


# The transition of chestnut (*Castanea sativa* Miller) from timber to fruit tree: Cultural and economic inferences in the Italian peninsula

Mauro Paolo Buonincontri, Antonio Saracino and Gaetano Di Pasquale

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## Abstract

Anthracological analysis has been carried out in the Medieval site of Miranduolo, a rural settlement in southern Tuscany with a sequence of occupation between the 7th and 14th century AD. Between the 7th and mid-9th century AD, during the phase of a Lombard farming village, the strong presence of *Castanea sativa* as timber for building showed that chestnut was the preferred species for carpentry and fuelwood, suggesting coppice management of chestnut woods for timber production. The Miranduolo data, set against the archaeobotanical data in the literature, rejected the hypothesis of chestnut cultivation as a fruit tree and corroborated the hypothesis that the plant was initially used for timber production during the Early Middle Ages, continuing the woodworking tradition of the Roman period. From the mid-9th century AD, during the Carolingian feudal system, chestnut in the feudal estate of Miranduolo ceased to be used for building and firewood, while deciduous *Quercus* was preferred. At the same time, chestnut fruits began to be picked and kept in warehouses at the disposal of the feudal lord, suggesting the management of chestnut woods for fruit production. Comparison with existing archaeobotanical data revealed that chestnut cultivation for fruits began in this period in other Italian regions also, encouraged by different economic systems. From the 10th century, in Miranduolo chestnut was exploited both for timber and fruit suggesting the abundance of this resource in high managed stands. Comparison with coeval archaeological sources, archaeobotanical data and pollen records suggested from this period the strong expansion of this species that gradually took place throughout central and southern Italy, becoming a 'multifunctional' high-forest. The current chestnut forest landscape in central Italy is thus of human origin, expanding and changing over about 1000 years of cultivation.

## Keywords

Carolingian feudal system, charcoal analysis, cultural landscapes, late Holocene, middle ages

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## Introduction

Today chestnut woods represent one of the most common man-made forest typology in European Mediterranean landscapes, widely replacing native woodland. Forest management practices have favoured the spread of this species well beyond the limits of its potential ecological range, albeit limited almost exclusively to acid or at most neutral soils. Chestnut woods in Europe cover an area of about 2 million ha, 40% of which (about 800,000 ha) are grown in Italy (Inventario Nazionale delle Foreste e dei Serbatoi Forestali di Carbonio (INFC), 2005).

For centuries, managed chestnut woods have been an important source of nutrition and income for many areas of Europe (Pitte, 1986). Especially in central Italy, historical sources have shown that the fruit of the so-called 'tree of bread' have constituted a major part of the diet for residents of the Apennines from late Medieval times (Cherubini, 1981). This dependence of the local economy on chestnut has led to the coining of the term 'chestnut culture', which expresses a closely knit cultural relation of upland peoples with this tree species and their knowledge and expertise in managing the forest in order to guarantee their economic autonomy (Cherubini, 1981).

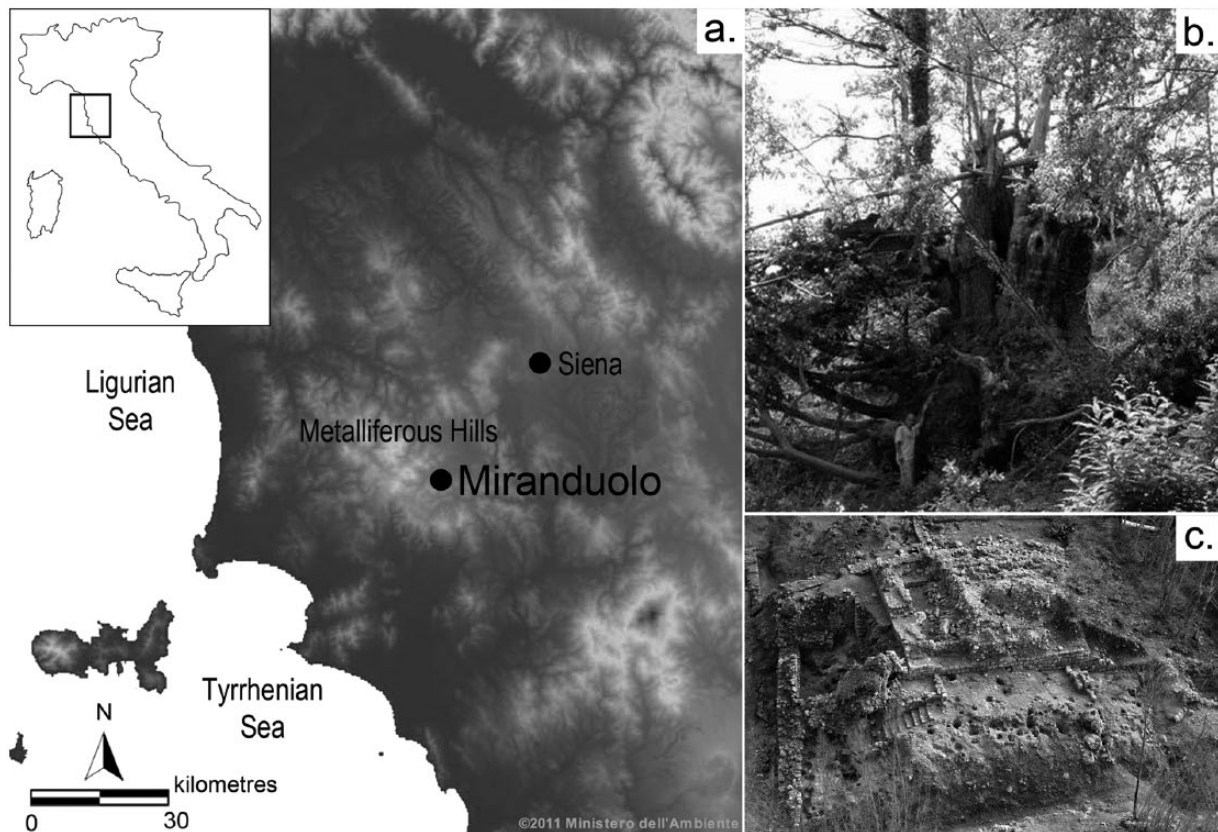
Despite its extensive distribution and socio-economic role, the history of the chestnut landscape is little known, both with regard to its origins, and to when and how chestnut cultivation spread. This gap of knowledge applies not only to Italy but also to the

whole of southern Europe (Durand, personal communication, 2014; López-Merino et al., 2010). In the Italian treatises of botany and silviculture (Bernetti, 1995; Gellini and Grossoni, 1997; Pignatti, 1982), of palaeo-ethnobotany and biogeography (Forni, 2002; Quézel and Médail, 2003; Van Zeist, 1991; Zohary and Hopf, 2000), it is reported that chestnut cultivation for fruit started and spread to western Europe by virtue of the Romans, despite the lack of documentary evidence. However, the analysis of historical sources and archaeobotanical records shows that the Romans never spread this tree for its fruit on a large scale, but that chestnut cultivation at that time was geographically limited to northern Italy (Insubria) and aimed for timber production (Conedera et al., 2004). In the Roman world, in the Mount Somma-Vesuvius (Campania, southern Italy) timber use is documented for a period from the 1st to the 5th century AD when chestnut became used for lumber as much as other tree species (Allevato et al., 2012; Di Pasquale et al., 2010). The increase in the presence of chestnut woods between the 5th and 6th century AD in an area

Department of Agriculture, University of Naples 'Federico II', Italy

## Corresponding author:

Mauro Paolo Buonincontri, Department of Agriculture, University of Naples 'Federico II', via Università 100, Portici, I-80055 Naples, Italy.  
Email: mauropaulo.buonincontri@unina.it



**Figure 1.** The archaeological site of Miranduolo: (a) location map of the site; (b) centuries-old chestnut (*Castanea sativa* Miller) tree still found in the castle area (photo: G Di Pasquale) and (c) aerial view of the castle of Miranduolo (source: <http://archeologiamedievale.unisi.it/miranduolo>).

of central-northern Italy between the Lugano Prealps and the Ligurian and Tuscan Apennines was recently interpreted as the consequence of an expansion of chestnut farming for fruit (Rottoli, 2014).

As regards the Medieval period, interestingly, in a recent study of the spread of the olive, walnut and chestnut in Italy, the pollen data show that the highest values of chestnut frequency are found in the Middle Ages (Mercuri et al., 2013). In his study of the Medieval diet in central and northern Italy, Rottoli (2014) maintains that chestnut spread at the beginning of the Medieval period because it was cultivated for its fruit. The Middle Ages in Italy correspond to about 1000 years of history which have repeatedly moulded and modified the society and economy of settlements and large areas (Wickham, 2005). Did the chestnut economy remain the same for these 10 centuries? Historical sources indicate that its presence as a food crop is extensively recorded only from the 10th century AD, when it attracted the interest of feudal landowners who began to see that the fruit was a potential source of income (Quirós Castillo, 1998).

Analysis of charcoal remains pertaining to a rural settlement mid-way along Italy's Tyrrhenian seaboard (Miranduolo) provides a special opportunity to gain insights into chestnut cultivation and the uses of timber during the Middle Ages in Italy for several reasons: the finds extended over a long time period (between the 7th and mid-14th century AD), a large number of samples were analysed, and the charcoal records can be compared with great precision with the archaeological data and the cultural evolution of the settlement. Moreover, by comparing the anthraological results with the corresponding long sequence of carpological data (Buonincontri et al., 2014), the use of agricultural and forest resources can be examined in depth. This paper thus aims:

- To document the variations in the use of chestnut along the settlement diachrony;

- To understand the role of chestnut in the economy of the various phases of the settlement;
- To verify the existence of a common evolutive pattern in chestnut cultivation in a larger geographical area.

## Study area

Miranduolo is situated between 350 and 750 m a.s.l. on the eastern slopes of the so-called Metalliferous Hills in southern Tuscany (central Italy) near the Tyrrhenian coast, 40 km SW of Siena (Figure 1a) along the upper valley of the River Merse. The mean minimum temperature in the coldest month (February) is 2°C and the mean maximum in the warmest month (August) is 29°C. Annual rainfall amounts to about 1000–1100 mm/yr, irregularly distributed during the various seasons, peaking in the autumn–winter and at its lowest in the summer (Pentolina weather station, 450 m a.s.l., 14 km from the study site).

Mixed broadleaf woods, chiefly *Quercus cerris* L. and *Q. pubescens* Willd., alternate with farmland around the settlement; there is also a small stand of *C. sativa* Miller with several centuries-old trees (Figure 1b). Evergreen Mediterranean vegetation dominated by *Quercus ilex* L. is found on the hill-tops. On the plain close to the River Merse, the forest vegetation consists of isolated stands of *Q. pubescens* and *Fraxinus oxycarpa* Bieb., as well as riparian vegetation with *Populus nigra* L., *Salix alba* L. and *S. eleagnos* L.

## Archaeological settings

Since 2001, the castle of Miranduolo (Figure 1c) has been the focus of archaeological surveys carried out by the University of Siena (Valenti, 2009, 2011). According to historical sources, the castle has been in existence since the late 10th century AD, although archaeological digs have shown that a village settlement was founded on the site in the 7th century AD during the Lombard

**Table 1.** List of samples from Miranduolo. Sequence of the sampled stratigraphic units (SUs), grouped by archaeological structure of provenance and chronological phase of settlement.

Settlement phase		Archaeological structure	Interpretation	SU	Interpretation	Char-coal	
Palace	AD 1250–1350	EDM01c	Nobleman's palace	2008	Collapses of structures	422	
Feudal castle II	AD 1025–1150	ED08	Building	12, 18, 15	Inhabited layers	30	
		ED10	House	9	Inhabited layers	5	
		ED10	House	6,32	Collapses of structures	60	
		ED11	Building	257, 327	Inhabited layers	60	
		ED11	Building	235	Collapses of structures	3	
		ED12	Building	275	Inhabited layers	4	
		ED12	Building	260	Collapses of structures	30	
		EDM01	Building	10	Collapses of structures	6	
		EDM01	Building	23	Postholes	30	
		EDM05	Building	89	Inhabited layers	18	
		EDM05	Building	85	Collapses of structures	90	
		Open place			67, 79, 57, 87, 13	Inhabited layers	57
		GL02	Levelling		73, 84, 89, 95	Inhabited layers	81
		F01	Palisade		90	Inhabited layers	4
Feudal castle	AD 975–1025	C12	Warehouse	1103, 1193	Inhabited layers	228	
		EDM02	Hut	21, 36, 63	Inhabited layers	17	
		EDM02	Hut	20	Collapses of structures	31	
		EDM04	Warehouse	558	Collapses of structures	304	
		EDM11	Building	43, 130	Collapses of structures	30	
		EDM11	Building	133	Postholes	30	
		SF08	Crop processing area	1155	Collapses of structures	30	
		SF24	Crop processing area	1188, 1191, 1210	Postholes	64	
Carolingian manor	AD 850–975	F06	Palisade	81	Inhabited layers	22	
		C01	Warehouse	211, 150, 400	Inhabited layers	431	
		C01	Warehouse	162, 238	Collapses of structures	304	
		C13	Hut	136, 138, 165	Postholes	70	
		C14	Hut	14	Collapses of structures	30	
		C14	Hut	28, 36, 38, 43, 51, 53	Postholes	77	
		C17	Hut	66, 89, 155	Inhabited layers	50	
		C19	Hut	39	Inhabited layers	30	
		C20	Hut	55	Inhabited layers	8	
		C28	Hut	165	Inhabited layers	6	
		Open place			212	Inhabited layers	75
		Open place			103	Inhabited layers	23
		SF11	Silo pit		1228, 1259, 1364, 1361	Inhabited layers	102
		SF23	Silo pit		1344	Inhabited layers	40
		F06	Palisade		99	Collapses of structures	4
		F06	Palisade		1143	Postholes	4
		F08	Palisade		1236	Postholes	4
		Lombard village II	AD 750–850	AF2b	Crop processing area	1330	Inhabited layers
C26	Hut			320	Inhabited layers	7	
Lombard village	AD 600–700	C23	Hut	42, 54, 105	Inhabited layers	71	
		C23	Hut	123, 126	Postholes	18	

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era, whose history may be divided into two phases: one in the 7th century AD and one between the mid-8th and mid-9th century AD. With the spread of the feudal system in the Carolingian era (mid-9th century AD), Miranduolo became a feudal estate (manor); the hill was fortified with ditches and palisades to protect a court with warehouses of agricultural products accrued by its lord. In the late 10th century AD, the manor was further fortified with the creation of a stone castle to defend the area and its agricultural products continued to be stored in the settlement. Between the first quarter of the 11th and the mid-12th century AD, the archaeological survey revealed the castle's second functional phase during which the castle was rebuilt with stone bricks

and when external walls encircled all the settlement. After a period of abandonment caused by a siege, between the mid-13th and mid-14th century AD, a local aristocratic family restored the castle, transforming it into a palace.

Over time, several fires affected the settlement, leading to carbonisation and conservation of a large quantity of botanical material in the archaeological contexts examined.

## Materials and methods

Archaeological sediments from 79 stratigraphic levels, herein after stratigraphic units (SUs), were sampled, correlating to 33

'archaeological structures' (Table 1). This term is used to indicate the presumed function of the excavated contexts in each settlement phase, such as warehouses, huts or buildings. Identification of the samples follows the numbering of the SUs and the archaeological structures classified in the excavation report. The charcoal finds span the whole chronological interval surveyed, with the exclusion of the mid-12th to mid-13th century AD when, due to a siege, the site had been reduced to ruins and its frequentation was sporadic. For this period, the material sampled was considered insufficient.

The sediment samples were floated and sieved on a sieving column with a grid size of 4, 2 and 0.5 mm. The charcoal fragments exceeding 4.0 mm were identified under a reflected light microscope at magnifications of 100× and 1000×, consulting both atlases of anatomy (Abbate Edlmann et al., 1994; Greguss, 1955, 1959; Schweingruber, 1990; Vernet et al., 2001) and the wood collection at the Laboratory of Vegetation History and Wood Anatomy at the University of Naples Federico II.

The SUs interpreted as 'inhabited layers' (45 SUs in 23 structures) were selected and grouped by chronological phase since they contained extensive charcoal fragments, dispersed by long-term activities and processes, useful to reconstruct the history of the local forest cover (Chabal, 1997; Figueiral and Mosbrugger, 2000). The samples from SUs interpreted as 'collapses of structures' (16 SUs in 13 structures) or 'postholes' (18 SUs in 8 structures) constituted, in turn, two types of contexts grouped by chronological phase and considered separately to specify the use of wood in carpentry and in constructing buildings.

In the three groups of sample origin (inhabited layers, collapses of structures, postholes), the percentages of each taxon were calculated on the total number of anthracological finds analysed in each phase of the stratigraphic sequence (Figure 2). To understand the use of wood as fuelwood or timber in the stratigraphic phases, the percentages of chestnut, deciduous oaks and the other taxa were calculated on the total of the fragments identified in the inhabited layers (fuelwood) and compared with the percentages calculated on the total of fragments identified in collapses of structures with postholes (timber) (Figure 3). In Table 2 and the correlated Figure 4, we report the evidence from 29 studies concerning the use of chestnut timber and fruits in 29 Italian archaeological sites in each cultural period: the late Roman era (3rd–6th century AD), the early Middle Ages (7th–10th century AD) and the late Middle Ages (11th–14th century AD). In Figure 4, the percentages show the frequencies of chestnut charcoals on the total of wood charcoals reported in the studies considered. Among chestnut fruits, the figure reported only presence and absence; we added the amount of chestnut fruit remains in the text for each site cited.

## Results

Overall, 3027 charcoal fragments were analysed allowing 27 taxa to be identified. The results below are presented according to the origin of the sample: inhabited layers, collapses of structures, and postholes (see also Table 1).

### Inhabited layers

From the levels of settlement activity in five of the six chronological phases examined, 1386 charcoal pieces were analysed and 24 taxa determined (Figure 2a). From the first Lombard village phase (7th century AD), examination of 71 charcoal fragments from a hut (Table 1) showed that the most frequent taxon was *Castanea sativa* (59.2%), followed by deciduous *Quercus* (32.4%) and *Ostrya carpinifolia* (1.4%). *C. sativa* is also the taxon most frequently found (41.7%) in the second village phase (mid-8th to mid-9th century, 24 fragments), followed by deciduous *Quercus* (20.8%) and *Sorbus* (4.2%).

From the Carolingian manor phase (mid-9th to the third quarter of the 10th century), 765 charcoal pieces were analysed from nine

structures (Table 1), including four huts, a warehouse, and several contexts for processing and storing farm produce. The most commonly found taxon was deciduous *Quercus* (63.1%), followed by *C. sativa* (14.5%). Many other deciduous taxa were determined, the most frequent being *O. carpinifolia* (5.8%) followed by *Fraxinus ornus* (1.4%), while *Acer*, *Fagus sylvatica* and *Ulmus* do not exceed 1%. Evergreen maquis shrubs (*Arbutus unedo*, *Erica* and *Cistus*) and *Juglans regia* are recorded at frequencies below 1%.

From a warehouse, the palisade, and a hut of the first feudal castle phase (last quarter of the 10th to the first quarter of the 11th century), 267 charcoal fragments were analysed (Table 1). Deciduous *Quercus* still represents the most frequently occurring taxon (61.4%), followed by *C. sativa* (11.2%) and various deciduous taxa, the most frequent being *F. ornus* (5.8%), while other taxa do not exceed 1%. *Cotinus coggygria* (2.2%) and *Vitis vinifera* (0.4%) were also identified.

From the second castle phase (second quarter of the 11th to the mid-12th century), 259 charcoal fragments were analysed from eight structures (Table 1), including three buildings, a house and the palisade. Deciduous *Quercus* dominates the anthracological assemblage (72.9%), once again followed by *C. sativa* (13.8%). Some deciduous taxa were present in lower percentages, including *O. carpinifolia* (3.3%), *Acer* (1.9%) and *Sorbus* (1.5%). The sclerophyllous evergreen shrub *A. unedo* (<1%), and the deciduous fruit species *J. regia* (2.2%) were also present.

### Collapses of structures

In the layers of the collapsed archaeological structures, 1344 charcoal fragments were analysed and 21 taxa determined from the last four chronological phases of the settlement (Figure 2b). From a hut, a warehouse, and the palisade to defend the Carolingian manor (mid-9th to the third quarter of the 10th century), 338 charcoal fragments were analysed (Table 1). Deciduous *Quercus* (76.3%) is the most frequent taxon, followed by *C. sativa* (10.4%). There are also many deciduous and evergreen taxa, albeit with very low percentages (<1.5%): deciduous tree species include *Ulmus* and *F. ornus*; among the shrubs there was the evergreen *A. unedo* and the deciduous *Cornus* and *C. coggygria*.

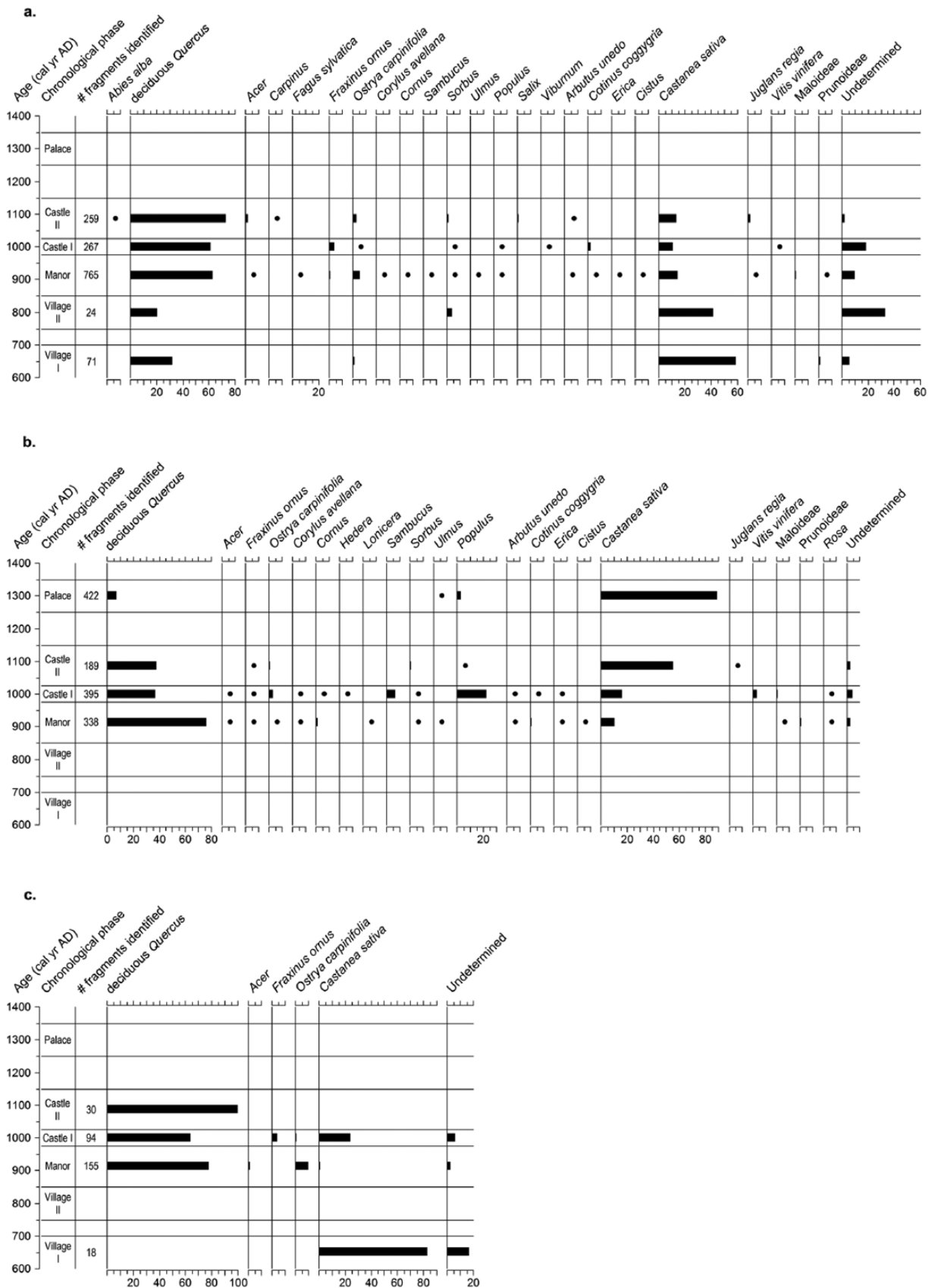
From the four collapsed structures of the first feudal castle phase (last quarter of the 10th to the first quarter of the 11th century), including a warehouse, a hut and a building (Table 1), 395 charcoal fragments were analysed. Deciduous *Quercus* is the most frequent taxon (37.2%), followed by other deciduous taxa: *Populus* (22.8%), *C. sativa* (16.2%), *Sambucus* (6.6%) and *O. carpinifolia* (3%). Some evergreen taxa, such as *A. unedo* and *Erica* (both <1%), were also identified. *V. vinifera* was the only fruit species found (3.5%).

From the second feudal castle phase (second quarter of the 11th to the mid-12th century), 189 charcoal fragments from four buildings and a house (Table 1) were analysed. *C. sativa* dominates the charcoal assemblage in this phase (55.6%), followed by deciduous *Quercus* (38.1%). Deciduous taxa (*O. carpinifolia* and *Sorbus*) and fruiting species (*J. regia*) were also determined, albeit with very low frequencies (<1%).

From the last settlement phase (mid-13th to mid-14th century AD), 422 charcoal fragments from the collapse of the palace roof were analysed. The dominant taxon is *C. sativa* (89.1%), followed by deciduous *Quercus* (7.6%) and other deciduous taxa such as *Populus* (3.1%).

### Postholes

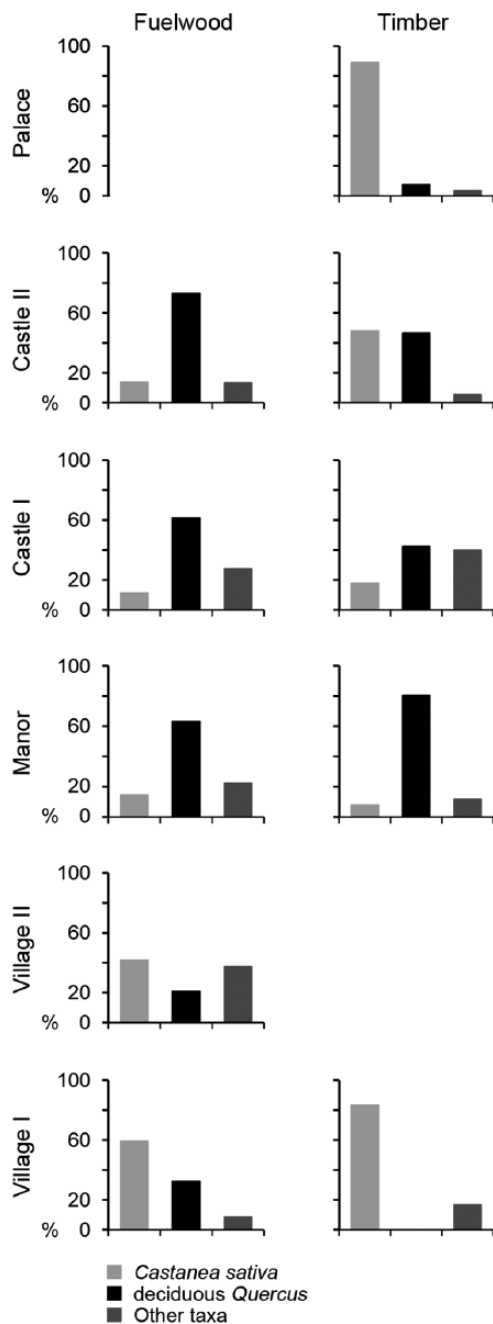
As regards the sampling of the holes for wooden posts to support the settlement structures, 297 charcoal fragments were analysed and five taxa determined for the four chronological phases of the settlement (Figure 2c). From a Lombard village hut (7th century AD) only *C. sativa* occurs among the 18 charcoal fragments examined.



**Figure 2.** (a) Charcoal analysis diagram of the inhabited layers, (b) the collapses of structures, (c) and the postholes, from the archaeological sites of Miranduolo. Solid circles represent relative percentages of <1%.

From the four structures pertaining to the Carolingian manor (mid-9th to the third quarter of the 10th century), 155 charcoal pieces were analysed, including the palisades and two huts.

Deciduous *Quercus* accounts for about 80% of the charcoal record, followed by *O. carpinifolia* (~10%) and *C. sativa* and *Acer* (both <2%).



**Figure 3.** Use of *Castanea sativa*, deciduous *Quercus* and other taxa as fuelwood or for construction timber from the archaeological site of Miranduolo. The percentage frequencies were calculated over the total number of charcoal fragments identified from inhabited layer for fuelwood and collapses of structures with the postholes for timber.

From the first feudal castle phase (last quarter of the 10th to the first quarter of the 11th century), 94 charcoal fragments from a building and the crop processing area were analysed. *C. sativa* shows a higher percentage (24.5%) compared with the manor phase, deciduous *Quercus* amount to 63.8% and *F. ornus* to 4.3%. From the second castle phase (second quarter of the 11th to the mid-12th century), 30 charcoal pieces from a single building were analysed. The only taxon identified was deciduous *Quercus*.

## Discussion

### Between the 7th and 9th century AD: the two phases of the Lombard village

The first sequence of charcoal data available spans the 7th and mid-9th century and concerns the two phases of the Lombard village.

From the village dating to the 7th century, which represents the beginning of the settlement, the charcoal record mainly concerns the foundation posts, consisting in 20- to 40-cm diameter holes, for a 17-m<sup>2</sup> circular hut. The only material used to create the structure was chestnut wood (Figure 2c). Since trunks for posts were used from the first settlement activities, chestnut was probably already present and used as a resource when the site was founded. The charcoal data pertaining to levels of human occupation also show the intense use of chestnut for fuelwood (Figure 2a). Clearly, chestnut woods were a distinguishing feature of the forest landscape around Miranduolo and represented a resource extensively available in the area. There were also other taxa typical of the mesoxerophile forest, chiefly deciduous oaks such as *Q. cerris* and *Q. pubescens* (Figure 2a).

The contexts of the village in the mid-8th to mid-9th century offer samples attributed to the use for fuelwood. In this period, chestnut was the most widely used wood, even though less than in the previous period (Figure 2a). This confirms the widespread availability of chestnut around Miranduolo during the early Middle Ages and suggests the continuity of its use (250 years) by the inhabitants, both for building material and fuelwood as a preferential choice over timber from deciduous oaks (Figure 3).

Between the 7th and 8th century AD, the use of chestnut wood has been found in other Lombard settlements, such as the city of Brescia in the Upper Po Valley and in two rural settlements in the north-western Tuscan Apennines (Figure 4). The best surveyed context in terms of quantity of archaeobotanical material is Brescia: here chestnut dominates the charcoal spectrum insofar as it is the main material used for the structural elements of buildings. Here, Castiglioni et al. (1999) considered the intense use of chestnut wood and the presence of three fragments of fruits as a consequence of the widespread availability of fruiting chestnuts.

In the Tuscan Apennines, the chestnut wood found in the early Medieval settlements is also believed to come from plantations for fruit production (Castelletti, 1977, 1986). To date, this is still the most accredited hypothesis to justify the early Medieval replacement of mixed oak woods with chestnut stands intended as a source of food alternative or complementary to cereals (Quirós Castillo, 1998; Rottoli, 2014; Squatriti, 2013).

In our opinion, at least for Tyrrhenian central Italy, there is no archaeobotanical evidence to support the hypothesis of fruit production. Like in the Lombard Miranduolo, carpological analysis of coeval sites (Figure 4) revealed the absence of chestnuts in the fruit remains (Buonincontri et al., 2014; Castelletti, 1977, 1986). A close view of the carpological data as a whole clearly shows that this portion of Italy is characterised by continuity with the agricultural tradition of the Roman world, with good quality crops (Buonincontri et al., 2014; Castelletti, 1977). In this view, a food economy mainly based on chestnut is non-essential and rather improbable. Further in the Ligurian and Tuscan Apennine, as well as in Metalliferous Hills, pollen records do not show any expansion of chestnut in disadvantage of the mixed oak forest (Branch and Marini, 2014; Guido et al., 2013; Magny et al., 2007). To sum up, we believe that the dominance in the anthracological spectra may be viewed as an intentional choice of timber production, considered more useful for the housing requirements of the populations settled in this large area.

The role of chestnut as a timber species was emphasised by Roman writers since the 1st century AD (Conedera et al., 2004); due to its very straight shoots, this species was cultivated for posts in agriculture, for construction and assortments of suitable trunks for woodwork and carpentry (Conedera et al., 2004).

In a recent synthesis of several pollen records, Krebs et al. (2014) suggested the appearance of chestnut plantations in the Lugano Prealps in the 1st century AD, and its gradual expansion during the Roman and late Roman Ages. In this region, the archaeobotanical data (Figure 4) showed that chestnut wood dominated at first in few archaeological settlements of the Roman era,

**Table 2.** Geographical data and references of the 29 archaeological sites recording chestnut charcoals and fruits reported in Figure 4.

#	Region	Site	Elevation	Latitude	Longitude	References
1	Western Rhaetian Alps	Castelaz	1214	46.4266	10.3486	Castiglioni (2009)
2	Lugano Prealps	Monte Barro	670	45.8325	9.3736	Castelletti and Castiglioni (1991) and Castiglioni et al. (2001)
3		Ponte Lambro	304	45.8258	9.2261	Madella (1991)
4		Angera	218	45.7763	8.5844	Rottoli (1995)
5	Po Valley	Trezzo	183	45.6063	9.5136	Castiglioni and Rottoli (2012)
6		Brescia	148	45.5402	10.2291	Castiglioni et al. (1999)
7		Desenzano	86	45.4700	10.5386	Castiglioni and Rottoli (2007)
8		Pavia	85	45.1847	9.1566	Castelletti (1978)
9	Langhe Hills	Alba	167	44.6997	8.0350	Castelletti and Motella De Carlo (1999)
10		Cherasco	280	44.6480	7.8580	Motella De Carlo (1996)
11	Ligurian Alps	Peveagno	624	44.3202	7.6250	Motella De Carlo (1996)
12	Ligurian Apennines	Priamar	11	44.3044	8.4838	Cottini and Rottoli (2001)
13		Vado Ligure	6	44.2691	8.4397	Arobba et al. (2013)
14		Finalborgo	18	44.1765	8.3266	Arobba et al. (2003)
15	Tuscan Apennines	Filattiera	211	44.3308	9.9372	Rottoli and Negri (1998) and Terzani (2011)
16		Luscignano	428	44.2027	10.1497	Castelletti (1986)
17		Corvara	318	44.1715	9.7332	Cagnana et al. (2008)
18		Gorfigliano	709	44.1550	10.2433	Montanari and Scipioni (2004)
19		Luni	3	44.0638	10.0171	Castelletti (1977)
20		Terrazzana	680	43.9936	10.7290	Quirós Castillo (1998)
21	Metalliferous Hills	Rocchette	441	43.1097	10.8916	Buonincontri et al. (2013)
22		Populonia	163	42.9880	10.4902	Di Pasquale et al. (2014)
23	Mount Amiata	Castel Vaiolo	1014	42.8344	11.4817	Nucciotti (2007)
24	Tofla Mountains	Allumiere	552	42.1583	11.9041	Sadori and Susanna (2005)
25	Tiber Valley	Roma	17	41.8946	12.4784	Nisbet (1990)
26	Mount Somma-Vesuvius	Somma	136	40.8758	14.4238	Allevato et al. (2012)
27		Pollena	87	40.8666	14.3760	Allevato et al. (2012)
28	Phlegrean Fields	Cuma	8	40.8483	14.0577	Di Pasquale et al. (2010)
29	Belice Valley	Segesta	291	37.9400	12.8375	Castiglioni and Rottoli (1997)

Elevation is expressed in m a.s.l.; latitude and longitude in degrees N and E, respectively.

linked to construction and woodwork, as at Angera (Rottoli, 1995) and Ponte Lambro (Madella, 1991) in the Lugano Prealps. Fruit remains ( $n > 100$ ) were found in three necropolis as votive offering dated between the 1st and 3rd century AD (Rottoli and Castiglioni, 2011). Between the 5th and 6th century AD, the finds of chestnut wood become even more frequent (Figure 4) from the Lugano Prealps (Castelletti and Castiglioni, 1991; Castiglioni et al., 2001) to the Upper Po Valley (Castiglioni and Rottoli, 2007, 2012; Castiglioni et al., 1999). Interestingly, in this historical phase, out of the six settlements surveyed, only in one chestnut fruits were found; nevertheless, the chestnut fruits ( $n > 500$ ) found in Monte Barro in Lugano Prealps were interpreted, by their size, as coming from wild plants coppiced for supplying the settlement with timber (Castelletti and Castiglioni, 1991). These data suggest that probably, until the end of the Roman period, chestnut plantations were chiefly coppices for the production of timber and their fruits were considered a secondary product (Krebs et al., 2014).

Along the Ligurian Alps and the Tyrrhenian mountains, archaeobotanical data seem to draw a similar history, however, starting with a strong difference: on the basis of pollen and anthracological data, this area falls within an extensive upper Tyrrhenian postglacial refuge area for chestnut (Di Pasquale et al., 2010; Krebs et al., 2004). Between the 3rd and 6th century AD, in the Ligurian Alps (Figure 4) chestnut is scarcely attested as fuelwood and one fruit was found (Motella De Carlo, 1996). In the close Ligurian Apennines (Figure 4), several epicarps of chestnut fruits ( $n > 100$ ) are recorded for the 3rd and 4th century AD at Vado Ligure (Arobba et al., 2013). These data could suggest a prevalent use of the chestnut as fruit tree. Nevertheless, in the settlement of Filattiera, in the nearby Tuscan Apennines (Figure 4), a 400-year diachrony documented the use of chestnut wood from the 3rd century AD (Rottoli and Negri, 1998), becoming dominant in the 5th–6th century AD (Rottoli and Negri, 1998; Terzani, 2011).

Rottoli and Negri (1998) interpreted this increase in the use of chestnut wood as a consequence of the expansion of chestnut orchards (Rottoli, 2014; Rottoli and Negri, 1998). In this respect, it deserves note that the pollen sequences in the Ligurian and Tuscan Apennines indicate the presence of chestnut in the vegetation record, but do not show a rising curve for chestnut between the 5th and 6th century AD (Branch and Marini, 2014; Guido et al., 2013). Overall, data suggest in north-western Italy the presence of chestnut wood managed mainly as coppices, and their fruits considered as secondary products.

In Latium (Figure 4), a strong use of chestnut timber in the 5th century AD is attested in the settlement of Allumiere in the Tofla Mountains (Sadori and Susanna, 2005); here, chestnut fruits are not recorded in the carpological analysis. In the ancient Campania, the early presence of chestnut in archaeological sites is related to construction from the 1st century BC (Allevato et al., 2012). Analysis of ~3000 charcoals of the Roman period from two sites on the Mount Somma-Vesuvius (Figure 4) indicated the widespread, dominant use of chestnut wood as a construction material from the 1st to the 5th century AD (Allevato et al., 2012; Di Pasquale et al., 2010). Finds from the nearby city of Cumae in the Phlegrean Fields (Figure 4) showed that chestnut wood was already present in the 2nd century AD and became common from the 5th to 6th century AD (Di Pasquale et al., 2010). Pollen sequences in Campania, as in Ligurian and Tuscan Apennines, do not indicate the spread of chestnut pollen between the 5th and 6th century AD (Russo Ermolli et al., 2014); thus, this is a clear evidence of progressive use of pre-existent chestnut wood as coppices (Di Pasquale et al., 2010).

To sum up, the use of chestnut wood in Roman times may well have begun in areas where the species was already present in deciduous woods in the lowlands and submontane zones, and the native populations knew the characteristics of the timber and its uses.





Therefore, until the end of the Roman period, chestnut was chiefly used for timber and its fruit was considered a secondary product. The Miranduolo data testify that the tradition of using chestnut timber continued into the early Middle Ages. The Lombard settlers who founded the site in the 7th century AD far preferred chestnut to other forest species such as deciduous oaks, confirming its widespread use among various peoples, whether Roman or not.

#### *Between the mid-9th and the end of the 10th century AD: the Carolingian manor phase*

Starting from the mid-9th century and until the end of the 10th, with the transformation of the settlement into a feudal Carolingian estate, the charcoal data show a sharp fall in the presence of chestnut wood (Figure 3): the data concerning collapsed structures and the woodwork used to create such structures show a more than 70% use of deciduous oaks, followed by chestnut at 10% (Figure 2b), suggesting the clear preference for wood from deciduous oaks in wooden structural work. The samples from the postholes of the huts and palisade also show an overwhelming use of deciduous oak and other tree taxa (Figure 2c). In these contexts, chestnut compared with the previous period is practically absent (~1%). Thus, starting from the period of the manor, the inhabitants of Miranduolo chose to use deciduous oaks to recover large-size timber for the foundation of buildings and the construction of the defensive palisade (Figure 3). The data also show the sporadic use of other deciduous and evergreen tree and shrub taxa (Figure 2b–c), generally used for small items (pegs) and brushwood used in roofing (Figure 3). The charcoal data from the levels of human occupation show intense use of deciduous oaks also as fuel and only secondarily the use of chestnut (Figure 2a). In this case, the charcoal data also reflect a less selective use of forest resources, indicating the presence of other deciduous and evergreen taxa and suggesting mixed forest types. Summing up, as shown in Figure 3, the manor phase was characterised by the dominant use of oak timber for every activity, followed by other tree and shrub taxa. Compared with the previous village period, the data seem to indicate a reduction in the presence and availability of chestnut in the Miranduolo area.

In this historical phase, the pollen record of Lake Accessa in the area of the Metalliferous Hills testifies the rise of chestnut from ~1000 cal. yr BP (mid-10th century AD; Magny et al., 2007). In the same region (Figure 4), in accordance with the findings from Miranduolo, a moderate use of chestnut for lumber was also attested in the manor of Rocchette (Buoincontri et al., 2014). Thus, the crossing of pollen and charcoal data overall suggests that chestnut woods were abundant in the landscape but scarcely exploited for timber. In this respect, it is interesting to note that at the Miranduolo site several fruits of chestnut appear in the storerooms when the use of its timber diminishes (Buoincontri et al., 2014).

After the end of the Lombard kingdom and the Frankish conquest of the Italian peninsula under Charlemagne at the end of the 8th century AD, the feudal system gains ground. With the Carolingian era, the archaeological evidence shows that the previous Lombard villages were fortified and reorganised into feudal manors, with the renovation of spaces and the territory under the control of aristocratic families (Wickham, 2005). In the Metalliferous Hills, in particular, settlements are characterised by the construction within the fortified walls of structures for the storage of foodstuffs and the accumulation of surpluses from feudal taxation, indicating control in agricultural management and production (Bianchi and Grassi, 2012).

In Miranduolo, carpological analysis suggested that in this historical phase there was a change in land use strategy, with the choice of cereal crops, such as wheat, rye and barley, to improve production capacity and obtain a production surplus (Buoincontri et al., 2014). The data concerning the phase of the manor of

Miranduolo indicated the presence of these cereals together with chestnut fruits in storerooms for the proceeds of feudal taxation (Buoincontri et al., 2014). The sharp fall in the use of chestnut wood in Miranduolo might thus be attributed to a change in land use strategy. The extensive use of deciduous oaks could reveal the desire of the feudal lords to preserve the chestnut woods from coppicing and transform them into fruit production, insofar as they were now considered more important economic resources than timber. Conedera et al. (2004) hypothesised that the great interest in managing chestnut plantations for fruit production developed later than the Roman period. The Miranduolo findings should allow this event in the Metalliferous Hills to be dated with precision: from the mid-9th century AD.

It is interesting to note that the matching of pollen and charcoal data in this period suggested the beginning of olive tree growing in the Metalliferous Hills to satisfy a rising demand for food and luxury products (Di Pasquale et al., 2014). Therefore, the specialisation in chestnut cultivation for fruit crops in the Metalliferous Hills should be related to a historical phase in which the maximum economic income was to be sought even in the space occupied by woodland. In this respect, the common assumption of chestnut orcharding in the High Middle Ages as a subsistence food (Quirós Castillo, 1998; Rottoli, 2014; Squatriti, 2013) is not believable for the Metalliferous Hills. It is interesting to note that in the close Mount Amiata (Figure 4), a very large amount of toasted chestnuts (~60) were found in a storeroom of a rural settlement similar to the manor of Miranduolo (Nucciotti, 2007). Here, according to the archaeobotanical analysis, the size of fruits highlighted a precise strategy of selection and cultivation of chestnut trees (Nucciotti, 2007).

Concerning the evolution of the chestnut landscape in a broad geographical range, a unique evolutive pattern valuable throughout the Italian peninsula cannot be traced. Indeed, in the Lugano Prealps, pollen record showed a strong rise of the chestnut woods (Krebs et al., 2014); according to the authors, here, due to the orographic mountain conditions, the chestnut orchards become an indispensable source of subsistence so as to be named ‘bread tree’. Interestingly, historical sources attested for this period only sparsely evidences of chestnut coppice in this area and the nearby river valleys, but strong records of chestnut woods for fruit production (Krebs et al., 2014). It is worth noting that where several dozen chestnut fruits were found, as at Castelaz ( $n > 200$ ) in the Western Rhaetian Alps (Figure 4), chestnut was not noted among the charcoal finds and hence not used either for timber or for fuelwood (Castiglioni, 2009).

In the area of the Langhe Hills and Ligurian Apennines (Figure 4), a moderate use of chestnut lumber is now attested (Castelletti and Motella De Carlo, 1999; Cottini and Rottoli, 2001; Motella De Carlo, 1996), in particular in lower zones such as the Langhe Hills. As in the Metalliferous Hills, these data could constitute evidences of chestnut expansion in the landscape; it seems stimulating to note that this increase of chestnut woods is parallel to the progressive expansion of the feudal system in the Langhe (Micheletto, 1999).

In the Tuscan Apennines, pollen records testified for increase in chestnut forests (Guido et al., 2013). According to charcoal data in this region (Figure 4), the prevailing use of these forests seems to be, at present, timber exploitation (Montanari and Scipioni, 2004; Quirós Castillo, 1998; Terzani, 2011).

#### *From the end of the 10th to the mid-14th century AD: castle and palace phases*

From the end of the 10th century AD, the settlement underwent a further evolution, becoming fortified as a castle. Overall, the records for construction timber show the resumption of chestnut wood, especially in the second castle phase (Figure 3). The data

from the building collapses indicate that the timber in the structures was in the first castle phase chiefly from deciduous oaks, together with other deciduous trees and shrubs, such as *Populus* and *Sambucus*, for small-size constructions and brushwood (Figure 2b). In the second castle phase, chestnut wood is used widely once again in woodwork (Figure 2b). Concerning the foundation posts of the castle structures, deciduous oaks remain the material most frequently used in both phases, while the first castle between the end of the 10th and beginning of the 11th century saw a resumption of the use of chestnut (Figure 2c). Instead, the charcoal data for the levels of human occupation continue to show an intense use of deciduous oaks for firewood in both castle phases (Figure 2a). Thus, what emerges from the analysis of the charcoal record is that, from the end of the 10th century, chestnut wood is once again used, but only for large pieces, initially for building foundations and later for buildings and storerooms (Figure 3). That said, the resumption of chestnut wood in carpentry seems limited in both castle phases to the structures of the seigneurial area, suggesting its exclusive use for the structures of feudal power. However, the lack of lower class buildings does not allow us to be sure that chestnuts were used elsewhere too. In the same phase in the Miranduolo settlement, the remains of chestnuts are found in more than half of the contexts (Buonincontri et al., 2014).

Between the mid-13th and mid-14th century, an aristocratic family restored the castle as a nobleman's palace. The charcoal data concern only the collapse of a ceiling, documenting the use primarily of large chestnut timber to build roofing.

Hence, the archaeobotanical record might suggest that between the end of the 10th to the mid-14th century AD chestnut wood was exploited for large timber as well as for fruit. The carpological record suggests that chestnut fruit is not a primary subsistence food since the strong presence of any kind of cereals and fruit indicates an efficient agro-forestry economy (Buonincontri et al., 2014). Pollen data attest in this region the continuous rise of the chestnut (Magny et al., 2007) that is now clearly an abundant resource, even in the coastal site as testified by charcoal records from Populonia (Figure 4; Di Pasquale et al., 2014). To sum up, we believe that chestnut might have become a 'multifunctional' high-forest from which mainly fruit and then some timber were obtained.

During the feudal period starting from the 11th century AD, chestnut wood is found in more settlements than in the previous Carolingian period (Figure 4). In north-western Italy, chestnut charcoal continues to be present and even preponderant in the settlements of the Langhe Hills (Castelletti and Motella De Carlo, 1999; Motella De Carlo, 1996), in the Ligurian (Arobba et al., 2003) and Tuscan Apennines (Cagnana et al., 2008; Castelletti, 1977; Montanari and Scipioni, 2004; Quirós Castillo, 1998; Terzani, 2011). Pollen sequences recorded a further expansion of chestnut woods suggesting that it definitively established in the landscape of the Ligurian and Tuscan Apennines (Branch and Marini, 2014; Guido et al., 2013; Vescovi et al., 2010). According to Figure 4, the archaeobotanical evidence for fruit is scarce (only one fruit in Finalborgo in the 14th century AD; Arobba et al., 2003), but in these areas, there is a peak in the finds at the archaeological sites of the 'testello', a flat terracotta disc, currently used for baking *focaccia* from wheat and chestnut flours, indicating an increase in the distribution and use of these flours in the diet (Pruno, 2003). Moreover, a strong role of chestnut fruit in the diet in central and northern Italy is attested by a huge number of historical sources during the transition from the early to late Middle Ages (Montanari, 1979; Wickham, 1988).

On the whole, in this period the chestnut forest seems definitively established in the Italian landscape and is probably exploited both for raw wood and food. Chestnut fuelwood and timber is attested even in urban contexts such as in Pavia in the Po Valley (Figure 4; Castelletti, 1978) and in Rome in the Tiber Valley (Figure 4; Nisbet, 1990). Chestnut lumber was attested

also in the Belice Valley in north-western Sicily (Figure 4; Castiglioni and Rottoli, 1997) when also a strong rise of chestnut pollen in central (Sadori et al., 2013) and south-western Sicily was recorded (Noti et al., 2009).

The history of chestnut in the other countries of south-western Europe still remains to be documented in all its various aspects. However, in southern France, where there are no glacial refugia for the species, the historical sources and pollen records testify the appearance of chestnut in the forest landscape around the year 1000 AD and charcoal data attest the use of timber in settlements (Durand, personal communication, 2014; Pitte, 1986; Planchais, 1987; Ruas, 2005). However, the recovered shells of chestnuts in central Gaule gave evidence of human consumption between the 4th and the beginning of the 5th century AD of late Roman Age, suggesting a probable introduction of chestnut orchards by Romans (Wiethold, 2003) as in Italian Lugano Prealps. As regards the Iberian peninsula, where the presence of refugia has been well documented on the basis of pollen data (López-Merino et al., 2010), the history of this tree is still to be written.

## Conclusion

Charcoal fragments from the rural settlement of Miranduolo in the Metalliferous Hills (southern Tuscany) were analysed in order to survey 750 years of forest resource use in the area, with particular reference to chestnut wood. Functional characterisation of the sampled contexts and the long time period involved allowed the classification of wood according to its use for building or fuelwood.

Between the 7th and mid-9th century AD, while the settlement was a Lombard village, chestnut was the preferred species for carpentry uses, employing also large-size pieces. In the early Middle Ages, the coppice management of chestnut woods for timber production needed for building purposes is documented along the Tyrrhenian seaboard and has been erroneously interpreted as the consequence of greater availability of chestnut timber with the spread of chestnut cultivation for fruit. The Miranduolo data, when set against a detailed chronological, quantitative and spatial analysis of the archaeobotanical data in the literature, refutes the hypothesis of chestnut cultivation as a fruit tree and corroborates instead the hypothesis that in the early Middle Ages the plant was used for timber production, continuing the woodworking tradition of the Roman period.

From the mid-9th century AD, with the start of the Carolingian feudal system, chestnut in Miranduolo ceased to be used for building and firewood. In its place, deciduous oaks were preferred. In this context chestnut fruits began to be picked and kept in storerooms where all the feudal farm produce was at the disposal of the feudal lord. Comparison with existing archaeobotanical data allows us to hypothesise that chestnut cultivation for fruit thus spreads to the southern Tuscany at the same time as the spread of the Carolingian socio-economic system which reorganised the land and agricultural production to obtain a production surplus and added value from processed products, which is typical of the market economy. Although some environmental, cultural and socioeconomic differences are recognisable in the other Italian regions, there is no doubt that the great interest in managing chestnut woods for fruit production developed in this historical period even in other areas, such as northern Italy.

In the next feudal period, the process of gradual expansion affects the whole territory of Italy as far as Sicily, and it would be definitively established by the late Middle Ages under the name of the 'chestnut culture' (Cherubini, 1981).

Chestnut was thus used for a very long period, which probably began prior to the Roman Age, as a forest species especially for its timber, outweighing the tree's nutritional and economic importance as a food crop; from this point of view, we hypothesise that

the use of chestnut for timber should be reappraised, as should the history of all those tree species normally considered as a source of fruit or as having a ritual function, such as walnut or cypress.

The chestnut forest landscape in central Italy is thus of human origin, expanding and changing in terms of physiognomy and structure in about 1000 years of cultivation. However, its origins are to be sought in the feudal Middle Ages, when the desire to take profit from forest areas spreads. Further studies are still needed in order to clarify the evolutive pattern of the cultural history of this tree in a larger area than central Italy.

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