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NOTES

ANTHROPOGENIC POLLEN INDICATORS (API) FROM ARCHAEOLOGICAL SITES AS LOCAL EVIDENCE OF HUMAN-INDUCED ENVIRONMENTS IN THE ITALIAN PENINSULA

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Abstract – Pollen data from twenty-six archaeological sites are reviewed to investigate the development of human-induced environments through the presence of selected Anthropogenic Pollen Indicators (API). The sites are located in six Italian regions - Veneto, Emilia Romagna, Tuscany, Basilicata, Calabria, and Sicily - and in the Republic of San Marino. Their chronology spans from the Bronze to the Renaissance ages, from approximately 4200 to 500 years BP. The API which are common in these sites are properly considered important markers of human activity and anthropization in the Mediterranean area. The most frequent API taxa in pollen spectra are seven: *Artemisia*, *Centaurea*, Cichorieae and *Plantago* are ubiquitous and therefore they have the major relevance, followed by cereals and *Urtica*, and by *Trifolium* type. The spread of plants producing these pollen grains is sometimes marked by high percentage values in pollen spectra. Pollen records show that, as expected, cereals and wild synanthropic herbs were widespread near archaeological sites but local differences are evident. Ecological and chrono-cultural reasons may be at the base of the observed differences. In general, the synanthropic plants well represent the xeric environments that developed as a result of the continuous human pressure and changes in soil compositions. These changes have occurred especially during the mid and late Holocene.

Keywords: pollen, anthropogenic indicators, synanthropic plants, cultural landscape, archaeological sites, Italy, Mediterranean

Introduction

The transformations of natural environments into anthropogenic landscapes are evident from the long-term action of humans who have selected and exploited cultivated and wild plants for millennia in the Mediterranean basin. As humans lived in a region, ‘cultural transformations of natural habitats’ began, and were an inevitable consequence of human presence in lands (Birks et al., 1988; Faegri & Iversen, 1989; Berglund, 2003; Jalut et al., 2009; Birks, 2012; Marinova et al., 2012). Consequently, changes in flora and vegetation cover may have occurred earlier near settlements and in the places that today we call ‘archaeological sites’.
It may therefore be hypothesised that weak anthropogenic influence, and then impact, on the environment firstly occurred in the vicinity of the settlements. Then, human impact became evident at a larger regional scale depending on the chronological and cultural variables, and on the distance and intensity of activity performances (Kunes et al., 2008; Mercuri et al., 2010a, 2012).
A change in composition and distribution of forested and open lands in the Mediterranean area is known to have occurred under direct or indirect human actions particularly since the mid-Holocene (Zohary & Hopf, 2000; Roberts et al., 2011). In pollen diagrams from these regions, the clearest signal for human influence or impact is given by the spread of cereals (Cerealia-type; primary indicators *sensu* Behre, 1990) and by the increased abundance of wild synanthropic plants growing on farming contexts and open disturbed ground (secondary indicators *sensu* Behre, 1990).
A great deal of attention has been paid to the cultivated plants, and in general to the plants related to (agri)cultural issues, as part of the classical archaeological theme. However, the wild synanthropic species that were

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involuntary favoured by the spread of human activities are particularly useful to reconstruct the transformations and dynamics of past and present anthropogenic ecosystems (Brun, 2011). This is a main focus of palaeoenvironmental sciences helping to investigate past human activities and their impact on the environment.

Can the palynology of archaeological sites be useful to study these palaeoenvironmental aspects? In archaeological contexts, the preservation of pollen can be poor, humans and animals largely bring it to the site and thus cultural variables strongly influence the pollen spectrum. Far from being a problem, this peculiarity of palynology of archaeological sites is crucial to explore human behaviour and cultural aspects of plant exploitation (Mercuri, 2008). Moreover, an impressive number of samples related to relatively short time periods may be obtained from archaeological sites (Mercuri et al., 2013). This research explores the significance of some wild and cultivated plants as markers of human environments in past contexts. How much local pollen records help to reconstruct spatial and temporal differences in the expansion of human landscapes in the Italian peninsula?

Previous research and aim of the paper

Our previous research on marine and terrestrial cores has shown that anthropogenic pollen indicators, as general indicators of arid environments, were abundant in pre-Holocene times and spread during Late Glacial dry oscillations in the Italian peninsula (Mercuri et al., 2013; Fig. 1). They include pollen of the cereal type produced by wild grass species (that does not mean that domesticated species occurred; Behre, 2007; Mercuri, 2008), and a number of taxa that are known to have ecological characteristics of weeds and ruderals.

In the lake core PALB94.1E from Lago Albano, the API values are high (Fig. 1) between ca. 14,000 and 12,000 cal BP, and then they decrease before the beginning of the Holocene. At the early Preboreal, the API curve is high again with oscillations matching a trend similar to that observed in the diagram of PNEMI94.1B of Lago di Nemi. After ca. 10,000 cal BP, the API curves decrease in the two lake cores, and increase later at around ca. 4000 cal BP.

In mid-Holocene times, the set of anthropogenic pollen indicators (API) became common evidence of farming practices in off-site records and archaeological sites. According to Mercuri et al. (2013), the development of human environments in a modern sense, meaning the permanent transformation of soils and land morphology, and the expansion of agrarian landscapes, with open spaces, fields, pastures and groves, is a relatively recent phenomenon developed in the second half of the mid-Holocene.

In the marine core RF93-30, collecting pollen from the Italian peninsula, anthropogenic pollen indicators began to

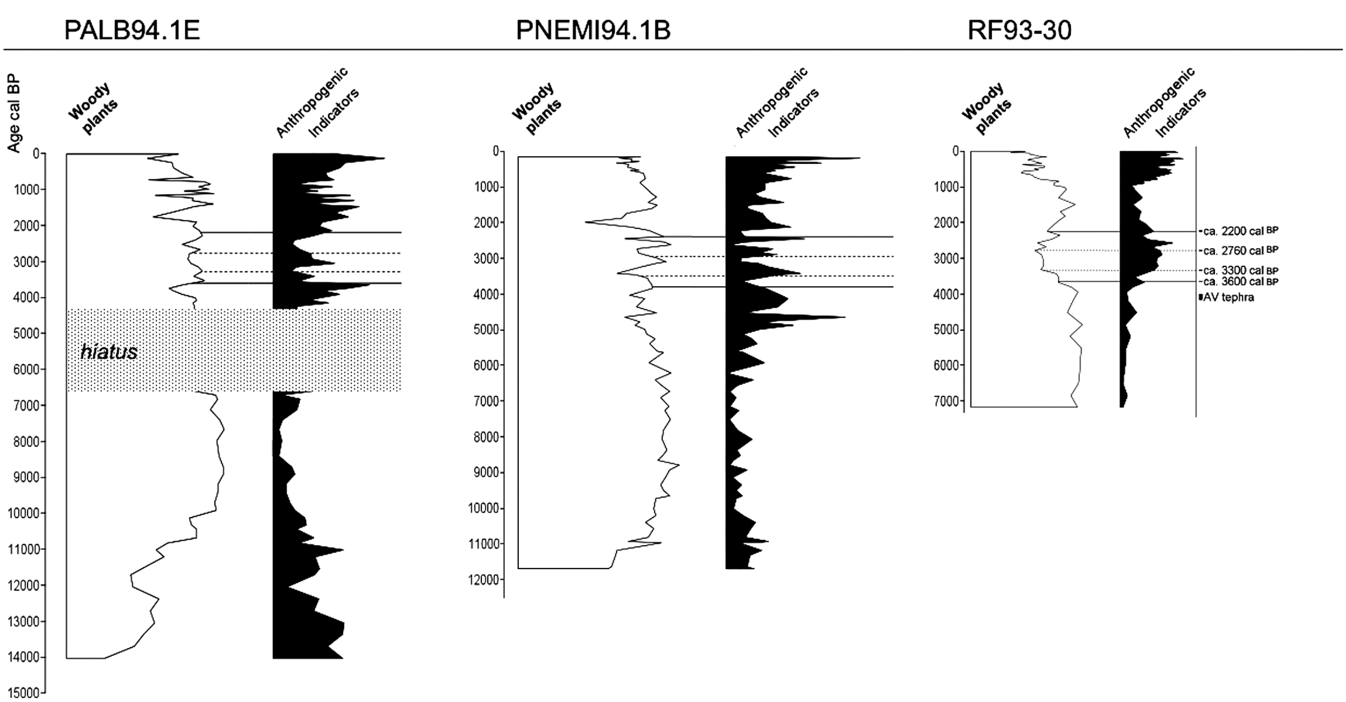

Fig. 1 - Comparison of the trends of synthetic diagrams from three off-site cores, from the left, Lago Albano, Lago di Nemi, and Adriatic Sea core RF93-30; the selected anthropogenic pollen indicators are cereals, Cichorieae, *Centaurea*, *Plantago* and *Urtica* (from Mercuri et al. 2013, modified).

rise at about 5400 cal BP, during a phase of increasing aridity, and increased at around 3600 cal BP, during the bronze age human impact (Mercuri et al., 2012, p.359; Fig. 1). Actually, the development of cultural landscapes started in the Middle Bronze age (Mercuri & Sadori, 2012). The OJC trees, possibly also favoured by climate, marked the human environments of the last four millennia, expand together with the Roman culture, from about 2700 cal BP (Mercuri et al., 2013).

This paper focuses on selected anthropogenic pollen indicators that were recurrent in spectra from archaeological sites of the Italian peninsula and Sicily. Thus, they are correlated with sites that are, by definition, locally affected by human presence and activity. Besides cereals, the set of weeds and ruderals discussed in this review are *Anagallis*, *Aphanes/Agrostemma* cf., *Artemisia*, *Centaurea* (*C. nigra* type, *C. cyanus*, *C. jacea*), Cichorioideae-Cichorieae, *Cirsium*, *Convolvulus, Galium* type, *Mercurialis, Papaver rhoeas* type, *Plantago* (*P. lanceolata* type*, P. media/major*), *Polygonum* (*P. aviculare* type, *P. persicaria* type), *Rumex*, and *Urtica* (*U. dioica* type, *U. pilulifera* type, *U. membranacea*) (Behre, 1981; Carrión et al., 2003; Marinova & Atanassova, 2006; Mazier et al., 2007; Miras et al., 2010; Brun, 2011; Ejarque et al., 2011; Rull et al., 2011). *Cannabis*, which can represent a weed or a cultivated plant, is included (Mercuri et al., 2002, 2006). Other taxa such as *Juniperus*, Poaceae, Apiaceae, Brassicaceae, Chenopodiaceae and Ranunculaceae are ambiguous, somewhat generalist and less informative in general contexts, and therefore were not included.

Material and methods

Pollen samples have been collected from archaeological layers of twenty-six sites (Fig. 2). Pollen results have been published elsewhere (Mercuri et al., 2006, 2007, 2009, 2010b; Montecchi, 2010; Bosi et al., 2011; Florenzano & Mercuri, 2012; Florenzano et al., 2013; Rattighieri et al., 2013; Vaccaro et al., accepted), while the review of evidences in relation to the OJC sum and off-site cores is reported in Mercuri et al. (2013). The interpretation of these on-site pollen spectra was made by taking into consideration that pollen was largely transported in layers by humans and their animals, and that inferences were made by multidisciplinary teams including archaeologists, geoarchaeologists, zooarchaeologists, archaeobotanists. They are also considered as single points within a macroregional site - the Italian peninsula.

The sites are situated in six regions of Italy (Veneto, Emilia Romagna, Tuscany, Basilicata, Calabria, Sicily) and one site is located in the Republic of San Marino (no. 26, Domagnano; Table 1). A total of 300 pollen samples, taken from layers opened during excavations, were selected avoiding ambiguous chronological attributions (such as, e.g., layers 'under/before' or 'over/after' the main context studied). Chronology is based on archaeological data and radiocarbon dates. Dates span from approximately 4200 to 500 years BP. The samples were prepared using tetra-Na-pyrophosphate, HCl 10%, acetolysis, separation with Na-metatungstate hydrate, HF 40% and ethanol (van der Kaars et al., 2001; Florenzano et al., 2012). Pollen slides were mounted on glycerol jelly. *Lycopodium* tablets were added for calculation of concentrations (expressed as pollen per gram - p/g). Residues in glycerol were mounted in permanent slides.

Pollen was identified at 1000x magnifications, with the help of atlases and the reference collection of the laboratory of Modena. Cerealia pollen identification was based on Andersen (1979), Beug (1964), Faegri & Iversen (1989, with a correction factor for glycerol jelly). Percentages were calculated on a pollen sum including all pollen types.

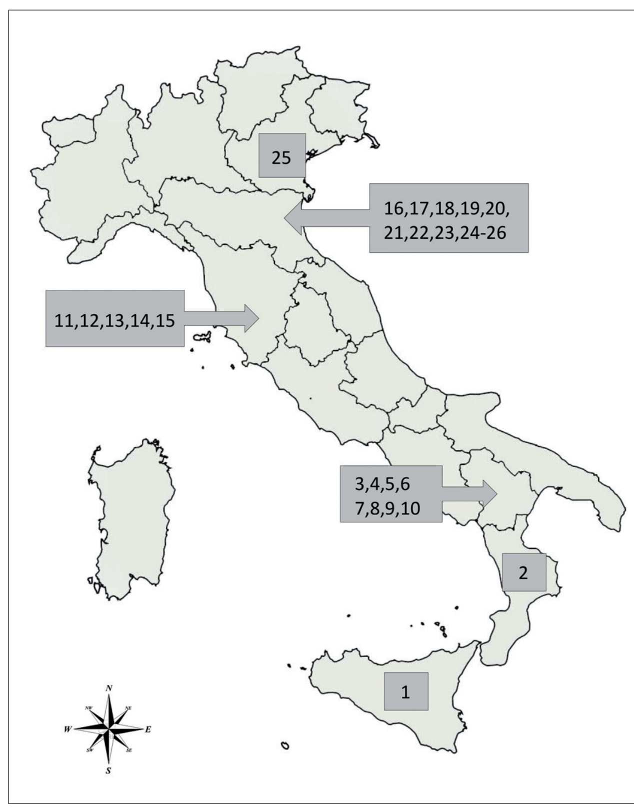

Fig. 2 - Location map of the sites whose data are elaborated in this paper. Numbers from 1 to 26 correspond to the archaeological sites reported in Table 1.

Table 1. List of the 26 archaeological sites, ordered according to increasing latitude (from 37° to 46° N) and decreasing longitude (from 16° to 10° E), following S-N, and then E-W directions. Sites cover, sometimes with overlapping, the following chronocultural layers: 5 sites dated to the Early-Middle-Late Bronze (22nd-12th century BC), 1 to Iron (12th – 7th century BC), 5 to Hellenistic (6th-2nd century BC), 13 to Roman (6th century BC-7th century AD), and 7 to Medieval/Renaissance ages (8th-17th century AD). The periods from the Middle Bronze to the Imperial Roman ages covering the two thousand years from about 3600 to 1600 years BP are the best represented. Partial data from the Terramara di Baggiovara (series 2 and 6 + 7), and from Sant'Angelo Vecchio (series 2, 10 and 8 + 9). (*) = Sites with radiocarbon dates.

Site No.	Area	Archaeological site	Chronology	
1	Sicily	Villa del Casale di Piazza Armerina	Roman, Medieval	1st-5th cent. AD, 10th-15th cent. AD
2	Calabria	Jure Vetere di San Giovanni in Fiore	Medieval	12th/13th cent. AD
3	Basilicata	Altojanni	Roman, Medieval	3rd-5th cent. AD, 2th-15th cent. AD
4	Basilicata	Torre di Satriano	Hellenistic	6th-5th cent. BC
5	Basilicata	Miglionico	Medieval	14th-15th cent. AD
6	Basilicata	Difesa San Biagio	Hellenistic	3rd-2nd cent. BC
7	Basilicata	Pizzica	Hellenistic	5th-4th cent. BC
8	Basilicata	Fattoria Fabrizio	Hellenistic	6th-4th cent. BC
9	Basilicata	Pantanello	Roman	2nd-1st cent. BC
10	Basilicata	Sant'Angelo Vecchio	Hellenistic-Roman	6th-1st cent. BC
11	Tuscany	San Martino	Roman	1st cent. BC-1st cent. AD
12	Tuscany	Podere Terrato	Roman	1st cent. BC-1st cent. AD
13	Tuscany	Case Nuove	Roman	1st cent. BC-1st cent. AD
14	Tuscany	Colle Massari	Roman	1st cent. BC-1st cent. AD
15	Tuscany	Poggio dell'Amore	Roman	1st cent. BC-1st cent. AD
16	Emilia Romagna	Monte Castellaccio of Imola	Middle Bronze	18th-15th cent. BC
17	Emilia Romagna	Montegibbio	Roman	2nd-4th cent. AD
18	Emilia Romagna	Terramara di Montale	Middle/Late Bronze	17th-12th cent. BC (*)
19	Emilia Romagna	Necropoli di Casinalbo	Middle/Late Bronze, Iron	18th-7th cent. BC (*)
20	Emilia Romagna	Baggiovara - Opera Pia Bianchi	Middle Bronze	17th-16th cent. BC (*)
21	Emilia Romagna	Argenta - Vie Vinarola/Aleotti	Medieval	3th-14th cent. AD
22	Emilia Romagna	Palazzo Boschetti of Modena	Roman	1st-7th cent. AD
23	Emilia Romagna	Cognento	Roman, Medieval-Renaissance	6th-7th cent. AD, 13th-17th cent. AD
24	Emilia Romagna	Piazza Garibaldi of Parma	Roman, Medieval	3rd/2nd cent. BC, 11th cent. AD (*)
25	Veneto	Canàr di S.Pietro Polesine	Early/Middle Bronze	22nd-18th BC (*)
26	San Marino	Domagnano	Roman- Gothic	1st cent. BC-6th cent. AD

RESULTS AND DISCUSSION

Percentage average values and maxima of the 18 taxa of anthropogenic pollen indicators per site are reported in Table 2. Their total values ranged from ca. 67% (site no. 18-Terramara di Montale) to ca. 4% (no. 25-Canàr) of the mean spectra from the sites.

Seven taxa are frequent: *Artemisia*, *Centaurea*, Cichorieae and *Plantago* are ubiquitous; cereals and *Urtica* are absent only from one site (no. 7-Pizzica and no. 24-Piazza Garibaldi, respectively), and *Trifolium* type is absent from two sites (no. 6-Difesa San Biagio and no. 25). Other seven taxa are fairly common: *Galium* type and *Polygonum* were found in twenty sites, and then in decreasing frequency there are *Convolvulus* (in nineteen sites), *Papaver rhoeas* type (eighteen), *Cirsium* (seventeen), *Aphanes* type (fifteen) and *Rumex* (thirteen). Only *Anagallis* (in twelve sites), *Cerastium* type and *Cannabis* (in eleven sites), and *Mercurialis* (in ten sites) were found in less than half of the sites.

Cichorieae pollen reaches the highest values (26% on average, and max. 75% in no. 18), followed by cereals (4%, max. 33% in no.18). Only *Centaurea* (1.6%), *Plantago* (1.5%) and *Urtica* (1.0%) have mean values ≥1%.

The characteristic anthropogenic pollen indicators from archaeological sites

Pollen grains of cereals, *Artemisia*, *Centaurea*, Cichorieae, *Plantago, Trifolium* type and *Urtica* are particularly important and characterise the human-induced environments near the examined archaeological sites (Fig. 3).

Cereals - The presence of these anthropochores signalling agricultural activity is well attested in all archaeological sites with a few exceptions. Cereal pollen was not found in the site no.7-Pizzica, a Hellenistic drainage channel near a necropolis. This means that the site was used as a sacred/burial area and therefore it was presumably far from crop fields. Also, cereals are < 0.5% on average in the sites no. 6-Difesa San Biagio (0.1%) and in site no. 19-Necropoli di Casinalbo

Table 2. Main data of the selected anthropogenic pollen indicators from the archaeological sites discussed in this paper. Sites are ordered in geographical order, as in Table 1.

Part A

Site No.	Number of pollen samples	Cereals %		*Cannabis* %		*Anagallis* %		*Aphanes* type %		*Artemisia* %		*Centaurea* %		*Cerastium* type %		Cichorieae %		*Cirsium* %	
		mean	max	mean	max	mean	max	mean	max	mean	max	mean	max	mean	max	mean	max	mean	max
1	48	0.9	20.6	0.1	0.9	0.02	0.5	0.01	0.4	0.3	6.0	0.1	3.1	0.03	0.6	46.5	76.6	1.1	40.8
2	4	4.3	7.0	0.1	0.3	0.2	0.3	0.2	0.5	0.8	1.0	0.4	0.6	0.5	1.7	32.0	38.4	2.0	4.5
3	11	0.6	2.9	-	-	-	-	0.1	0.5	1.5	5.6	2.8	7.2	0.02	0.2	26.4	41.3	0.02	0.2
4	4	6.4	9.4	-	-	-	-	0.1	0.4	0.4	1.1	2.2	3.5	-	-	22.3	30.7	1.1	2.2
5	10	1.6	3.6	-	-	-	-	0.1	0.3	0.4	1.0	1.0	2.1	0.03	0.3	26.3	48.7	0.2	0.7
6	9	0.1	0.5	-	-	-	-	-	-	0.2	0.7	2.0	3.9	-	-	27.2	39.9	-	-
7	5	-	-	-	-	-	-	-	-	0.03	0.2	1.2	2.4	-	-	39.4	53.3	-	-
8	10	2.0	4.0	-	-	0.02	0.2	0.03	0.2	0.2	0.7	0.9	1.6	-	-	11.9	15.3	0.3	0.8
9	12	4.5	11.6	-	-	0.2	1.0	0.1	0.9	0.03	0.3	0.1	0.5	-	-	41.2	53.5	0.1	0.4
10	27	0.7	3.2	0.01	0.2	0.01	0.2	0.1	1.3	0.7	2.9	0.8	2.4	-	-	21.1	36.2	0.7	1.9
11	8	1.4	2.7	-	-	-	-	-	-	0.20	1.3	2.3	6.0	-	-	34.7	42.7	-	-
12	11	3.2	5.4	-	-	-	-	-	-	0.5	2.2	5.3	8.9	-	-	31.6	38.1	-	-
13	15	4.3	10.2	-	-	0.1	0.6	-	-	0.7	2.0	2.1	4.8	-	-	23.6	33.7	-	-
14	4	3.4	5.4	-	-	0.2	0.6	-	-	0.6	0.3	4.4	8.5	-	-	35.8	47.6	-	-
15	5	3.0	5.7	-	-	0.1	0.3	-	-	0.7	1.6	4.4	6.2	-	-	34.0	38.4	-	-
16	7	8.8	23.0	-	-	-	-	0.1	0.4	0.2	0.6	0.1	0.8	0.7	1.9	22.2	66.5	0.3	0.9
17	2	1.9	1.9	0.3	0.3	-	-	0.3	0.4	0.6	0.8	0.4	0.5	-	-	31.0	33.5	0.5	0.8
18	29	9.5	33.1	0.1	0.5	-	-	0.01	0.1	0.1	0.4	2.5	5.0	0.3	0.8	53.2	75.4	0.5	1.6
19	17	0.3	2.7	0.1	0.9	-	-	0.04	0.4	0.3	0.9	2.4	2.7	0.1	1.2	43.5	60.2	0.1	0.6
20	20	0.6	1.9	0.6	3.0	-	-	0.2	2.7	0.1	0.6	0.8	2.6	0.05	0.6	28.6	55.9	0.05	0.6
21	2	12.7	20.0	-	-	0.2	0.2	0.2	0.3	0.5	0.6	0.2	0.3	0.0	0.04	1.8	2.5	-	-
22	4	5.9	8.9	-	-	0.1	0.4	-	-	0.2	0.2	0.8	1.6	-	-	9.3	13.4	0.3	1.0
23	6	3.3	4.2	0.2	0.9	0.2	0.6	-	-	1.8	3.9	0.9	2.2	0.4	1.5	11.6	19.5	0.03	0.2
24	7	15.1	24.8	0.04	0.3	-	-	-	-	0.5	1.4	2.0	5.3	-	-	9.5	25.2	0.5	0.8
25	10	2.0	6.1	0.02	0.2	-	-	-	-	0.2	0.9	0.02	0.2	-	-	0.1	0.4	-	-
26	13	6.4	14.3	0.0	0.1	0.01	0.1	0.1	0.6	0.5	4.3	0.6	1.4	0.05	0.4	19.8	40.8	0.2	0.4

Part B

Site No.	Woody plant %	*Convolvulus* %		*Galium* type %		*Mercurialis* %		*Papaver rhoeas* type %		*Plantago* %		*Polygomum* %		*Rumex* %		*Trifolium* type %		*Urtica* %	
		mean	max	mean	max	mean	max	mean	max	mean	max	mean	max	mean	max	mean	max	mean	max
1	13	0.7	30.7	0.1	1.3	-	-	0.1	0.8	1.8	10.1	0.1	0.7	0.1	0.7	0.3	2.2	0.1	1.3
2	29	-	-	0.3	0.5	0.4	1.6	0.1	0.3	3.2	5.8	0.1	0.3	-	-	0.1	0.3	1.1	1.3
3	14	0.1	0.5	0.04	0.2	0.1	0.5	-	-	2.8	15.2	-	-	-	-	0.2	0.7	0.9	2.4
4	6	0.1	0.3	0.1	0.3	-	-	0.2	0.6	2.1	3.8	0.1	0.3	-	-	2.2	3.4	0.7	1.5
5	11	0.1	0.6	0.1	0.3	0.02	0.2	0.1	0.5	3.6	8.6	0.1	0.3	-	-	2.2	8.6	0.3	1.3
6	5	-	-	-	-	-	-	-	-	0.6	3.2	-	-	-	-	-	-	0.2	0.6
7	12	-	-	0.1	0.4	-	-	-	-	0.2	0.5	-	-	-	-	0.1	0.2	0.5	0.9
8	19	0.1	0.4	0.5	0.8	0.02	0.2	0.4	1.1	2.5	4.2	0.1	0.4	0.2	0.5	3.2	4.7	1.3	2.9
9	3	0.1	0.5	0.2	0.7	-	-	0.5	2.1	4.6	10.5	-	-	0.1	0.4	0.8	1.5	1.4	1.9
10	12	0.1	0.6	0.2	0.6	0.01	0.3	0.1	0.9	1.7	3.6	0.1	0.4	0.2	0.9	2.4	5.6	4.8	34.4
11	16	0.3	0.9	0.04	0.3	-	-	-	-	0.6	1.5	0.02	0.2	-	-	1	1.6	0.6	1.5
12	16	0.02	0.4	-	-	-	-	-	-	1.2	2.4	0.1	0.5	0.01	1	0.5	1	0.8	1.9
13	13	0.01	0.2	-	-	-	-	-	-	0.8	2.3	0.01	0.6	-	-	1.5	3.4	1.0	3.4
14	21	0.8	1.8	-	-	-	-	-	-	0.4	1.4	0.05	0.2	-	-	0.5	1.2	0.5	2.0
15	13	1.1	1.6	-	-	-	-	-	-	1.2	2.0	0.2	0.6	-	-	1	1.5	1.2	2.0
16	26	-	-	0.4	0.7	0.04	0.3	0.3	0.6	0.9	2.1	0.04	0.2	0.1	0.3	0.3	0.7	1.1	1.9
17	14	-	-	0.4	0.4	-	-	0.1	0.2	2.2	2.4	0.8	0.9	-	-	0.2	0.2	0.1	0.2
18	12	0.1	0.4	0.02	0.2	<0.01	0.1	0.03	0.2	0.5	1.3	0.03	0.2	0.02	0.5	0.1	0.8	0.1	0.4
19	20	0.1	1.1	0.3	1.9	-	-	0.01	0.2	1.5	5.8	0.1	0.9	-	-	0.1	1.8	0.4	1.8
20	22	1.1	6.0	0.1	0.7	0.02	0.3	0.03	0.6	1.0	2.6	0.1	0.6	0.04	0.7	0.9	3.3	4.6	10.6
21	40	0.5	0.7	0.1	0.1	-	-	0.1	0.1	1.1	1.2	0.7	1.3	0.7	1.0	0.2	0.4	1.1	1.2
22	38	0.1	0.2	0.5	1.2	-	-	0.2	0.5	1.2	3.8	-	-	0.1	0.2	0.3	0.8	0.7	1.9
23	30	-	-	0.6	1.2	-	-	0.03	0.2	1.5	2.4	0.3	0.6	0.3	0.8	0.1	0.4	1.9	2.7
24	20	0.2	0.9	-	-	-	-	0.2	1.2	0.4	1.0	-	-	-	-	0.6	1.8	-	-
25	45	-	-	0.05	0.2	0.05	0.2	0.02	0.2	0.3	0.9	0.6	1.7	0.2	0.4	-	-	0.1	0.6
26	25	0.1	0.4	0.2	0.6	0.01	0.1	0.1	0.3	1.2	2.5	0.1	0.2	0.01	0.1	0.3	2.2	0.4	0.9

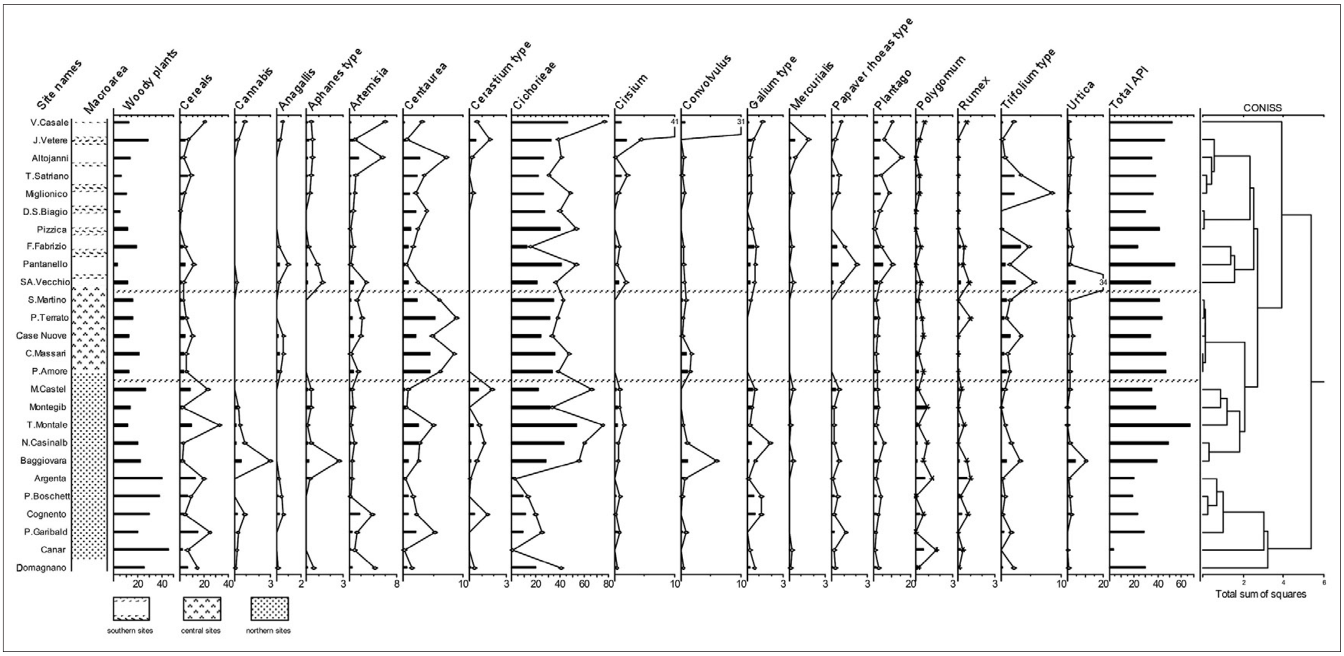

Fig. 3 - Pollen percentages and total concentrations of the 26 archaeological sites discussed in this paper, according to decreasing latitude (see also Table 1). Bars show mean values, and lines show maximum percentages. API = the sum includes the Anthropogenic Pollen Indicators discussed in this paper, and all reported in this diagram. CONISS = constrained incremental sum of squares. The diagram and cluster analyses were plotted with TGView (Grimm, 2004).

(0.3%). The first site is located in the same region (Basilicata) and has chronology comparable to Pizzica, the second is another similar context of necropolis (although located in another region).

Cereal pollen includes a few types with different size and exine: a) *Avena/Triticum* group, with wheats (*Triticum* ssp.), cultivated oat (*Avena sativa*) and a few wild grasses; b) *Hordeum* group, with barley (*H. vulgare*), einkorn (*Triticum monococcum*) and some wild grasses; c) *Panicum* cf., which includes common millet (*P. miliaceum*) and some wild grasses; d) *Secale cereale*. Though the latter species has a good pollen-production (Piotrowska, 2008), other cereals include low pollen production species, barley and wheat are autogamous, and their large pollen size (> 40 µm) causes a fall speed roughly double than that of smaller wild grasses (Fyfe, 2006). As cereal pollen is not easily transported far from the field, its occurrence is highly indicative of the presence of fields near the majority of the studied sites (Fig. 3). In some cases, very high values of cereal pollen, > 20%, were found in specific samples (maximum values in Table 2). They belong to sites no. 1-Villa del Casale, no. 16-Monte Castellaccio, no. 18-Terramara di Montale, no. 20-Argenta, no. 24-Piazza Garibaldi, suggesting a peculiar accumulation of these plants, brought to the site by people (Robinson & Hubbard, 1977; Bottema, 1992). Flowering spikes, or mature spikes with pollen trapped within the glumes, or pollen trapped on cereal collectors, or pollen deposited with dung by herbivores (no. 16) were the possible reason of the recovery of high amounts of this pollen in waste deposits (no. 24), reclaiming areas (no. 20), or storehouses (no. 18, possibly no. 1).

Artemisia - The genus is a typical element of steppe vegetation, in pre-Holocene and in modern times. Although species with a different ecology are known, the majority of species grows in open vegetation, and with ecology of weed under disturbed conditions. Along the Mediterranean coasts, *Artemisia* lives also in saline flats (Bottema & Woldring, 1990). The highest values of its pollen were found in the southern sites no. 1 and no. 3-Altojanni, with ca. 6% each, where the dry environmental conditions favoured the growing of these plants. However, the pollen reaches ca. 5% also in the sites no. 23-Cognento and no. 26-Domagnano, which are located in northern regions with relatively wetter general conditions. This confirms the cosmopolitan synanthropic behaviour of these plants although, in general, their pollen has frequently very low values in spectra (almost always < 1% on average).

Centaurea **-** The genus is common in disturbed places, often in dry, sunny, weedy waste areas; it is as well a good indicator of pastures (e.g., *C. nigra* type, Court-Picon et al., 2006), as shown by the increased abundance of pollen values in grazed areas (Bottema & Woldring, 1990; Brun et al., 2007). The highest values were found in small farmhouses from central Italy, no. 12-Podere Terrato and no. 14-Colle Massari (ca. 9% each), and in the southern site no. 3 (ca. 7%) that includes an open area for corralling of domestic animals.

Cichorieae - This tribe, with about 93 genera among the apophyte Cichorioideae, includes plants of mesic meadows and pastures (Faegri & Iversen, 1989; Funk et al., 2009). The high percentages of Cichorieae pollen in archaeological layers, between 21% and 53% in twenty of the studied sites, is usually explained by two very different interpretations: i) selective corrosion of the less resistant exines (Bottema, 1975) resulting in their over-representation in poor conservative sediments, like some layers from archaeological sites; ii) presence of pasturelands (Behre, 1986; Birks et al., 1988) in which these pollen grains are abundant as herbivore action and animal browsing lead to a certain selection of plants. Actually, in these sites Cichorieae pollen is often associated to other Local Pastoral Pollen Indicators-LPPI (Mazier, 2007) and to coprophilous fungal spores (Florenzano & Mercuri, 2012). The low values of Cichorieae, between 2% and 12%, which were found in five sites, from no. 21 to no. 25, located in northern regions, may reasonably suggest, therefore, that pastoral activities were not so important in these sites as in the majority of the studied sites. Also in the southern site no. 8-Fattoria Fabrizio, Cichorieae were low (12%) but, in this case, this may be an effect of the local development of the Mediterranean macchia (Mercuri & Florenzano, in press).

Plantago **-** The genus is recurrent in all types of anthropogenic habitats (Brun, 2011). Behre (1981) indicates *Plantago lanceolata*-type as preferential marker of wet meadows and pastures, and *Plantago major/media*-type as preferentially associated with trampled and ruderal places. They both grow on soils subjected to compaction of sediments due to trampling; in sandy soils, compaction causes a reduction of soil water porosity and a higher moisture content exists in the upper layers of the soils (Noë & Blom, 1981). These ecological features are common to all the plantain species, and therefore their distribution in a territory largely depends on the presence of human groups and herbivore herds. High values of *Plantago* pollen were observed to mark an increase of site frequentation in combination with *Urtica* (Giraudi et al., 2013; see below). Although plantain pollen reached maxima > 10% only in three sites (no. 1, no. 3, no. 9-Pantanello), it is almost always < 1% on average marking the frequentation of the sites.

Trifolium **type** - It is one of the largest genera in the family of Fabaceae, with species living in wide varieties of habitats from mountains to forest clearings and meadows. Clover plays an important role in pasturelands through its nourishment to animals and beneficiary act to soils. Though a few species can be poisonous, other species are commonly part of the fodder of domestic animals. The highest values were found in the southern sites no. 5-Miglionico (ca. 9%), no.10-Sant'Angelo Vecchio (6%) and no. 8 (ca. 5%), where probably the plants were part of the (cultivated) fodder given to the domestic animals, grown around the settlement.

Urtica **-** The genus includes nutrient-rich soil plants growing in both grazed areas (Court-Picon et al., 2006; Ejarque et al., 2011) and settlements (Li et al., 2008). This type is the most common indicator of ruderal habitats, and is also linked to animal breeding and pastures (Brun, 2011). Pollen curves of *Urtica dioica* type, together with those of *Plantago*, increase together as a result of the spread of human landscapes in the Italian peninsula during the late mid-Holocene (Mercuri et al., 2012). An extraordinary high percentage of 34% was found at site no. 10, as an unusual pollen over-representation: its interpretation is doubtful, but the growth of nettles in the past context may have been favoured by the archaeological walls found next to the sampling point. In site no. 20-Baggiovara, *Urtica* has ca. 11% maximum, and this is probably evidence of animal dung dropping, which enriched soils near the houses of the settlement. In the other sites, the mean values of this pollen ranged between 1% and 2%.

Notes on the distribution of API in the archaeological sites

The site no. 25-Canàr, an Early Bronze age pile dwelling of Veneto dated to ca. 4000 cal BP, shows the minimum 4% of API. It is highly probable that the wet environmental conditions, supplied by the Po plain where the site was settled, were unfavourable to the growing of most of the dryland anthropogenic pollen indicators. However, later, in sites located in the southern Po plain, API are decidedly higher ranging from 40% to 67%. They are sites no. 18- Terramara di Montale, no. 19-Necropoli di Casinalbo and no. 20-Baggiovara that belong to the Middle Bronze age *terramare* culture of Emilia Romagna, dated to about four hundred years later.

All considered, the sites numbered from no. 21 to no. 26, all located in northern regions, and the sites no. 8 and no. 6, located in Basilicata-south Italy, do not overlie 30% of the total API. This is especially due to the low values of Cichorieae. Apart from no. 25-Canàr, these sites cover from Hellenistic to Medieval chronological phases but the API (24% on average in the five sites) are not so low as in the site of Early Bronze age studied.

Conclusions

Since the Bronze age, the chronology of the earlier archaeological sites reported in this paper, the evidence of human-induced environments is clear from the combination of cereal and synanthropic pollen in the records. Farmers had permanent settlements surrounded by 'areas of influence' where their continuative action on a limited area had consequences on ecological adjustments and the development of evident cultural landscapes (Mercuri et al., 2006; Mercuri & Sadori, 2013).

Literally, landscapes shaped by culture had developed before these times with the beginning of agricultural systems but they are hardly recognizable in pollen diagrams. The Neolithic spread of cultivated fields, in fact, would not have caused notable signals in the pollen rain because cereals are generally under-represented species. Conversely, the effects of tree cutting on forest cover, as those observed in the Middle Bronze age (Sadori et al., 2004; Mercuri & Sadori, 2012; Mercuri et al., 2013), was impressive since deforestation events involved most of the high-producing anemophilous forest species.

The human impact became evident at a larger regional scale, as in the marine core RF93-30 (Fig. 1), depending on the chronological and cultural variables, and on the distance and intensity of activity performances. Interestingly, in our data, this hypothesis is supported by the notable increase of API observed at the transition from the Early to the Middle Bronze age sites. As only one Early Bronze site was examined in this study, further data are needed to detail local differences but the general datum is confirmed by the late mid-Holocene rise of API curves in off-site cores (Fig. 1).

The API records, common in and near archaeological sites, may be useful to reconstruct similarity and differences in the expansion of human landscapes in the Italian peninsula. If we accept the prerequisite that, at the scale of Italy, contemporaneous societies were at fairly comparable technical-cognitive level, they must generate comparable cultural landscapes. However, significant differences were evident. A combination of effects on landscapes from local ecological diversities and economy peculiarities should be advanced to explain these results.

The interpretation of API in pollen spectra is complicated by the different archaeological contexts, and by the fact that climate has been acknowledged as one of the main factors shaping the landscape behind land use and economy shifts (Berglund, 2003; de Beaulieu et al., 2005; Berger & Guilaine, 2009). Reactions or adaptation of human societies to climate oscillations make complex and unpredictable effects on landscapes, especially in the Mediterranean regions (Gronenborn, 2009; Weninger et al., 2009; Carrión et al., 2010; Mercuri et al., 2011). Climatic changes have influenced the spread of more drought-tolerant species in times of increasing dryness, as at times just around the 4000 cal BP.

The wild synanthropic species included in API were part of steppe and grassland vegetation types widespread in dry-cool oscillations of pre-Holocene times. In this sense, though human settlements were significantly present in the Italian peninsula, for example, during the Younger Dryas (Mussi & Peresani, 2011), the early presence of API has not had an unquestionable significance of indicators of human action. Pre-Holocene climate and vegetation, for example, favoured the large herds that need open grasslands; their survival was threatened by forest; the reduction of herds that occurred at those times, caused a reduction of the grazing that had contributed to maintain grasslands. Large mammals played a key role in vegetation development at the Pleistocene/Holocene transition (e.g., Burney & Flannery, 2005).

Only when found in archaeological layers, API may be considered indicators of human activity with the greatest level of reliability.

In the Holocene archaeological sites of this study, the highest values of API were reached in southern Italian regions. Human action, as overexploitation of thinned plant resources including overgrazing, generally favours the expansion of xeric environments (Jalut et al., 2009; Mercuri et al., 2010b). These plants, therefore, continue to represent similar ecological situations, i.e. the xeric environments that developed as a result of continuous human pressure, especially in the mid and late Holocene.

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