997; Marcantonio 2001; Marchi 2010).

The historian Dionysius of Halicarnassus, who lived in the 1st century BC, praised the Salento and the Capitanata regions for their extensive olive groves in his *Antiquities of Rome* (Dion. Halic. *Ant. Rom.* 1, 37, 2, Cary 1937). During the early years of the Roman Empire, most of the olive oil produced in Puglia was for export.

Varro, a classical author active in the 1st century BC, refers to Brindisi as one of the major ports for trading olive oil (Varr. *Re Rust.* 2, 6, 5, Hooper and Ash 1934), and the oil exported from there came from a local olive variety called 'sallentina', which was also known to Pliny (Plin. *Nat. Hist.* 15, 20, Rackham 1942). The role of Brindisi as a regional centre for the trade in the oil produced in the Salento region is confirmed by the presence of nearby settlements near the modern Apani, Giancola and Marmorelle, which were centres for the extraction of the oil and the production of amphorae since the 2nd century BC (Manacorda 1990; Palazzo 1994a, b).

Amphorae for the shipment of the olive oil produced in Brindisi are found in plenty on the opposite shores of the Adriatic, on the Albanian coast, as well as in the western Mediterranean, in France and Spain (Nonnis 2001).

Another important place where Puglian olive oil was traded from was the port of San Cataldo; traces of a kiln for firing amphorae used as olive oil containers, of the same type produced in Giancola and Marmorelle, were found 5 km away from the port, in Masseria Ramanno (Valchera and Zampolini Faustini 1997). Further evidence includes the makers' stamps on the amphorae, typical of olive oil containers produced in Felline (Pagliara 1968).

Other archaeological evidence from Salento is available for the Province of Taranto, including structures for olive oil extraction in Oliovitolo, active since the 5th century BC, in Pizzariello and Angiulli (De Juliis 1985; Andreassi 2006). The role of Taranto as a centre of olive oil production is recorded by the Latin poet Horace, who, in his *Odes* in 30 BC, expressed his desire to spend his old age in the most beautiful place he knew. The author was referring to Taranto, a town which produced oil so excellent as to be comparable with that of Venafro in Campania, considered the best in the entire Italian peninsula (Hor. *Odes and Epodes*, 2, 6, 9–16, Rudd 2004).

Outside Salento, archaeological evidence for the production of olive oil during the Republican and Early Imperial period is scarce. A small installation for the extraction of olive oil was found in the *pars fructuaria* (room for the processing of olive oil and wine) of a villa farm in Botromagno, central Puglia (Ciancio and Small 1990). Inscriptions on amphorae found in a rich tomb in Arpi suggest that the trade in olive oil flourished in the Tavoliere area during the 2nd century BC (Volpe 1995).

Archaeobotanical analyses carried out in northern Puglia provide additional information; the study of the plant offerings in the Roman cemeteries of Via Ciotta and Masseria Amendola proves that olives were grown on the Monti Dauni in the 1st century BC (Caracuta and Fiorentino 2013, 2018).

In 7 BC the Roman Emperor Augustus reorganised Italy into regions, and large senatorial estates were created in the area with facilities for refining and storing olive oil, and by the 1st century AD olive groves had been established on the hilltops of the Monti Dauni, at Rota/San Lorenzo and Radogna (Fig. 6, ESM; Volpe 1990).

Between the 1st and the 3rd centuries AD, Roman influence spread around the Mediterranean Basin, opening up new sources of supply to meet the growing demand for food for Roman citizens (Panella and Tchernia 2002). Western Africa and Spain became the preferred sources of olive oil, to the detriment of the Italian provinces such as Puglia, which struggled to compete by the 2nd century AD, despite the economic stimulus provided by the Emperor Trajan in the form of loans to landowners (*Alimenta*). Historians have suggested that many of the Italian olive groves were converted into cereal fields as a consequence of the crisis that struck the agricultural sector (Pani 1979). Signs of this change can be seen in the pollen records of Alimini and Battaglia, where olive pollen suddenly decreases around the 2nd-3rd centuries AD, at the beginning of BAT1 and ALI-5 (Fig. 5). This decrease is accompanied by a general decline in trees and shrubs of the Mediterranean maguis and an increase in herbs, which can be related to human disturbance (Di Rita and Magri 2009, p. 300; Caroli and Caldara 2007, p. 323). If there was indeed a change towards cereal based agriculture, olive production did not completely disappear from Puglia. Structures for the extraction of olive oil have been found and dated to the Early Imperial period as well as the Imperial and Late Roman periods, and olive remains are ubiquitous at archaeological sites throughout the Roman period, such as Piazzetta Castomediano and Epulione, Muro Rotto, Perazzone and Faragola (Figs. 3, 4; Caracuta and Fiorentino 2009; Primavera 2011; this study). The stele from *Herdoniae* also shows that a group of olive processors was still active in northern Puglia in the 2nd century AD (Mommsen 1883).

Warfare, crisis and recovery of olive growing: Early and Late Middle Ages

The information available on olive cultivation in Puglia from Late Antiquity to the Early Middle Ages is relatively scarce. A possible reason for this might be the wars and upheavals which affected the region in the 5th and 6th centuries AD. There was first famine and Byzantine raids, then the Greek and Gothic conflict in AD 535–540, followed by the arrival of the Lombards around AD 568. The resulting wars may have reduced the population of the region and had an impact on farming, making it difficult to cultivate the land (De Robertis 1972). The written sources available for the Gothic period indicate a general recovery of the agricultural sector, but no specific references are available for olive growing according to Cassiodorus, a Roman consul serving Theodoric, king of the Ostrogoths, in AD 537 (Cassiod. *Variae epistolae*, I, 16, Barnish 1992).

The perpetual state of conflict that then developed in the 7th century between Byzantines and Lombards exacerbated the demographic crisis that had affected Puglia since the beginning of the 6th century AD. Large portions of the countryside were abandoned and the remaining labourers went to work on estates owned by the Church (Licinio 1979). Over the course of the 7th century, the influence of the clerics grew exponentially thanks to donations of large portions of the countryside and the support of the Lombard rulers for the Beneventan abbeys, so that rural dioceses became the driving force of the local agricultural economy (Martin 1993).

For the 7th and 8th centuries AD, there is evidence from northern Puglia, an area under the influence of Lombard

rulers. The pollen record from Battaglia shows that olives were grown along the Gargano Coast, while a written document mentions olive groves as part of the property of the Beneventan Abbey of Canosa (AD 725). The bulk of the evidence comes from southern Puglia, a stronghold of the Byzantines, where olive remains are found at all sites that were occupied in the 7th–8th centuries, such as Apigliano, Scorpo and Paretone, while olive pollen corresponding to this time was found in abundance in the Alimini results ($\geq 20\%$) (Arthur et al. 2008, 2012; Di Rita and Magri 2009; Grasso et al. 2012; Stranieri 2019).

In the 9th and 10th centuries, much land in Puglia was abandoned as a consequence of the conflict between the Lombards and the Byzantines and the continuous raids by Saracens on the coastal areas (Martin 1993). When the Byzantines finally prevailed, new settlements were established to increase agricultural productivity and a new system of roads facilitated the transport of the surplus produce from the countryside to the ports. Central Puglia was among those areas that showed early signs of economic recovery, thanks to the role of Bari as the capital of the Byzantine Province of Italy from AD 970 onwards (Martin and Nové 1989). The majority of the documents dated to this period mention olive groves on the calcareous Murge Hills in central Puglia around Bari, Genna, Monopoli, Polignano, Conversano and the Benedictine Abbeys of Trani, Canosa and Conversano (Fig. 6; Table 2, ESM). There are fewer reports of olive groves on the Gargano promontory and Tavoliere delle Puglie plain at Lesina and Lucera (Leccisotti 1937, 1949). For the Salento Peninsula, olive groves are mentioned in the countryside around Taranto at Massafra, Misicuno and Pulsano, and Nardò (Fig. 6; Table 2, ESM; Robinson 1928; Pastore 1964; Martin 1993).

Less than a century after the foundation of the Catepanate Byzantine Province, the production of olive oil exceeded the local demand, and oil from Puglia was shipped to Constantinople from the Port of Bari, where a cargo was recorded as having being burnt in AD 1051 (Anonymi Barensis Chronicon 1724).

Thanks to the archaeobotanical data from the excavation of the Vico dei Sotterranei, we know that olives were also cultivated around Lecce in the 10th century AD, although there are no mentions of them in the written documents (Colaianni 2008b).

If Father Bonaventura da Lama is to be trusted, this is also the period when the Saracens introduced new olive cultivars and technological advances, significantly improving olive cultivation in Puglia (Bonaventura da Lama 1724).

Historians who have studied the documents of the Byzantine period agree that olives played a role in the economy of Puglia during that time, but they consider it to be less important than those of grapes and cereals, since these two dominate the administrative records of the 10th and 11th centuries (Lizier 1907; Touber 1981; Martin and Noyé 1989).

Byzantine control came to an end in AD 1071 when the Normans conquered Bari and extended their influence over the entire region. At the time of the conquest in 1070, the chronicle of the Church of Saint Nicholas recorded the raids by the Normans, who plundered the stock of olive oil, wine and cereals from the countryside around Bari (Nitti de Vito 1900, p. 87).

After an initial period of crisis due to the war, farming quickly recovered thanks to the action of the new rulers, who granted privileges to the Benedictine order to repopulate the countryside and plant vineyards and olive groves in marginal areas (Touber 1981).

The new rulers were very committed to olive growing, as shown by an episode occurring in the aftermath of the conquest of Taranto, when Robert Guiscard granted a local monastery the right to use the olive groves that had become part of his estate (AD 1080). The privilege was renewed by his son, Bohemond in AD 1090 (Marsicano 1115).

After the Norman Conquest, the presence of olive progressively increased in the region, and the number of places where olive is recorded in administrative records increases from 25 in the 11th century to 34 in the 12th century (Table 2).

Until the 12th century, olives were mostly grown in small patches and often in association with other trees, such as fig, almond and carob, and also vines. After the 12th century, olives became a specialized crop with hundreds of trees being cultivated together (Licinio 1983; Cortonesi 2005).

Compared to the previous centuries, when olives were mostly planted in connection with monasteries and the production of olive oil was meant to satisfy local demand, the 12th century marks the development of large groves and an increase in the number of olive presses for large scale production (Rivera Magos 2013).

A survey that examined 1,519 documents dated to the Norman period (11th–12th centuries) shows that the most productive areas were those around Bari. The percentage of agricultural land under olives varied, being higher in Molfetta (81%) and Bari (66%) and lower in Barletta (36%), Conversano (32%) and Terlizzi (24%) (Iorio 2005).

Four varieties of olive are mentioned in the documents; the first, *primitane*, is recorded in Trani (Prologo 1877, p 102), while the other three, named *urcatenke*, *celina* and *olkarta*, were cultivated in Monopoli (Coniglio 1975, p. 79).

From the 12th century onwards, cultivation became more extensive and the documents often describe large portions of clerical estates as olive groves (De Leo 1940, pp. 137–143); substantial investments or financial incentives were put in place to improve the state and the revenue of the church properties.

Examples of such incentives are recorded in Troia, where in 1162 the Benedictine Abbot Rainaldo granted a profit exemption for the money from olive groves and vineyards to the new tenants of the farm at Castellone in exchange for the renovation of the property (Dalena 2010). Similar agreements were adopted everywhere in Puglia and became effective measures to ensure the success of agriculture including olive growing during the 12h century.

The Swabian rulers from the end of the 12th century continued the policies of their predecessors, building new fortifications in Puglia, mostly manor farms, to control large territories (Norwich 1971) and conceding benefits to monastic orders to improve farming.

A peculiar trait of the 13th century is the rise of the monastic-knightly orders, such as the Templars, who acquired vineyards and olive groves in strategic locations in Puglia close to main roads, to facilitate the shipment of olive oil and wine overseas (Petracca 2016).

Under the Swabians, agriculture remained the strongest part of the economy and the production of olive oil was among the most successful enterprises, being largely traded abroad (Iorio 2005). The crown also began to regulate the oil trade by introducing specific taxes and export duties, which aimed to relieve the taxes paid by local farmers on retail sales of the oil they produced (Rivera Magos 2013). The merchants showed their appreciation and the local oil trade undoubtedly benefited. Thanks to Venetian and Florentine merchants, olive oil from Puglia was regularly traded to other parts of Italy, Sardinia, Genoa, Mallorca and Ragusa, and also abroad to Constantinople, Akko (Acre), Alexandria, Tunisia, Cyprus and Rhodes (Balducci Pegolotti 1343).

The success of olive cultivation in central Puglia was such that a fair dedicated to the olive oil trade was established (Cherubini 1987).

By the mid 13th century, olive groves were the dominant element of the agricultural landscape in the provinces of Bari and Otranto. The role played by Benedictine Abbeys in their spread there has long been known (Petrucci 1961; Coniglio 1975). The archaeobotanical data from Quattromacine, Capanne and Castello Carlo V confirm the presence of olives in the Salento Peninsula, while the charcoal and olive stones from San Lorenzo in Carminiano and Montecorvino show that olive groves were also found on the Tavoliere Plain and on the sub-Apennine Hills (Grasso and Fiorentino in press; Fiorentino 1999; Caracuta and Fiorentino 2012; Pasquino 2015).

Conclusions

This study represents the first attempt to combine all the available evidence into a complete history of the olive in Puglia. Based on the marine pollen record, *Olea* is likely

to have arrived in Puglia around 8500 BC, during the Postglacial period, when there were milder climate conditions in the lower Adriatic. This hypothesis has yet to be confirmed by the data, since the earliest undisputable evidence of olive in Puglia is dated much later, to the beginning of the 7th millennium cal BC.

From the Early Neolithic onwards, wild olive trees were used for their wood and later for their fruit, but only by the communities settled along the coast, where the conditions must have been suitable for olives (Fig. 7). The olive continued to be appreciated by the Aeneolithic people, who used the wood in funerary rituals.

There is a hiatus in the archaeobotanical data for the 4th and 3rd millennium BC, which limits our understanding of the role played by olives during the Aeneolithic (Copper Age). Data from pollen records for that period show a wooded landscape dominated by evergreen oaks, where the olive was just another thermophilous tree. A significant change is recorded between the ~ 24th and 21st/20th centuries BC, when the presence of olives and other trees and shrubs is reduced and the wooded landscape was opened up, mainly as a result of drought.

After this period, the earliest archaeological records are dated to the Early Bronze Age, the 20th–16th centuries BC, and come exclusively from coastal areas, where the ecological conditions were favourable for the wild olive stands. Some finds, such those from Piazza Palmieri, suggest that the local olive populations had developed morphological features that resemble those of domestic types, but the evidence in support of early domestication is not conclusive (Fig. 7). While domestication might have taken more time to be completed, it is possible that by the Middle Bronze Age, some useful traits had been *unwittingly* selected as a consequence of managing wild olives. Interactions between the indigenous communities and the Aegean people might have favoured the assimilation of new agricultural techniques that



Fig. 7 Origin and development of olive cultivation in Puglia in the various cultural periods

eventually led to olive domestication, and residues of olive oil on containers might indicate it had been produced locally.

The period from the 13th to the 9th centuries BC, which marks the transition from the Bronze to the Iron Age, must have been crucial for the success of the domestication of the olive, but no archaeobotanical data are available from then. The pollen records show an increase in human activities, including intense woodland clearance, but olives played a marginal role until the beginning of the 1st millennium BC.

The importance of the olive then grew exponentially during the second half of the 1st millennium, with an increasing number of finds detected outside its original ecological range, which suggests that domestication had been completed by that time (Fig. 7). The first olive presses are dated to this period, a sign that olive oil had become a much-used resource.

With the inclusion of Puglia in the Roman Empire in the 3rd century BC, the olive grew in importance and the number of installations for the extraction of olive oil increase. Olive oil from Puglia became a resource for the region, and kilns were built for making amphorae in which to ship the oil around the Mediterranean from the Ports of Brindisi and San Cataldo. Olive oil from Puglia was also renowned among classical authors, who praised its quality in their poems.

The expansion of the Roman Empire, which led to the inclusion of other areas specialized in the production of olive oil such as Spain, might have had a negative impact on olive growing in Puglia, but the evidence is inconclusive. While pollen records indicate a decrease in the area of land under olives, the archaeobotanical and archaeological evidence shows a steady presence of olives in the region until the Late Roman period.

The disruption of farming that followed the end of the Roman Empire did affect olive growing, which did not fully recover until the 10th century AD (Fig. 7). This was possible thanks to the initiative of the Byzantine rulers, who promoted the planting of olives in central and southern Puglia, and the Lombard rulers who supported the agricultural enterprises of the Benedictine abbeys in the north.

Under the Norman rulers in the 11th and 12th centuries, olive growing became a specialized crop in central Puglia, where more than half of the land was devoted to it, and olive oil from Puglia was sold on the international market. In the following centuries, the Swabians supported olive cultivation, applying economic policies that made olive oil from Puglia a desirable item for export.

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