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BRIDGING DISCIPLINES: SELECTED PAPERS IN HONOUR OF PROFESSOR CARLO TOZZI

Atti della Società Toscana di Scienze Naturali, Memorie, Serie A

Edited by Elisabetta Starnini & Cristiana Petrinelli Pannocchia, DCFS, Università di Pisa

Per celebrare la lunga e prestigiosa carriera accademica del Prof. Carlo Tozzi, questa parte del volume degli Atti della Società Toscana raccoglie una miscellanea di saggi nelle materie che egli ha per molto tempo insegnato e in cui ha ricercato con approccio multidisciplinare, coniugando in particolare le Scienze della Natura con le Scienze dell'Uomo. I contributi sono quindi necessariamente eterogenei per materia e per autori, spaziando tra giovani allievi dell'Università di Pisa e del Professore, colleghi e amici, ma spiccano tutti per l'attualità degli argomenti trattati e la metodologia utilizzata. Le curatrici auspicano che questo doveroso omaggio alla lunga carriera e all'importante contributo scientifico e didattico del Professore sia a lui gradito.

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Curriculum in breve del Prof. Carlo Tozzi

Laureato in Scienze geologiche a Pisa nel 1962
Assistente volontario di Antropologia nel 1962/63 e dal 1965/66 al 1970/71
Assistente volontario di Geologia a Pisa nel 1963/64 e nel 1964/65
Assistente di ruolo di Geologia a Pisa dal 1970/71 al 1972/73 e nel 1974/75
Assistente di ruolo di Antropologia nel 1973/74 e a partire dal 1975/76
Libero docente in Paletnologia a Pisa dal 1972/73
Professore incaricato di Ecologia preistorica nel 1973/74
Professore associato a Pisa (Scienze MFN) dall'1/8/1980
Professore straordinario a Sassari dal 2/4/1987, ordinario dal 7/4/1990 al 1992
Professore ordinario di Paleontologia umana alla Facoltà di Scienze MFN di Pisa dall'1/11/1992 (E03B – BIO/08). A riposo dall'1/11/2010
Professore *Emeritus* dell'University di Pisa.

Ha svolto ricerche sul Paleolitico e sul Mesolitico con studi specifici e scavi in siti del Paleolitico inferiore dell'Abruzzo (Valle del Foro e Selvotta - CH), del Carso Triestino (Riparo di Visogliano - TS) e della Liguria (Grotte di Toirano - SV), del Paleolitico medio e superiore del versante tirrenico della Penisola (Grotta di Gosto - PG, Riparo Biedano e Cenciano Diruto - VT, Grotta La Fabbrica - GR, Grotta del Capriolo e Buca della Jena - LU, Pontecosi, Orecchiella, Riparo Piastricoli e Riparo Fredian - LU), del Mesolitico della Toscana settentrionale (tra cui La Greppia, La Murella, Monte Frignone, Garfagnana - LU e Appennino tosco-emiliano), della Corsica (Monte Leone) e della Sardegna settentrionale (Riparo di Porto Leccio).
Ha svolto ricerche anche sul Neolitico dell'Italia centro-meridionale con scavi in Abruzzo (Catignano - PE), Puglia (Ripa Tetta, Lucera - FG), Toscana (Pianosa e, in Garfagnana, Muraccio e Pian di Cerreto) e Sardegna (Perfugas - SS, Torre Foghe - OR). Oltre allo studio tipologico dei materiali litici e ceramici, ha posto particolare attenzione alla ricostruzione degli aspetti economici e paleoambientali delle culture preistoriche.

È stato membro del Comitato Nazionale del XIII Congresso UISPP e ha coordinato i Colloqui XIII (Formation of the European Mesolithic Complexes) e XIV (Adaptation to Postglacial Environment).

È stato membro della VIII Commissione dell'Unione Internazionale delle Scienze Preistoriche e Protostoriche (UISPP), come rappresentante dell'Italia.

È Socio fin dagli anni Sessanta del secolo scorso della Società Toscana di Scienze Naturali di cui negli anni Ottanta è stato anche Segretario Generale. Dal 2006 al 2018 ha ricoperto il ruolo di Vicepresidente della Società e dal 2019 al 2022 ha svolto l'incarico di Revisore dei conti.

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Cristiana Petrinelli Pannocchia [1], Daniele Arobba [2], Alice Vassanelli [3]

BOTANICAL REMAINS FROM THE NEOLITHIC SETTLEMENT OF RIO TANA (L'AQUILA, ABRUZZO, ITALY): A PRELIMINARY REPORT

Abstract - C. Petrinelli Pannocchia, D. Arobba, A. Vassanelli, *Botanical remains from the Neolithic settlement of Rio Tana (L'Aquila, Abruzzo, Italy): A preliminary report*.

This study presents the preliminary results of archaeobotanical analyses conducted on materials from Rio Tana (L'Aquila, Abruzzi, Italy), a Neolithic settlement in central-southern Italy, dated to the first half of the 6th millennium BC. The recovered botanical remains, including charred seed/fruits of cereals/legumes, and charcoals, provide new insights into the agricultural practices, environmental adaptations and land-use strategies of the community that occupied the site. The carpological assemblage indicates a crop package dominated by einkorn (*Triticum monococcum*), emmer (*Triticum dicoccum*), and barley (*Hordeum vulgare*), while anthracological analysis identified hop-hornbeam (*Ostrya carpinifolia*) and deciduous oaks (*Quercus* spp.) as the most frequent taxa, suggesting the presence of a mixed thermophilous woodland in the surrounding landscape. These findings reflect the integration of early farming and woodland management within a diversified subsistence system, thus contributing to a broader understanding of agricultural practices in Mediterranean Neolithic communities.

Key words - Early Neolithic agriculture, archaeobotanical remains, Neolithisation, Italy, impressed wear pottery

Riassunto - C. Petrinelli Pannocchia, D. Arobba, A. Vassanelli, *Resti botanici provenienti dall'insediamento neolitico di Rio Tana (L'Aquila, Abruzzo, Italia): relazione preliminare.*

Questo studio presenta i risultati preliminari delle analisi archeobotaniche condotte sui materiali provenienti da Rio Tana (L'Aquila, Abruzzo, Italia), un insediamento neolitico dell'Italia centro-meridionale datato alla prima metà del VI millennio a.C. I resti vegetali rinvenuti, comprendenti semi/frutti di cereali e legumi carbonizzati e frammenti di carboni lignei, offrono nuovi elementi sulle pratiche agricole, sugli adattamenti ambientali e sulle strategie di uso del territorio della comunità che occupava il sito. L'insieme carpologico indica un complesso colturale dominato da farro piccolo (T*riticum monococcum*), farro (*Triticum dicoccum*) e orzo (*Hordeum vulgare*), mentre l'analisi antracologica ha identificato carpino nero (O*strya carpinifolia*) e querce decidue (*Quercus* spp.) come taxa più frequenti, suggerendo la presenza di un bosco misto termofilo nel paesaggio circostante. Questi dati riflettono l'integrazione tra agricoltura e gestione delle risorse forestali all'interno di un sistema di sussistenza diversificato, contribuendo a una comprensione più ampia delle pratiche agricole delle comunità neolitiche del Mediterraneo.

Parole chiave - Agricoltura del Neolitico antico, resti archeobotanici, Neolitizzazione, Italia, ceramica impressa

Introduction

Research into the early spread of agriculture in the Mediterranean area demonstrates that a specific group of cereals played a pivotal role in the diet of Neolithic populations from the very beginning (Zohary & Hopf, 1993; Zohary, 1996; Zohary *et al*., 2012; Harris, 1996; Zeder, 2006, 2011; Colledge & Conolly, 2007; Weiss *et al*., 2012; Fuller *et al*., 2014). These cereals include wheat (*Triticum aestivum/durum/turgidum*), emmer (*Triticum dicoccum*), einkorn (*Triticum monococcum*), and barley (*Hordeum vulgare*). Pulses such as lentils (*Vicia lens*), peas (*Lathyrus olearaceus*), chickpeas (*Cicer arietinum*), and bitter vetch (*Ervilia sativa*) accompany these crops. From the first moment of their appearance in the Near East (Weiss & Zohary, 2011), the presence of the so-called founder crops varies from site to site, but they are always found in combination. The adaptability of these old-tolerant crops to different environments and soils likely influenced their selection. This facilitated their spread to the westernmost regions of the Mediterranean over the following two millennia (Weiss *et al*., 2012). The spread of agricultural systems can be considered as a process of dispersal and expansion. It is natural to expect branching patterns of change, as progressively modified sets of traits are transmitted from one location to another (Coward *et al*., 2008). Indeed, differences in the distribution and timing of crop assemblages are evident during the Neolithisation of Europe, influenced by a combination of environmental factors, cultural practices, and human migration patterns (Zapata *et al*., 2004; De Vareilles *et al*., 2020; Conolly *et al*., 2008; Filipović, 2014; Gaastra *et al*., 2019; Rottoli & Castiglioni, 2009; Bouby *et al*., 2020).

The archaeobotanical data from the Italian peninsula provide a comprehensive overview of the plant food resources and cultivation practices of the first farming communities, indicating that the founder crop package (comprising emmer, einkorn, barley, and

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pulses such as lentil and pea) was fully adopted on the peninsula (Costantini, 2002; Rottoli & Castiglioni, 2009; Fiorentino *et al*., 2013; Mercuri *et al*., 2015). This agricultural system formed part of a broader complex of artefacts, production practices, traditions, and symbolic expressions introduced by the early Neolithic farming groups who spread throughout the peninsula at different times and with regional variability (Pessina & Tiné, 2008; Binder *et al*., 2017; Radi & Petrinelli Pannocchia, 2018; Natali & Forgia, 2018; Biagi *et al*., 2020). Gathering wild fruits and herbs, as well as hunting wild fauna, continued to play a crucial role in these communities with a productive economy, especially during the early phase of the Neolithic.

In the central-southern region of Italy, archaeobotanical research experienced significant growth between the mid-1970s and the late 1980s. During this period, numerous Neolithic sites were investigated, allowing researchers to outline a chrono-cultural framework for the Neolithic peninsular phase that remains broadly valid today (Radmilli, 1972; Tinè, 1978, 1983; Bagolini & Von Eles, 1978; Geniola, 1979; Cipolloni Sampò, 1985; Ammerman, 1987; Cremonesi, 1974; Cremonesi *et al*., 1987). Data derived from plant remains (Evett & Renfrew, 1971; Nisbet, 1982; Sargent, 1983; Castelletti *et al*., 1987; Jones, 1987; Follieri, 1977-1982; Costantini & Tozzi, 1983; Costantini & Stancanelli 1994; Castiglioni & Rottoli, 2003; Ciaraldi, 2004) have revealed a high degree of taxonomic diversity in cereal crops. This includes a notable prevalence of *Triticum* species and *Hordeum vulgare*, alongside other taxa such as various pulses during the 6th millennium BC. Towards the middle of the same millennium, a notable shift in crop composition is observed, with a slight decrease in barley values accompanied by an increase in naked grains (*Triticum aestivum/durum*), suggesting evolving agricultural practices (Fiorentino *et al*., 2013). In the central and southern Adriatic area of the Peninsula, neolithisation represents a second-generation event, characterised by the migration of human groups from the southern coast to the northernmost sectors (Radi & Petrinelli Pannocchia, 2018). This movement facilitated the secondary diffusion of crops that were initially introduced to the peninsula. To explore the resilience of the first crops and the adaptive choices made by early farming communities, it is crucial to understand the agricultural practices of the earliest Neolithic phase in this area. However, archaeobotanical information remains limited and scattered, often derived from the analysis of plaster and ceramic materials (Evett & Renfrew, 1971; Coppola & Costantini, 1987; Costantini & Tozzi, 1983; Costantini *et al*., 2003; Castiglioni, 2003; Conati Barbaro & Celant, 2021).

This study aims to present preliminary results from the analysis of botanical remains found at Rio Tana, a settlement located in the innermost part of modern-day Abruzzo and dated to the first half of the 6th millennium BC. Despite being a work in progress, we believe that the data gathered offers essential insights into a geographical area that remains underexplored.

Despite the challenges encountered during the archaeological investigation – details of which will be discussed later – an archaeobotanical record was assembled. The analysis of this data aims to achieve several key objectives: to provide insights into the village's agricultural practices, to support the interpretation of specific areas and structures under study, and to establish a chronology for the various phases of settlement. The preliminary results of the analyses indicate that the village was inhabited for nearly three centuries.

Archaeological context

Rio Tana is located along the basin of Lake Fucino at an altitude of 705 metres above sea level. This karstic lake developed within a tectonic depression formed as a result of geological processes associated with the Apennine orogeny, which took place between the Pliocene and Quaternary periods. Due to its lack of natural outlets, Lake Fucino was subject to sudden and significant fluctuations in water level, resulting in periodic flooding and drying phases. Efforts to drain the lake date back to Roman times, during the reign of Emperor Claudius. However, the successful and permanent drainage of the lake was only achieved in the late 19th century by the Torlonia family.

During the Neolithic period, the settlement of Rio Tana was located about 2-3 km from the shores of the lake. The precise extent of Lake Fucino during this period remains a topic of debate, as climatic variations, earthquakes, and seismic activity caused significant deformations in the basin. These events likely led to altimetric changes that influenced the fluctuations of the lake's water level (Fig. 1).

The excavated area currently extends over a sub-rectangular sector of approximately 60 m^2. The site's stratigraphy is particularly complex, partly due to the "Tavana", a seasonal watercourse fed by snowmelt from the highlands. This stream has historically carved deep riverbeds in the valley. In the 1990s, an artificial channel to manage its flow further disturbed the area and partially removed the archaeological deposits (Radi & Ventura, 1993; D'Ercole *et al*., 2001). Despite these environmental challenges, the site appears to exhibit traces of occupation, albeit intermittent, from the early Neolithic to the Copper Age.

Based on the stratigraphy, two main horizons or phases of occupation can be distinguished (Level I and Level II), separated by an alluvial layer composed of medium to small pebbles. Level I, from which the data analysed in this paper originates, corresponds to the second Neolithic occupation phase. A radiocarbon date on charred caryopsis of *Hordeum vulgare* is currently available for this level: 6661 ± 30 BP (GrM-32925: 5635-5523 BC with 94% probability, Reimer *et al.*, 2020).

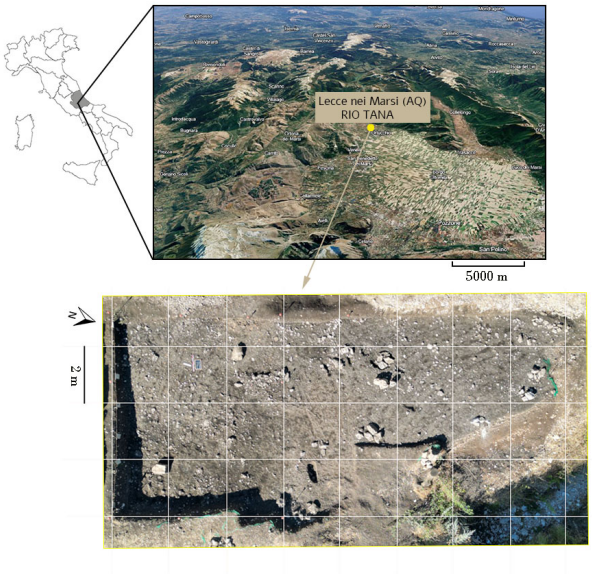

Figure 1. Top: The Fucino area, and the location of the site. Bottom: The excavation area of Rio Tana (AQ).

Level I is composed primarily of two main layers, which are from top to bottom:

- a layer (A) consisting of brown sandy-clay sediments, with abundant calcareous clast, in which archaeological materials referable to the early Neolithic period were found, and some pits and stone structures.
- a layer (B) composed of light brown clay-silt sediments within which most stone structures were set.

The archaeological remains from this part of the deposit are abundant and reflect a period of intense occupation. They include pottery production, mainly decorated with incised and impressed techniques; a chipped stone industry, based largely on raw materials sourced from the region; and a significant bone industry. The typological and technological characteristics of these artefacts establish a clear link between Rio Tana and other sites in the Adriatic region associated with the Impressed Pottery groups (Radi & Petrinelli Pannocchia, 2018). This correlation supports the attribution of this phase to an advanced stage of the early Neolithic (Petrinelli Pannocchia *et al.*, 2023). The faunal remains further emphasise the importance of hunting activities within an economy predominantly based on animal husbandry and agriculture (Petrinelli Pannocchia *et al.*, 2022). Among the activities inferred at the site, plant processing seems to have been of considerable importance, highlighting the role of this site in the subsistence strategies of its ancient inhabitants. Ongoing investigations have revealed several postholes, formed by circular arrangements of stone blocks and millstone fragments, of varying diameters. The evidence, therefore, indicates the presence of at least one covered structure (Petrinelli Pannocchia *et al.*, 2022). Data suggests more than one occupation of the area, although the uniformity of the artefacts suggests a rather short lapse between one phase and the next.

Materials and methods

Botanical remains were classified according to the two primary stratigraphic units that compose Level I (Layers A and B). The sampling strategy was defined based on the research objectives and influenced by the excavation conditions. However, several logistical and environmental constraints affected the implementation of the methodological procedures and the recovery of archaeobotanical samples. The flow of water in the artificial canal that cuts through the deposit is causing its progressive erosion and consequent loss of archaeological data. This situation limits the time available for excavation and flotation activities. Moreover, during the summer campaigns, the lack of local water sources and the need for water storage tanks further constrained the sampling and flotation operations.
Because of these limitations, it was not possible to conduct systematic sampling based on precise parameters, such as a standardised volume or number of samples per excavation unit. Despite this, the sampling followed a contextual approach, with samples collected from well-defined stratigraphic units directly associated with human activities, ensuring the reliability of the qualitative interpretation of the archaeobotanical record.
Plant macro-remains, consisting of charred seeds/fruits, were extracted from 432 litres of sediment by flotation/water sieving on 2-0.5 mm sieves, from both the upper (Layer A = 232 litres) and lower (Layer B = 200 litres) units of Level I.
The wood charcoal, from the same archaeological contexts, was instead collected on site during excavation and partly by dry sieving.
The carpological remains were analysed using a stereoscopic microscope (Olympus SZH10) at 10-70x, while the anthracological material was also analysed using a metallurgical dark field microscope (Olympus BHMJ) at 50-500x, based on the reading of the three standard anatomical sections.

Comparative collections and the use of atlases, analytical keys and computer archives aided species identification.

Results of the Archaeobotanical analysis

The examination of the carpological remains yielded 241 well-preserved finds, which were more abundant in Layer B than in Layer A (19 vs. 98 seeds/fruits per 100 litres of sediment).
Among the cereals (Tab. 1), caryopses of *Triticum monococcum* (n = 58), *Triticum dicoccum* (n = 57), *Hordeum vulgare* (n = 38) and *Triticum aestivum/durum* (n = 3) were identified. For barley, distinguishing between the hulled and naked varieties was not possible due to the eroded surfaces of the remains. A small portion, consisting of fragmented material, was generically classified as *Triticum/Hordeum* category and undifferentiated Cerealia.
Edible pulses, such as *Vicia lens* and *Ervilia sativa*, were less common, as were weeds (cf. *Lolium* and *Rumex* sp.). Regarding tree species of food interest, only two fragments of endocarp of *Prunus* sp. and *Cornus mas* were recorded. The results are presented as absolute values in Tab. 1, while the main results are summarised in Fig. 2.
The anthracological analysis of the 279 wood samples enabled the identification of 16 *taxa*, with percentage values recorded in the two Layers shown in the graph in Fig. 3. *Ostrya carpinifolia* fragments were the most abundant, showing a slight increase in frequency in the upper Layer (from 38.2% to 48.5%). The remains of deciduous oak (cf. *Quercus* subgen. *Robur* and *Quercus* subgen. *Cerris*), are also abundant, and relatively stable across both horizons (between 21.4 and 24.7%). Less frequent were evergreen oak (cf. *Quercus* subgen. *Ilex)* and *Fagus sylvatica*, the latter only documented in Layer B (2.8%). Other mesophilous deciduous trees were sporadic, including *Acer* sp. (cf. *A. campestre* and *A. pseudoplatanus*), *Ulmus* sp., *Tilia* sp., *Carpinus betulus* and *Fraxinus ornus*. Within the predominantly arboreal and shrubby plant community, *Corylus avellana*, *Laburnum* sp. and *Rosaceae* (cf. *Maloideae* and *Prunoideae*) were identified.

Table 1. Carpological remains found in Level I from Rio Tana site.

		Layers	**A**	**B**
		Depth (cm)	**+30/+3**	**+3/-30**
		Sediment volume (litres)	**232**	**200**
Cereals				
Triticum aestivum/durum	wheat	caryopsis		3
Triticum dicoccum	emmer	caryopsis	8	49
cf. *Triticum dicoccum*	cf. emmer	caryopsis fr.		2
Triticum monococcum	einkorn	caryopsis	9	49
cf. *Triticum monococcum*	cf. einkorn	caryopsis fr.		2
Triticum sp.	wheat	caryopsis fr.	3	28
Hordeum vulgare	barley	caryopsis	7	31
Triticum vel Hordeum	wheat or barley	caryopsis fr.	8	26
Cerealia indet.	cereals ind.	caryopsis fr.	5	
Pulses				
Vicia lens	lentil	seed	1	3
Ervilia sativa	bitter vetch	seed	1	
Weeds/ruderal plants				
cf. *Lolium* sp.	ryegrass	caryopsis		1
Wild Poaceae	grasses	caryopsis	1	1
Rumex sp.	dock	achene	1	
Fruits				
Prunus sp.	plum tree	endocarp fr.		1
Cornus mas	cornelian cherry	endocarp fr.	1	
		Total carpological remains	45	196

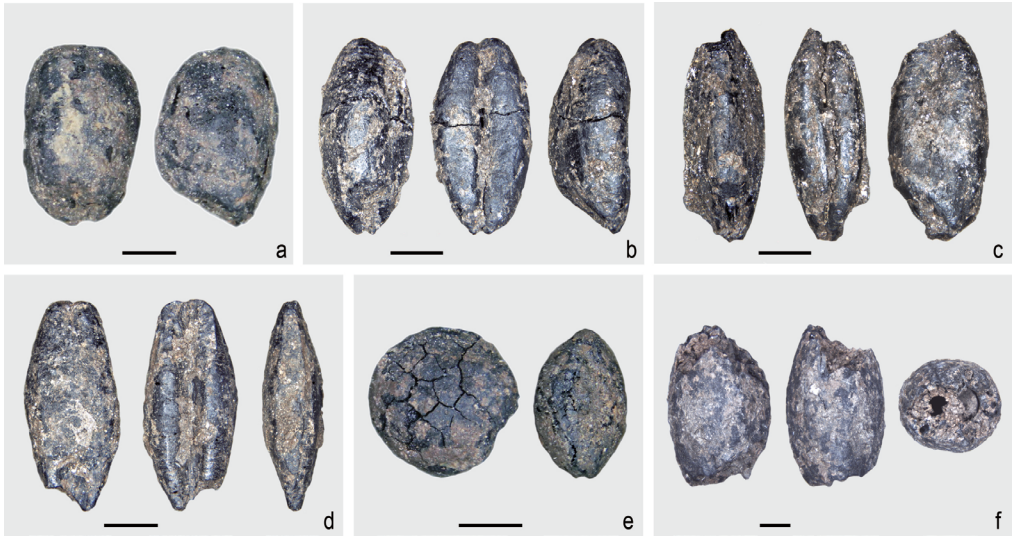

Figure 2. Charred carpological remains from Rio Tana. a. *Triticum aestivum/durum*; b. *Triticum dicoccum*; c. *Triticum monococcum*; d. *Hordeum vulgare*; e. *Vicia lens*; f. *Cornus mas*; scale bars = 1 mm (photos by D. Arobba).

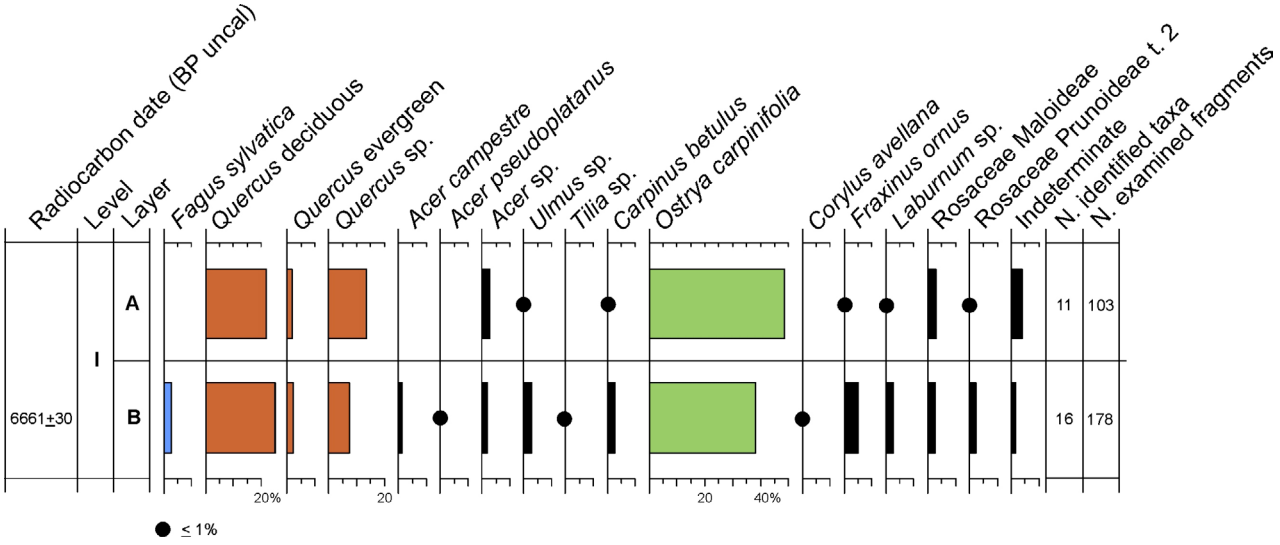

Figure 3. Results of the charcoal analysis presented as relative frequencies of the taxa from Rio Tana.

Discussion

From these preliminary investigations at Rio Tana, cereal remains emerged as the most frequently attested cultivated crop in terms of percentage frequency. The dominant species, in order of importance, are *Triticum monococcum* (einkorn), *Triticum dicoccum* (emmer), and *Hordeum vulgare* (barley). In contrast, *Triticum aestivum/durum* (wheat) is sporadically present, confined exclusively to the earliest moment of Level I. This suggests that the latter species were not of significant interest to the Neolithic community of Rio Tana, which appears to have preferred crops requiring lower soil fertility and demonstrating greater resilience to adverse climatic conditions to complete their vegetative cycle. Notably, the absence of spikelet remains is typically indicative of winnowing activities for separating and cleaning cereal stocks, which are generally less frequent in residential areas than in locations dedicated to crop processing

A first observation of apparent variations in agricultural production can be inferred from a slight decrease in cereal cultivation (from 96.9% to 88.9%), an increase in edible pulses (from 1.5% to 4.4%), and the proliferation of weeds and ruderal plants (from 1.0% to 4.4%) during the brief period separating the two occupation phases. This trend may reflect a more persistent and progressive anthropisation of the settlement (Fig. 4).

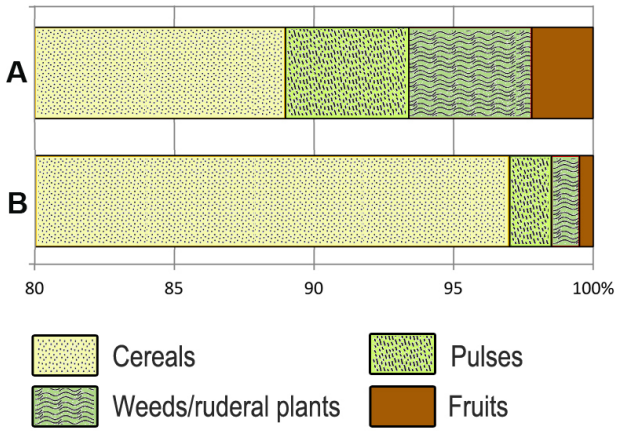

Figure 4. Results of the carpological analysis presented as relative frequencies of two archaeological phases in level from Rio Tana.

From a palaeoenvironmental perspective, anthracological data indicate the presence of thermophilous and xerophilous woodlands, likely widespread around the site in the hilly-mountainous belt at altitudes between 600 and 900 m. These were dominated by hop-hornbeam (*Ostrya carpinifolia*) and deciduous oaks, especially Turkey oak (cf. *Quercus* subgen. *Cerris*), rather than pedunculate oak, sessile oak, and downy oak (cf. *Quercus* subgen. *Robur*). Other more water-demanding elements, such as maple, elm, linden, ash, and hornbeam, point to mixed formations occupying areas with greater water availability.

The presence of sparse clearings within the forest formations, potentially resulting from early deforestation activities carried out both for wood procurement and the creation of open spaces for agro-pastoral purposes, is evidenced by heliophilous species such as laburnum (*Laburnum* sp.), hazel (*Corylus avellana*), and various shrubby Rosaceae.

Beech (*Fagus sylvatica*) is documented at low altitudes, probably due to occasional harvesting at higher altitudes, around 900 m a.s.l., where the current lower limit of beech forest in Abruzzo is located. The presence of evergreen oaks is also quite rare, traces of which remain today in thermophilic extrazonal contexts on rocky slopes in the area (Castiglioni, 2003; Pirone *et al*., 2010).

Regarding forest resource management, additional insights can be derived from various parameters recorded on the charred wood fragments. Overall, these fragments predominantly exhibit angular shapes (95.6%) compared to sub-angular forms (4.4%), a feature indicative of a low-energy sedimentary environment, free from displacement by water transport. Furthermore, 26% of the total wood charcoal displays radial cracks, suggesting the use of fresh wood as fuel. Fungal hyphae, typical indicators of dead wood collected from the forest floor, are absent from the wood tissues, while 5.1% of the fragments show signs of vitrification, which may result from high combustion temperatures in domestic fires or repeated heating episodes (Marguerie & Hunot 2007). Regarding the predominant size class of the wood used – mainly hop-hornbeam (*Ostrya carpinifolia*) and deciduous oak (*Quercus* sp.) – assessed based on the degree of curvature of the annual growth rings in the charred wood, it has been observed that the harvested specimens generally favoured branches, with 80-90% of the samples corresponding to diameters greater than 5-10 cm. This pattern suggests a deliberate selection of woody material of medium size, suitable for domestic fuel use and potentially for simple construction purposes, rather than the exploitation of large timber resources (Théry-Parisot *et al*., 2010).

The archaeobotanical data from Rio Tana fit well in the wider picture obtained from the Impressed Ware groups of the western Mediterranean area (first half of the VI millennium BC). The central-southern area of the Italian peninsula exhibits a notable homogeneity in the composition of the "crop package" and the structure of the farming economy during the Neolithic period. Emmer, einkorn, and barley consistently emerge as the dominant cereals across most of the archaeological sites belonging to the first half of the 6th millennium BC, such as Pulo di Molfetta (Apulia, Fiorentino, 2002; Primavera & Fiorentino, 2011) Rendina (Apulia, Follieri, 1977-82), Torre Sabea (Apulia, Marinval, 2003; Costantini *et al*., 2003), Coppa Nevigata (Apulia, Costantini & Stancanelli, 1994), Ripatetta (Apulia, Costantini & Tozzi, 1987) Passo di Corvo (Follieri, 1973), La Marmotta (Latium, Rottoli, 1993), and Grotta dell'Uzzo (Sicily, Costantini, 1981; Costantini *et al*., 1987). This pattern reflects a reliance on hardy cereal crops well-suited to the Mediterranean environment, characterised by seasonal rainfall and varied topography.

Naked grains (*Triticum aestivum/durum*) are quantitatively rare but frequently present within the cultivated package, as evidenced by the finds at Rio Tana, as well as in the earlier villages of the southern area, such as Torre Sabea, Rendina, Fontanelle (Coppola & Costantini, 1987) and Passo di Corvo. Naked barley is also recorded in Rendina and San Marco di Gubbio in Umbria. This suggests that the "crop package" brought by the settlers was diverse from the outset, as evidenced at Rio Tana and at the other early Neolithic sites mentioned above, and that the decision to focus on the trio of emmer, einkorn and barley was more likely influenced by cultural traditions and deliberate choices (Cipolloni Sampò, 2002).

In addition to cereals, cultivated pulses such as lentils and bitter vetch often complemented the agricultural system, providing essential elements to enrich the soil.

Data suggest that these early farming communities adopted small-scale mixed cropping strategies, balancing the cultivation of cereals with that of legumes and the maintenance of food-producing trees. In Rio Tana, *Prunus* sp. and *Cornus mas* have been recorded, but the gathering of wild fruits is documented in many sites. Among the remains identified at La Marmotta, currently the most complete and diverse archaeobotanical record of the Italian Neolithic, are numerous fruit species, including hazelnut (*Corylus avellana*), wild apple (*Malus* sp.), wild grape (*Vitis vinifera* subsp. *sylvestris*), blackthorn (*Prunus spinosa*), elderberry (*Sambucus* sp.), oak acorn (*Quercus* sp.), and fig (*Ficus carica*) (Rottoli, 2000-2001). These findings, together with evidence of strawberry trees (*Arbutus unedo*: Grotta dell'Uzzo), Cornelian cherries (*Cornus mas*), wild plums (*Prunus insititia*: S. Marco di Gubbio, Malone & Stoddart, 1992), and wild olive tree (*Olea europaea* var. *sylvestris*: Torre Canne in Apulia, Castelletti *et al*., 1987, and Grotta dell'Uzzo), although not always present and varying in quantity from site to site, testify to the extensive exploitation of the land surrounding the villages and a sophisticated mastery of agricultural practices.

Throughout the Neolithic period, the farming strategies of the human groups inhabiting the central-southern part of the Italian peninsula remained largely consistent. This stability is evident despite the gradual introduction of new species and a slight increase in the prevalence of naked grains. This is supported by archaeobotanical data from sites chronologically dated to between the second half of the 6th millennium BC and the beginning of the 5th millennium BC. Key sites include: Podere Casanuova (Cellai Ciuffi & Paoli, 1984) and Cava Barbieri, (Castelletti, 1976; Bellini *et al*., 2008) in Tuscany; Catignano in Abruzzo; Quadrato di Torre Spaccata in Latium (Celant *et al*., 1996), and other sites such as Passo di Corvo (Tiné, 1983) in Apulia, Capo Alfiere (Costantini & Costantini Biasini, 2010) in Basilicata, Grotta dell'Uzzo (from more recent stratigraphic levels), and Cala Colombo (Castelletti *et al*., 1987).

The anthracological assemblage from Rio Tana, dominated by *Ostrya carpinifolia* and deciduous oaks, finds close parallels in Early and Middle Neolithic contexts across central and southern Italy. Similar woodland compositions, combining deciduous and thermophilous taxa such as *Quercus*, *Olea*, *Pistacia*, *Phillyrea*, and *Arbutus unedo*, are documented at Catignano in Abruzzo (Costantini & Tozzi, 1983), Quadrato di Torre Spaccata in Latium (Celant *et al*., 1996), and several Sardinian Middle Neolithic sites, including Su Mulinu Mannu (Ucchesu *et al*., 2017). The recurrent exploitation of these taxa, well adapted to xeric and hilly Mediterranean environments, indicates that Neolithic communities across the peninsula relied on locally available mixed oak and hop-hornbeam woodlands for fuel, building activities, and limited deforestation. Comparable management of woodland resources is also documented at Coppa Nevigata in Apulia, where anthracological and pollen data point to thermophilous and riparian formations with *Quercus*, *Olea*, *Pistacia*, and *Fraxinus ornus* (Di Rita *et al*., 2011), and along the Adriatic coasts of Friuli and Dalmatia, characterised by mixed forests with *Quercus*, *Ostrya*, *Fraxinus ornus*, and *Corylus* (Reed & Rottoli, 2014). Collectively, these datasets reflect a stable pattern of forest use and progressive landscape opening accompanying the spread of early farming throughout the Mediterranean basin.

Conclusions

The archaeobotanical analysis at Rio Tana provides a significant contribution to the understanding of the agricultural practices and environmental adaptations among Neolithic communities in central-southern Italy. The dominance of emmer (*Triticum dicoccum*), einkorn (*Triticum monococcum*), and barley (*Hordeum vulgare*) within the crop assemblage reflects broader patterns observed across Mediterranean Neolithic sites, such as Pont-de-Roque Haut, Peiro Seignado in southern France, La Draga in north-eastern Spain and La Marmotta in the Tyrrhenian area (Rottoli, 1993; Bouby *et al*., 2020; de Vareilles *et al*., 2020; Rottoli & Arranz, 2023), highlighting a reliance on resilient cereal crops well suited to the region's variable climate and topography. The presence of naked wheat (*Triticum aestivum/durum*) and other secondary species, albeit in smaller quantities, suggests a diversified "crop package" introduced by early settlers and gradually adapted to local conditions.

The evidence for wild fruit gathering underlines the dual reliance on cultivation and the exploitation of wild resources in early agricultural economies. This balance between foraging and farming persisted throughout the Neolithic.

Anthracological data reveal a landscape characterised by mesophilous deciduous forest with thermophilous and xerophilous woodlands and sparse clearings. These findings suggest active forest management, including deforestation for agriculture and selective wood harvesting for fuel and construction, with deliberate selection of specific resources for long-term use.

Despite regional variations and the gradual introduction of new species, the stability of agricultural practices across the central and southern Italian peninsula during the Neolithic period indicates a high level of expertise in land management and crop selection. These strategies were shaped by environmental constraints, cultural traditions and adaptive decision-making processes. Data from sites such as Rio Tana contribute to a more detailed understanding of Neolithic lifeways

in the western Mediterranean, highlighting the importance of interdisciplinary approaches to reconstructing ancient human-environment interactions.

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Conflict of interest statement

The Authors declare that they have no conflict of interest nor known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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