



The research potential of wood and other plant remains in burial contexts with dry soil conditions: Case studies from Bulgaria

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ABSTRACT

Burial context in regions with predominantly dry soil conditions are often challenging for standard archaeobotanical studies. Although plant remains can be preserved in structures with dry, anoxic conditions (desiccation) or when metal objects and their corrosion products (mineralisation) are present, they were often overlooked and their study neglected.

This paper considers case studies from 30 ancient necropolises from the territory of modern-day Bulgaria to illustrate the possibilities and limitations inherent in the sampling and analysis of plant remains that have been preserved by a mechanism other than charring. Among the plant remains wood was the most common finding in burial structures used as construction material, for coffins, or belonging to different grave offerings placed in the graves – mostly parts of armament or other wooden objects. In some cases, fruits (*Amygdalus communis*, *Corylus avellana*), flowers like *Rosa* sp. and plant fibres/textiles were attested. With this overview, we aim to increase awareness of this often-neglected source of abundant information, and strongly suggest more careful sampling and documentation of such organic matter. The paper thus provides examples of strategies for obtaining rich information regarding the role of plants and their products in ancient burial practices, as well as the depositional conditions related to these finds.

1. Introduction

Plant remains are frequently found in ritual contexts. Their occurrence usually reflects the importance and symbolic meaning of plants and their products in rituals (Hansson & Heiss 2014). When uncovered and identified, wood and other plant remains provide information that can be used to interpret ancient cults and religious systems, but also the land use practices as well as long-distance transport of timber (Million et al. 2018). Burials are closed structures and one of the most common types of ritual context and reveal details of the ritual practices of a particular period of time and locality. In temperate or subtropical regions with dry soil conditions and changing humidity and temperature, the predominant mechanism of the preservation of plant remains in archaeological layers is charring. In such regions, archaeobotanical studies often use charred plant remains as a main source of information regarding rituals (Megaloudi 2005; Hansson & Heiss 2014) and burial contexts, i.e. cremations (Preiss et al. 2005; Hristova 2015; Popova

2018). However, when such remains are carefully sampled, desiccated or mineralised plant macro-remains as well as micro remains like, pollen and phytoliths (Out et al. 2022) can also be found. For pollen this is especially common for burial contexts where anoxic conditions occur (Kvavadze et al. 2008) or organic matter has come into contact with metals (e.g. copper, bronze, iron) and their corrosion products (Rösch 1999; Peška et al. 2006; Haneca et al. 2012; Hristova et al. 2024). Desiccation appears in tombs and cist/stone/brick graves, where very dry conditions with limited or extremely low oxygen supply keep low moisture levels, making it difficult for the bacteria responsible for organic decomposition to survive (Jacomet 2007). Moreover, when the organic matter is in contact with corroding metal, a corrosion layer covers or replaces the organic remain and forms either a negative imprint or replacement of the tissues. When copper is present the copper oxides inhibit bacterial decay and can result in preservation of the organic tissue itself, while iron cannot prevent the bacterial attack but its corrosion product covers the organic matter (Tegel et al. 2016;

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Haneca & Deforce 2020).

Thus, in burial contexts with dry soil conditions, mechanisms of organic preservation other than charring (i.e. by cremation) can significantly contribute to our understanding of burial rituals and provide information regarding the surrounding environment. A condition for this is, of course, an awareness of these sources of information, so that the plant remains that are present can be recognised and appropriately sampled.

Therefore, the current paper focuses on burial structures from intermediately dry sediment environments (*sensu* Fig. 2 in Campbell et al. 2011) that have yielded plant remains with preservation mechanisms other than charring. The specific examples come from the territory of modern-day Bulgaria (Fig. 1), and here we review their potential as sources of archaeobotanical information. The detailed analysis of organic remains from such contexts could be an important source for the further archaeological interpretation of the artefacts (Huisman 2009). Identifying the mechanisms behind the preservation of organic matter within those sites will help to build proper sampling strategies, especially when working with inhumations and such that contain metal objects. At the same time, the obtained results will enlarge our understanding of religious practices and the role of plants in these.

2. Archaeological settings

This paper includes information from 30 ancient burial sites situated in the modern territory of Bulgaria (Fig. 1, Supplementary material 1, Table 1), dated to a period extending from the late sixth century BC to fifth century AD. The only exception is the Varna Eneolithic Necropolis, which belongs to the Chalcolithic Varna culture and functioned between 4590 and 4340 cal BC (Higham et al. 2018). The sites were chosen because desiccated and/or mineralised (via metal corrosion) plant remains were uncovered at them. Most of the burials are inhumations, but several cremations were also included. Tumuli and flat necropolises with various grave structures (pits with or without construction, cists, wooden/stone sarcophagi, and tombs) are considered (Table 1). Most of the studied grave structures are rich in archaeological artefacts including metal and ceramic vessels, armament, jewellery, etc. (Supplementary material 1).

3. Material and methods

The study is based on examples from previously published data of plant remains found in dry-soil preservation environment (Table 1). The material considered consists of wood and other macro (including seeds/fruits, stems, textiles/fabrics with plant origin) and micro (pollen) plant remains, preserved either by the corrosion of metal objects or due to dry conditions in environments with extremely low oxygen supply, such as tombs and cist/stone graves. As the main emphasis is on possible mechanisms for preservation of non-charred plant matter in intermediately dry soil conditions, the current study does not discuss carbonised plant remains, even where these were found in the studied sites. However, cremation graves were included, but only if they contained plant remains other than those involved in the pyre. Thus, the included here plant remains were not exposed to heat (i.e. charring), and instead were added later as funerary offerings or were part of the grave construction. Special attention was paid to tumular necropolises on one hand, and tombs inside or outside tumuli, cist graves, stone/brick constructed graves, and stone sarcophagi on the other. All these types of burial structures create an environment that reduces the oxygen supply and result in dry conditions, facilitating the preservation of desiccated plant remains. The presence of metal artefacts offers another means of organic preservation, and such graves were considered with caution.

4. Results and discussion

4.1. Preservation of plant material

The most common type of plant remains found was wood (Table 2, Fig. 2, Fig. 3 a-c, e). This observation can be explained by its more robust structure compared to other plant parts, such as fruits, seeds, flowers, pollen, etc. Additionally, wood was more widely used as material (e.g. construction, furniture, objects, etc.) in the burials compared to other plant categories.

The review of the organic finds in burials with dry soil conditions clearly shows that an important prerequisite for plant preservation is the presence of a tumulus (Table 1). Grave structures covered with heaps of stone and an earth embankment, such as Pet mogili (Ignatov & Ivanov 2020), Malomirovo-Zlatinitsa (Agre 2011), and Belishka chuka (Tonkova 2016), create the necessary conditions for organic preservation by limiting the oxygen supply and fluctuations in humidity. Certain grave structures, such as tombs, stone sarcophagi, and cist graves, decrease the oxygen supply and humidity, contributing to organic preservation in both tumular and flat cemeteries (Table 1).

In simple burial pits without a burial mound, the likelihood of plant/organic preservation seems to be relatively limited, and this is confirmed by the fact that the published data on such examples is only sporadic. Another condition of organic preservation, independent of the grave structure and type of necropolis (tumular or flat), is the presence of metal objects such as bronze and iron. When metal objects are present in a grave, the probability of organic preservation in the proximity of such objects increases (Hristova et al. 2024). Examples include ones from the Varna Eneolithic necropolis, the ancient necropolis of Messambria (Hristova et al. 2024), Kitova mogila (Andonova et al. 2023) and others (Supplementary file 1). There are sites where both type of preservation are attested in one and the same grave structure: due to the specific anaerobic conditions and the contact with metals, like in Pet mogili (Ignatov and Ivanov 2020) and Malomirovo-Zlatinitsa (Agre 2011). Moreover, the products of metal corrosion not only create favourable conditions for plant macrofossil conservation but facilitate pollen preservation (Hristova et al. 2024). Pollen finds can also be expected in well-isolated burial structures such as the brick-made grave covered by stone slabs in the St. Sofia Basilica (Marinova 1998), where anoxic conditions occurred.

4.2. Functions and uses of wood and other plant remains in the burial context

The variety of not-charred plant remains found in burials reflect their different functions and uses (Table 2). As wood is the most commonly preserved type of plant material, the existing evidence is informative primarily regarding its role and function in burials. Wood is often used as either the main or a supporting construction material (Table 2, Supplementary material 1), as in the cases of Mogilanskata mogila (Torbov 2005) and Mezek (Filov 1937). Very often it is part of the roof structure: wood was used for beams to cover graves at Duvanli (Filov 1934), and to support stone/brick roofs at Kaloyanovo (Chichikova 1969) and Chatalka (Bujukliev 1986). Wood was also used for the doors of tombs, for example at Dolno Izvorovo (Nekhrizov & Parvin 2011). Generally, species identification has rarely been performed, but from the available data it can be concluded that the wood of oak (*Quercus* sp.) was most common taxa used as construction material (Fig. 4).

Concerning funerary furniture, it is usually the decoration and structure that are studied (Grudeva 2018), and very little effort is put on species identification. From the few examples, we can see a diversity in the wood used for furniture (Fig. 4): ash (*Fraxinus* sp.) used for the funerary bed at Lozarskata mogila (Filov 1934); coniferous wood for

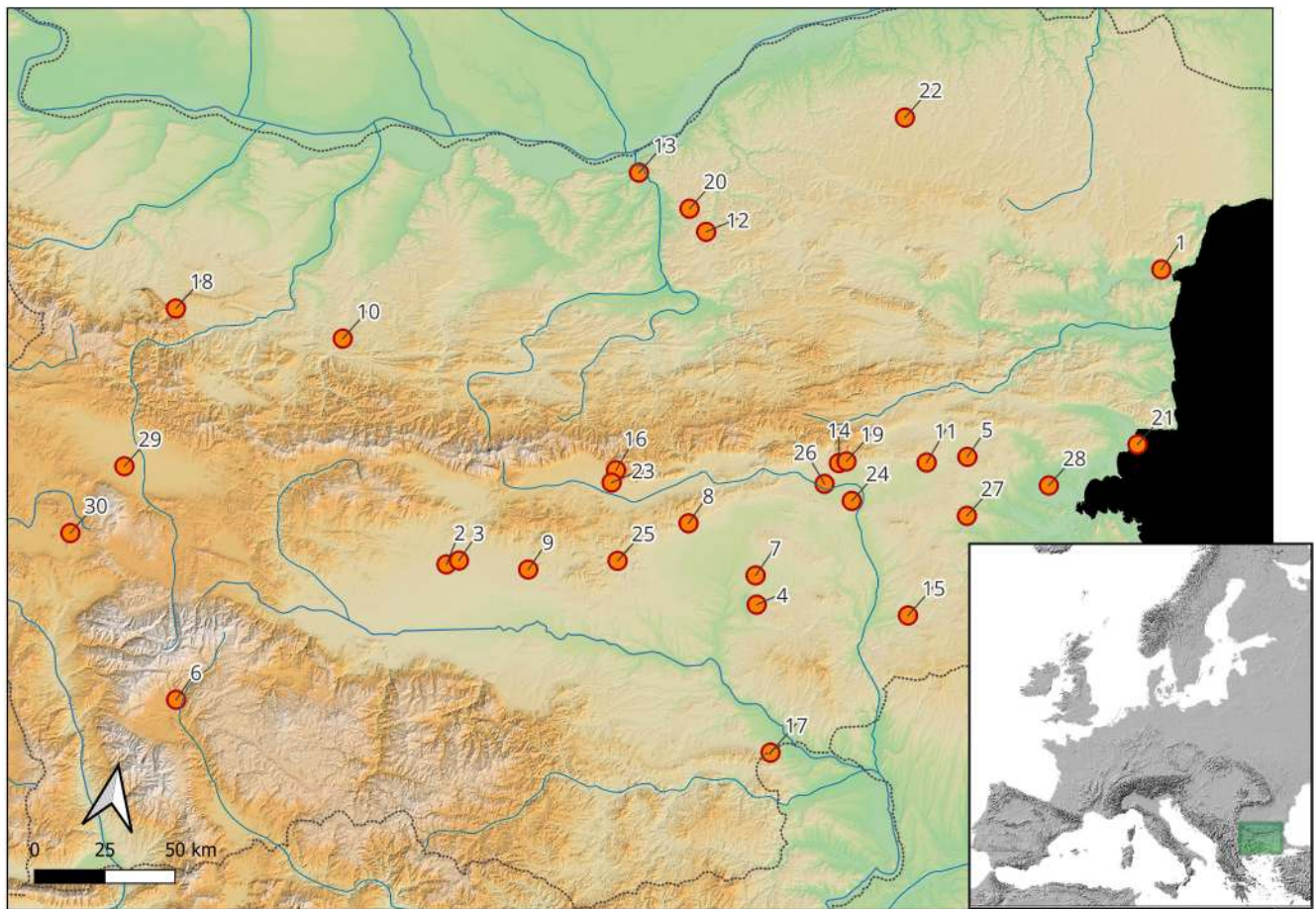


Fig. 1. Map of the study area. The numbers correspond to the site numbers in Table 1.

stool legs and beech (*Fagus* sp.) for the wooden strips of the stool at Belishka chuka (Popova 2008); and pearwood (*Pyrus* sp.¹) for a stool at Ginina mogila (Chichikova et al. 2012). Several cases exist where pieces of wood were found that most likely came from a piece of furniture but were either fragmented or for another reason not prioritised and were thus not further investigated (Table 2, Supplementary material 1).

It is often the case that the remains of wooden coffins were registered, but species identification was performed only sporadically (Table 2 and Fig. 4). Usually, this was done when the preservation of the wood material was comparatively good, and more or less recognisable whole objects were found. Coffins are often made of oak (Fig. 4), such as the examples from Pet mogili (Ignatov & Ivanov 2020). Other examples of wood materials that were preferably used for coffins include local and imported conifers, which give additional insights regarding the diversity of species used for that purpose: the coffin at Belishka chuka was made of Macedonian/Bosnian pine (*Pinus peuce/heldreichii*; Tonkova 2016), the one at Messambria was made of cedar (*Cedrus libani*; Hristova 2015), the one at Burgas was made of European yew (*Taxus baccata*; Mihailov et al. 1976), and the four coffins at Staro selo were made of pine (*Pinus* sp.; Nekhrizov & Todorova 2008).

Other wooden objects found often in graves include spear and arrow shafts (Fig. 3 c), wooden boxes, sword scabbard, and the handles of axes. Again, species identification is rare for such objects, although the available evidence shows the diversity of wood used. Moreover, there are some hints regarding preferences of certain species for some objects (Fig. 4): ash was often used for arrow shafts, like at Pet mogili (Ignatov &

Ivanov 2020) and Tash Bair (Hristova 2022), though oak was preferred at Chervenkovite mogili at Brezovo (Velkov 1934) for the same purpose. Similarly, pine was chosen for funerary wreaths at Messambria (Hristova et al. 2024). Data on the wooden part of spear shafts is available for example from Tash Bair, Dolno Izvorovo, Pet mogili, Dalboki, Kaloyanovo, and Burgas (Table 2, Supplementary material 1). Species identification of spear shafts was performed only at Dolno Izvorovo, where guelder rose (*Viburnum* sp.) was used (Hristova 2015) and Tash Bair, where hazel (*Corylus* sp.) was identified but the fragments were found around the spear heads and not directly coming from their openings (Hristova 2022). Evidence for handles of copper axes is available from Varna Eneolithic Necropolis, where cornel (*Cornus* sp.) and guelder rose were used (Hristova et al. 2024). The data on species identification is still very fragmented and does not allow clear patterns regarding the different uses of types of wood to be traced, nor comparison between different periods and regions to be made.

Plant parts other than wood have also been found as funerary offerings, although if they are not charred their preservation is much less probable; this is particularly the case for parts with finer textures, and such remains are rarely recorded. Contact with metal objects increases the probability of preservation in such cases. Examples include the hazel and almond nuts from the ancient necropolis of Messambria, where the almonds were spectacularly arranged on strigillas, suggesting a specific funerary ritual (Hristova et al. 2024). Close to the arrowheads at Tash Bair, the fruits of bulrush (*Typha* sp.) were identified and were either part of the quiver or used as padding inside (Fig. 3 d).

The presence of flowers has been attested in several cases. The buds and flowers of dog roses (*Rosa* sp.) were found in a brick-constructed grave at the St. Sofia Basilica (Marinova 1998). Additional proof of the presence of flowers was the numerous Rosaceae pollen grains, some

¹ The identification of the wood taxa is based on previously published data (Chichikova et al. 2012).

Table 1

Chronology, burial type and burial ritual (c – cremation and i – inhumation) for the sites shown in Fig. 1.

Nr. at Fig. 1	Abre- viation	Name	Chronological attribution	Burial ritual	Type of burial	tumular (x) or flat (o) necro-polis	References
1	VEN	Varna Eneolithic Necropolis	second half 5th millennium BC	i	simple pit	o	Hristova et al. 2024; Higham et al. 2018
2	D (M)	Duvanli (Mushovitsa)	end 6th – start 5th c. BC	i	simple pit	x	Filov 1934
2	D (LM)	Duvanli (Lozarskata mogila)	first half of 5th c. BC	c	stone sarcophagus	x	Filov 1934
2	D (AM)	Duvanli (Arabadjiskata mogila)	end of 5c. BC	i	simple pit	x	Filov 1934
2	D (BM)	Duvanli (Bashova mogila)	end 5th – start 4th c. BC	c	stone constructed	x	Filov 1934
3	Ch	Chernozem	6th-4th c. BC	i	simple pit	x	Kisyov 2002; Kisyov 2003
4	Ovch	Ovcharts	end 6th /start 5th c. BC	c	simple pit	x	Kalchev 1994; Tonkova, Savatinov 2001
5	Chat	Chatalevo	6th/start 5th c. BC	i	simple pit	x	Georgieva et al. 2008a
6	Be	Belishka chuka	second half 5th c. BC	i?	cist, stone&earth embankment	x	Tonkova 2016; Popova 2008
7	PM	Pet mogili	mid 3rd/4th to 5th c. BC	c	simple pit, stone&earth embankm.	x	Ignatov and Ivanov 2020
8	Dal	Dalboki	second half 5th c. BC	i	stone tomb	o	Filov 1930–1931
9	Br	Brezovo (Chervenkovite mogili)	second half 5th c. BC	i	stone/cist	x	Velkov 1934
10	T	Toros	5th c. BC	i	stone constructed	x	Velkov, 1938; Teleaga, 2015
11	TM	Tonchova mogila	5th c. BC	c	simple pit, covered by stones	x	Georgieva et al. 2008b
12	Kop	Koprivets	6th c. BC	i	wooden tomb	x	Stanchev 1994
13	TB	Tash Bair	end 5th c./first half 4th c. BC	c	stone tomb	o	Ivanov et al. in press; Hristova 2022
14	DM	Dalakova mogila	first quarter 4th c. BC	i	wooden tomb	x	Kitov 2008
15	M–Z	Malomirovo-Zlatinitsa	mid 4th c. B.C.	i	simple pit, stone&earth embankm.	x	Agre 2011; Kirilov 2011; Nikolova 2008
16	DI	Dolno Izvorovo	end 4th c. BC	i	stone tomb	x	Nehrizov, Parvin 2011; Hristova 2015
17	Me	Mezek	4th c. BC	c&i	stone tomb	x	Filov 1937
18	MM	Mogilanskata Mogila	4th c. BC	i	wooden tombs	x	Torbov 2005
19	Kal	Kaloyanovo	4th c. BC	i	stone tomb	x	Chichikova 1969
20	Bor	Borovo	4th c. BC	i	stone tomb	x	Stanchev 1994
21	M	Messambria	4th – 2nd c. BC	i&c	simple pit & cists	o	Hristova et al. 2024; Bozkova et al. 2011
22	GM	Ginina mogila	end first quarter 3rd c. BC	i	stone tomb	x	Chichikova et al. 2012
23	KT	Kazanlak tomb	second quarter 3rd c. BC	i	brick tomb	x	Parvin 2015
24	K	Kabyle	3rd c BC	i	simple pit	x	Getov 1991
25	Chatalka	Chatalka	1st- start 3rd c AD	c	stone sarcophagus/simple pit/brick constr.	x	Bujukliev 1986
26	KM	Kitova mogila	2nd c./first half 3rd c. AD	i	stone constructed	x	Andonova et al. 2023
27	Z	Zhitosvyat	2nd c. AD	c	simple pit	x	Georgieva, Momchilov 2000; Popova 2002
28	Bu	Burgas	mid 2nd c. AD	i	stone sarcophagus	x	Karaiotov 1976; Mihailov et al. 1976
29	S	St. Sofia basilica	2nd-4th c. AD	i	brick grave, plain stone cover	o	Shalganov 2005; Marinova 1998
30	SS	Staro Selo	end 4th – 5th c. AD	i	tomb of stones & bricks	o	Nehrizov, Todorova 2008

in the form of tetrads, in the same grave (Marinova 1998). Larger groups of *Vitis*, *Rosaceae/Cistus*, and *Fabaceae* pollen were identified in graves at the ancient necropolis of Messambria, indicating the use of flowers or twigs in burial rituals (Hristova et al. 2024). Vines are symbolically associated with the cult of Dionysus, and vine twigs were registered at several burial sites in the modern territory of Bulgaria. Some were found in a charred state, but still, their presence confirms their symbolic meaning (Popova 2002; Bujukliev 1986; Theodossiev & Manov 1993). *Daphne* pollen was registered in one of the graves at the Varna Eneolithic necropolis. *Daphne mezereum* was used as a medicinal plant in folk medicine (Moshiashvili et al. 2020), and has beautiful, light purple, strongly scented flowers. Given its flower morphology and possible medicinal uses, it is assumed that this plant was intentionally placed during a burial ritual (Hristova et al. 2024). Stalks of horse-tail

(*Equisetum* sp.) and thyme (*Thymus* sp.) were registered in a grave from Zitosvyat (Tab. 2; Popova 2002), and their presence has been connected with their medical properties (Georgieva & Momchilov 2000).

Textiles/fibres and matting are often observed and mentioned by archaeologists in their reports, but precise identification is rarely carried out (Tab. 2 and 3; Dimova 2018). The current paper does not focus on this type of remains, as their origin is not always vegetal. Nevertheless, there are several examples of plant-based fibres/tissues being registered (Fig. 3 e-h), including imprints of rush (*Juncus* spp.) stem in Varna, likely from matting, and in Messambria, where plant fibres were used in funerary wreaths (Fig. 3 e and h; Hristova et al. 2024). Matting made of spiny rush (*Juncus acutus*) was found close to the feet of the deceased at Kitova mogila (Fig. 3 f; Andonova et al. 2023), hemp textiles were

Identification and type of use of plant material found in the burial contexts discussed in the paper (x = presence, b = bed, s = stool).

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identified at Zhitosvyat (Popova 2002) and Malomirovo-Zlatinitsa (Nikolova 2008), and flax textiles were found at Burgas (Mihailov et al. 1976).

4.3. Information on local vegetation and imported plant materials

The finds and identification of wood and other plant remains provide information about local vegetation and its uses, along with the utilization of possibly imported plants. Oak wood is rather common, reflecting its abundance in the study area. Different oak species are dominating the natural forests in the lowlands up to 600 m above sea level (Bohn et al. 2003), where most of the study sites are situated. Findings of *Pinus peuce/heldreichii* also reflect the potential natural vegetation near the site of Belishka chuka, situated at ca. 850 m above sea level on the southern side of the Rila mountain range, where *Pinus peuce* naturally grows, and ca. 17 km from the northern side of the Pirin mountain range, where the Balkan endemic *Pinus herldreichii* grows together with *P. peuce*. The discovery of *Taxus*, which is very rare today in the natural vegetation of the study area (mainly existing in mountain areas), suggests its possible import to the site of Burgas, but could also reflect its wider spreading in the past. The closest modern populations of European yew are ca. 40–50 km to the south, but it is possible that the tree had a much wider distribution in the past that has been subsequently reduced due to anthropogenic degradation of the forests. *Taxus* is a coniferous tree valued for the durability and elasticity of its wood, and for which autochthonous populations have become rare and endangered in many European countries following a long history of human overexploitation (Uzquiano et al. 2015). Of interest is a cedar coffin found in Messambria (Fig. 2 b-c; Hristova 2015). Representatives of the genus *Cedrus* are unable to grow on the territory of Bulgaria, but further south, in the mountain ranges of Southwestern Anatolia and the Levant, which implies that the wood was imported. This demonstrates that trade relations existed with the Eastern Mediterranean in Hellenistic times. Furthermore, its presence leads to interpretations related to the possible higher social status of the deceased.

Almonds placed in Messambrian graves pose the question of the cultivation of this plant in the surrounding area. Almond fruits were commonly used in the Eastern Mediterranean during Hellenistic times (Zohary et al. 2012) but are also easily stored and transported. The scarcity of almonds outside of funerary contexts (Hristova 2015) suggests that they were not cultivated in the study area and were an imported good with a special ritual function. However, the presence of twigs of *Vitis vinifera* in the necropolises of Zitosvyat, Chatalka, and Dragodan, dated to the first to third century AD (Popova 2002; Bujukliev 1986; Theodossiev & Manov 1993), likely reflect the vine growing in the study area, which was established already during the Hellenistic period. Moreover, the long-distance transportation of vine twigs is not as realistic as that of its valued, sugar-rich fruits.

Many of the identified plants originate from open vegetation, suggesting the diversity of the land cover at the forest edges and in less dense woodland; these include *Cornus*, *Corylus*, *Pyrus*, and *Viburnum*. Other species, such as *Juniperus*, *Rosa*, and *Thymus*, indicate open, most probably secondary vegetation, the development of which allowed a much wider distribution of light-demanding plants.

Finally, the diversity of plant materials originating from the wetland zones, such as *Equisetum* sp., *Juncus* sp., *Typha* sp., and *Phragmites* sp., points to the use and accessibility of such zones in the area around the studied sites.

4.4. Suggestions for archaeological practice

The temperate climatic conditions that dominate the territory of Bulgaria and connected with them intermediately dry sediments are not

favourable for organic preservation via a mechanism other than charring. Nevertheless, in cases where specific archaeological structures create environments with low oxygen supply and consistently low humidity, and/or the organic material comes into contact with metals or their corrosion products, desiccated – subfossil or mineralised preservation can occur. It is quite easy to overlook such botanical/organic material, especially if they are desiccated, as the plant matter is usually extremely fragile and can be easily destroyed. For this reason, structures that can facilitate organic preservation, such as tumular necropolises, tombs and cist/stone/brick graves, should be very carefully approached during excavations. When they are established, organic findings must be documented well in-situ, ideally be uncovered together with a portion of the surrounding sediment for stabilisation, and finally be secured adequately for transportation and future analysis. A recommended approach would be to excavate and sample the complete organic structure in a block (or several smaller blocks), thus securing its transfer to a laboratory where the conditions for adequate analysis exist. The study and documentation of organic finds in laboratory conditions facilitates species identification, which is not possible when finds stay in the field and are exposed to fluctuating atmospheric conditions such as the heat of the sun and changing humidity, which cause rapid disintegration of the preserved materials. Therefore, prompt but careful sampling combined with gentle treatment of organic findings is crucial to maximising the information that can be gained from their study.

Flotation extraction is a common method in archaeobotanical studies but should be avoided for desiccated material preserved in such intermediately dry sediments, as the organic matter is destroyed by contact with water. Instead, close observation of the sediment with a magnifying glass is recommended, followed by gentle brushing and dry sieving with a set of nested, preferably plastic, geological sieves (with mesh sizes of 4.0, 2.0, 1.0 and 0.5 mm). If, as a result of the presence of charred material, flotation needs to be applied, parallel subsampling should be undertaken (White & Shelton 2015).

An important step in the sampling and study of organic remains preserved thanks to the contact with metals is working in cooperation with conservators who deal with metal artifacts. Observing metal patinas under low magnification can reveal imprints of organic matter, which can be documented and carefully sampled. Therefore, such surfaces should be sampled and studied in detail under a low-magnification (10–30x) microscope to allow recognising and collection of appropriate sample material. For further analysis reflected light microscopes, scanning electron microscopy, micro-computed tomography, etc. can be applied to reveal fine plant tissue and cellular structures. Furthermore, the corrosion products of metal objects lead to organic preservation, including microremains such as pollen. Therefore, homogenous patina products and the sediment around metal objects can be sampled and further processed for pollen analysis (see Hristova et al. 2024 for methodological details). It is also important to sub-sample the sediment surrounding the objects, particularly because dissolved metal salts usually prevent organic decay in a 2–10 cm radius, particularly when these salts are related to bronze and copper objects. This sampling shall be accompanied by a collection of reference sediment samples outside the burial to ensure comparison with the modern pollen rain (Dimbleby 1961).

5. Conclusions

Burials in regions with intermediately dry soil conditions are usually considered to have poor organic preservation. However, thanks to certain structures or the presence of metal grave goods creating specific preservation conditions, they still often contain archaeobotanical findings, largely wood but also other plant remains. Such findings enlarge the assemblage of funerary offerings and provide direct evidence

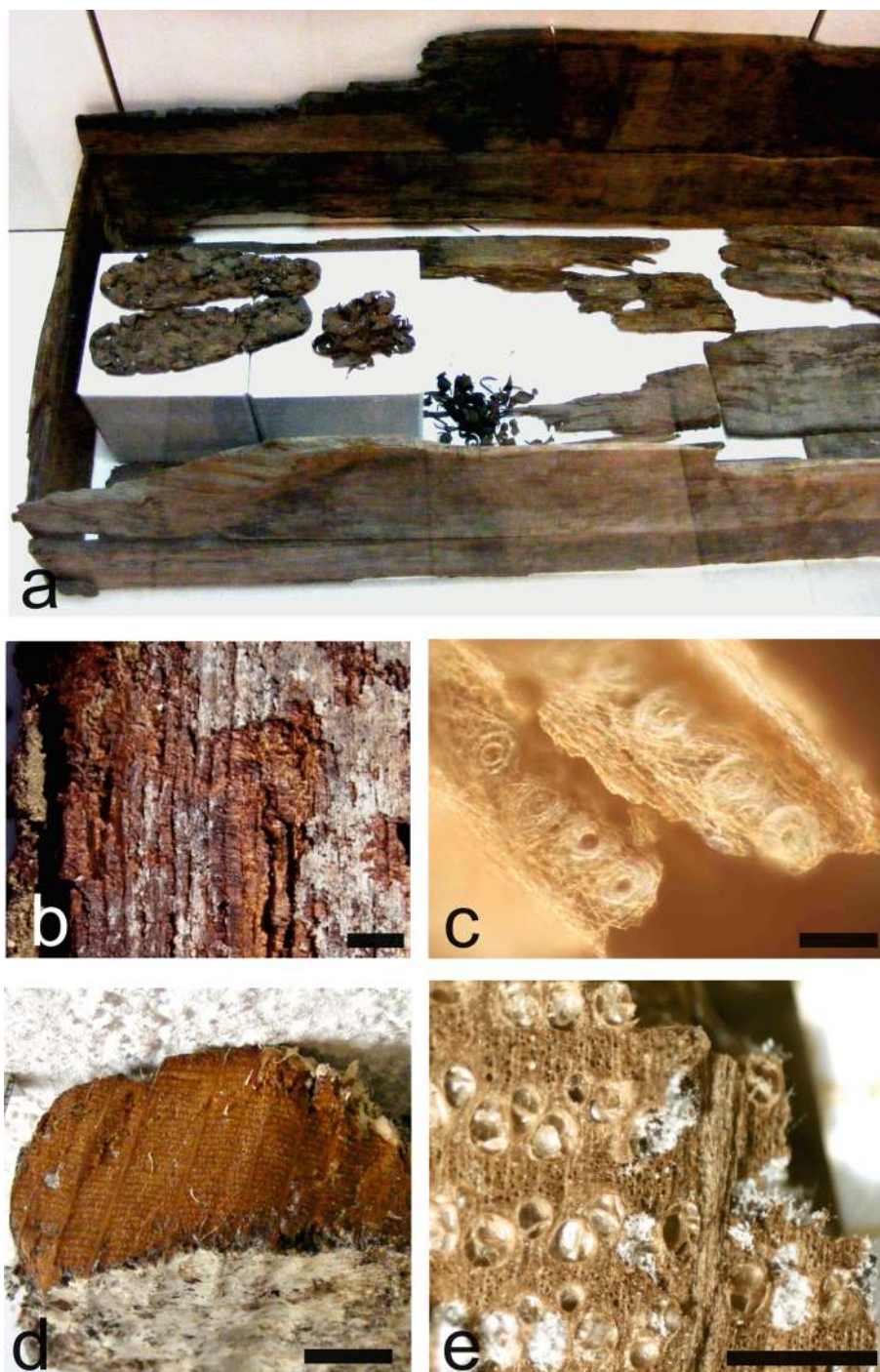


Fig. 2. Examples of preserved wooden objects: a. Burgas, remains of wooden coffin, made of European yew (*Taxus baccata*); b. & c. Ancient necropolis of Messambria, cist grave 1285, remains of wooden coffin, made of cedar (*Cedrus libani*): b. Macro image of the wood (scale 1 cm) and c. tracheids with characteristic bordered pits under reflected light microscope (scale 10 μm); d. Ancient necropolis of Messambria, oak beam, cist grave 878, possibly from coffin or funeral bed (scale 1 cm) and e. the same specimen under high magnification (scale 1 mm).

regarding the use of specific plant taxa in rituals. Therefore, such archaeobotanical finds significantly contribute to our understanding of burial rituals and reveal aspects of them not attained through other artefacts. They attest to the importance of organic grave goods, such as wooden objects, matting, products of plant origin, and flowers, all of which are perishable and routinely not detected at all.

Further, archaeobotanical study of material from closed contexts such as graves is crucial to reconstructing the vegetation and environment surrounding the burials during the corresponding historical period and providing additional information regarding trade contacts with

adjacent regions.

The present study gives insights into the potential of applying wood identification, carpological, and palynological analyses to burial contexts in regions with intermediate dry soil conditions with regard to gaining valuable information and enlarging the interpretation possibilities for both rituals and the environments around sites. It also points out the importance of planning thoroughly the sampling and handling of such finds so that the maximum from their analysis can be obtained.

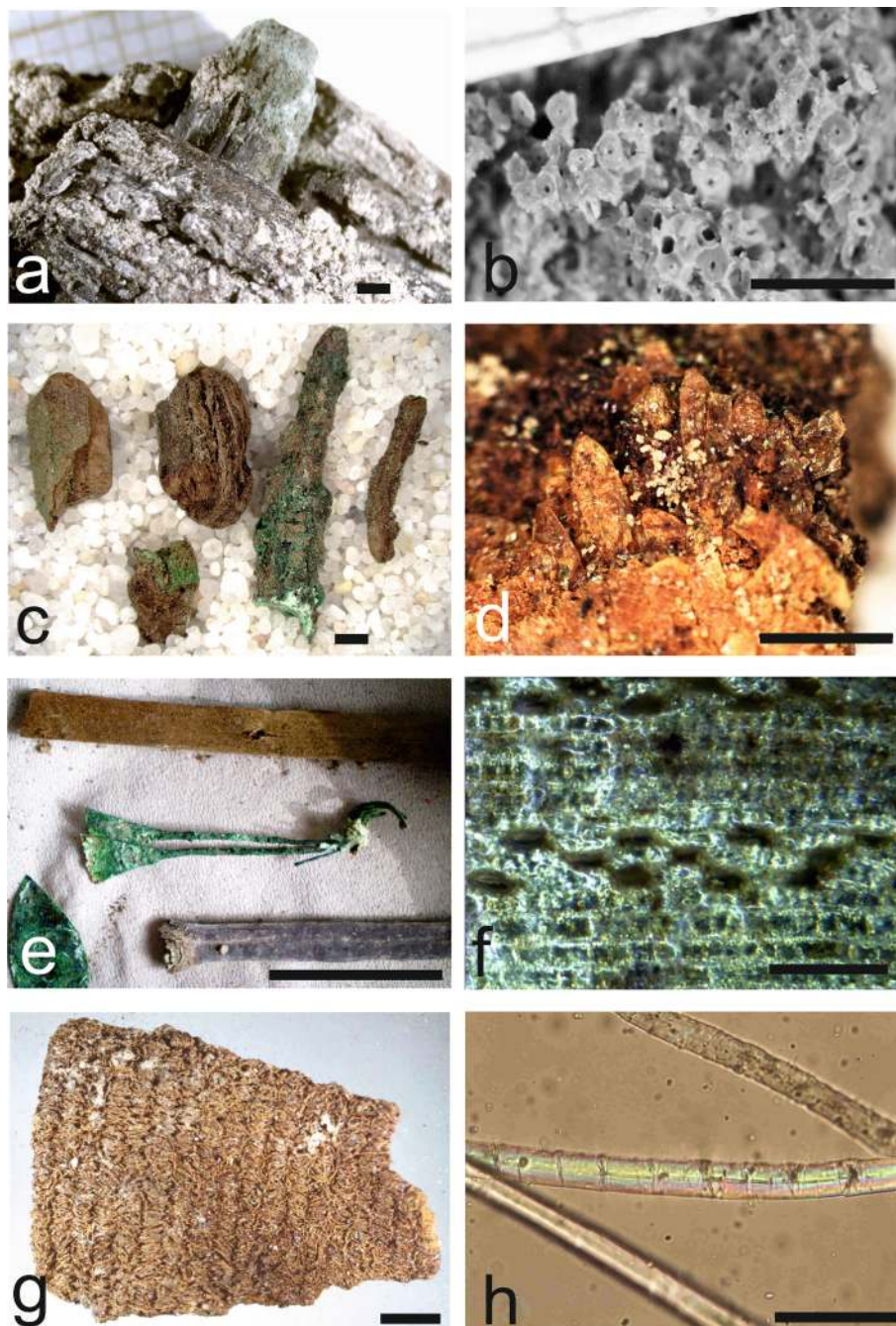


Fig. 3. Examples of grave goods made of plant materials: a. & b. Dolno Izvorovo: a. wooden object (scale 1 mm) and b. remains of unidentified wooden object, where the anatomical features of the wood are not recognisable due to mineralisation (scale 1 mm); c. & d. Tash Bair: c. arrowheads (sclae 1 mm) and d. *Typha* fruits (scale 1 mm) found around the arrowheads; e. Ancient necropolis of Messambria – funerary wreath (scale 5 cm); f. surface of matting fragment from Kitova mogila made of rush stems (*Juncus* sp.), scale 100 μ m; g. Ancient necropolis of Messambria – textile, grave 1091 (scale 1 mm); h. Ancient necropolis of Messambria – plant bast fibre, grave 1106 (scale 50 μ m).

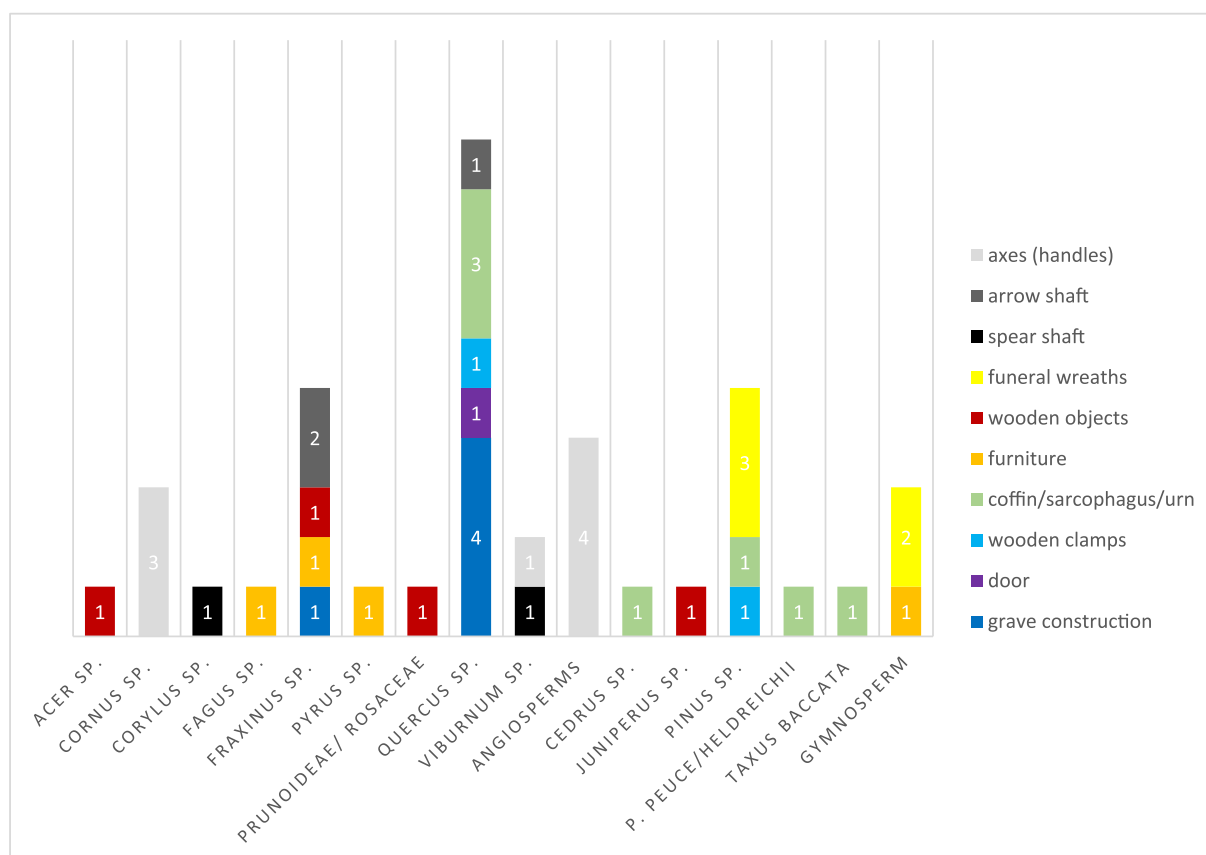


Fig. 4. Occurrence of wood taxa in correlation with the different types of wood use in the burials (number of studied graves is 44¹. (¹The number of graves differ from number of sites in Table 1 because in sites Messambria and Varna Eneolithic Necropolis more than one grave contained subfossil/mineralized plant remains (For more details see Hristova et al. 2024).

CRedit authorship contribution statement

I. Hristova: Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **E. Marinova:** Writing – review & editing, Writing – original draft, Visualization, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **J. Atanassova:** Writing – review & editing, Resources, Methodology, Investigation, Formal analysis, Conceptualization.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jasrep.2024.104835>.

Data availability

I have shared my data in the manuscript files.

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