INTEGRATED ARCHAEOBOTANICAL EVIDENCE ON THE VEGETATION RECONSTRUCTION AROUND THE TOMB OF SULTAN SULEIMAN I AT SZIGETVÁR (SW HUNGARY)

INTEGRÁLT ARCHAEOBOTANIKAI BIZONYÍTÉKOK I. SZULEJMÁN SZULTÁN SZIGETVÁRI EMLÉKHELYE KÖRÜLI NÖVÉNYZET REKONSTRUKCIÓJÁHOZ•

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Abstract

*During the archaeological excavation of the memorial place (*türbe*) of the Ottoman sultan Suleiman I, a moat was revealed north of the memorial place in 2015. The moat system was identified by boreholes and excavated in 2015, when 30–30 liter samples were taken from the 250 cm deep moat at 15 cm intervals for archaeobotanical and anthracological analyses. Samples were taken at 10 cm intervals for pollen studies from the archaeological profile of the moat filling.*

In our publication, based on the previously presented geochronological results, our aim was to reconstruct the vegetation around the memorial tomb of Suleiman, on the basis of archaeobotanical, anthracological and pollen analytical data. We were able to reconstruct ploughed lands (cereal cultivation), vegetable, fruit and vineyards, pasture lands, forest patches and trampled areas related to human activity (settlement). The military census of 1689 indicated similar tract of land structure of the crop production areas. The tomb and the Islamic pilgrimage monastery and pilgrim town (Ottoman name was Türbe kasabası*) were demolished from 1692/1693 and divided into agricultural zones, where orchards, arable lands, gardens and vineyards were established.*

Kivonat

Az I. Szulejmán ottomán szultán emlékére emelt türbét északról határoló, 2015-ben megtalált, feltöltődött árokban régészeti ásatással az egész árkot feltáró szelvényt alakítottak ki. A régészeti szelvénnyel feltárt 250 cm mély árok északkeleti falán egy földtani metszet került kialakításra, amelyből zavartalan magmintákat, 15 centiméterenként 30-30 liter üledéket emeltek ki archeobotanikai és antrakológiai vizsgálatokra, míg pollen elemzésre 10 centiméterenként.

Publikációnkban a vizsgálat célja a korábban bemutatott geokronológiai eredmények nyomán a Szulejmán-féle türbe körüli növényzet rekonstrukciója volt az archeobotanikai, antrakológiai, pollen eredmények alapján. A feltárt és azonosított növénymaradványok alapján szántóföldeket (gabonatermesztés), zöldség-, gyümölcs- és szőlőültetvényeket, legelőket, erdőfoltokat, ligeteket, és az emberi tevékenységhez (település) kapcsolódó taposott területeket tudtunk rekonstruálni. Az 1689. évi katonai összeírás hasonló növénytermesztési és a földhasználati szerkezetet mutatott. A türbét, az iszlám zarándokkolostort és zarándokvárost (oszmán nevén Türbe kasabası*) 1692/1693-tól kezdődően elbontották, és a területét új mezőgazdasági övezetekre osztották, ahol gyümölcsösöket, szántókat, kerteket és szőlőskerteket hoztak létre a 18. században.*

KEYWORDS: INTEGRATED ARCHAEOBOTANICAL ANALYSES, AGRICULTURE, HORTICULTURE, OTTOMAN TÜRBE

KULCSSZAVAK: INTEGRÁLT ARCHAEOBOTANIKAI ELEMZÉS, NÖVÉNYTERMESZTÉS, KERTKULTÚRA, OSZMÁN TÜRBE

• How to cite this paper: TORMA, A.; NÁFRÁDI, K.; TÖRŐCSIK, T. & SÜMEGI, P. (2023): Integrated archaeobotanical evidence on the vegetation reconstruction around the tomb of Sultan Suleiman I at Szigetvár (SW Hungary), *Archeometriai Műhely* **XX/3** 201–226.
doi: 10.55023/issn.1786-271X.2023-017

Introduction

One of the most dominant monarchs of the 16th century, Sultan Suleiman I died during the Ottoman siege of Szigetvár, close to the battlefield in Szigetvár – Turbék Vineyard Hill site, in the Hungarian Kingdom in 1566. On the place of Suleiman's death and his temporary burial site close to the battlefield, an Ottoman tomb and memorial place (*türbe*) were built in the second part of the 16th century (Pap et al. 2023). This memorial place was established with a new pilgrim town, the Ottoman name of which was *Türbe kasabası*, and a tomb, a mosque, a monastery, and an Ottoman cantonment. This memorial complex was surrounded by a palisade wall and a moat system (Pap et al. 2023: Figs. 1 and 2). This Ottoman memorial place and the pilgrim town were fully demolished during the Habsburg siege of Szigetvár in 1689 and the exact location disappeared with time. Based on historical written sources and archaeological excavation, the remains of the *türbe* were found by Norbert Pap and Pál Fodor in 2014. Next year a moat system was identified by boreholes by Professor Pál Sümegi and his son Balázs Pál Sümegi. After cleaning a profile in the moat, samples were taken at 15 cm and 10 cm intervals for detailed archaeobotanical, macrobotanical, and anthracological analysis. Radiocarbon analysis (Gulyás et al. 2022) was carried out on archaeobotanical remains, and the calibrated radiocarbon dates were correlated with coins and archaeological finds.

By the identification and evaluation of the macro-botanical, anthracological, and pollen remains of the Ottoman site from the 17th century, we aimed to reconstruct the land use, crop production, and eating habits of the former population, as well as their plant utilization, and compare them with written resources from the 17th century (**Table 1**).

Materials and methods

The geoarchaeological description and sampling process

Following the widely accepted historical ecological (cultural ecological) and geoarchaeological protocol (Stewart 1955; Evans 1978; Brooks 1985; DeLacy et al. 1996; Evans & O'Connor 1999; Rapp et al. 2006; Balée 2006; Roberts 2013; Szabó 2015), we cleaned the archaeological profile of the moat (Gulyás et al. 2022). The profile of the 250 cm moat was sampled at 15 cm intervals, and 30 liters per sample was taken for the archaeobotanical analysis. The upper part of the profile, from 40/45 cm towards the surface, contained construction waste and was isolated already during the field survey.

Archaeobotanical and anthracological analysis

The organic material was isolated in standard flotation equipment (Jacomet et al. 1999; Weiss & Kisley 2004) in the laboratory, to avoid recent contamination. We used a 0.4 mm diameter sieve to catch light-weight fractions such as smaller seeds (for example poppy seed), bones, and small snail shells (Atchison et al. 2005; Figueiral et al. 2010). The floated samples, both the heavy and light fractions were dried at room temperature, packed, and analysed. After the larger archaeobotanical remains visible to the naked eye were selected, the smaller ones were picked out using a binocular stereomicroscope. We used identification books, professional publications (Schermann 1966; Cappers 2006; Brecher 1960; Jacomet et al. 1999; Jacomet 2006; Nixon et al. 2011), and our recently compiled comparative material for the identification of the thousands of carpological remains (seeds/fruits).

The archaeobotanical findings were well preserved in the wet condition of the moat filling, half of the remains were carbonized, however still identifiable. Several thousands of pieces of charcoal remains were found that were analysed by an optical microscope at 10, 20 and 50 magnifications. Wood anatomical identification books (Greguss 1945, 1955; Jacquiot 1955; Schweingruber 1990; Vernet 2006), as well as our own subfossil and fossil reference collection (Náfrádi 2011) were used for the identification. We followed the work of Zohary et al. (2012) for the appellation of the scientific names of plant species. During the evaluation process, an archaeobotanical database and a palynological database (Törőcsik & Sümegi 2019) were used for the Carpathian basin for the 17th century. In this database, predominantly self-processed archaeobotanical and paleoecological sites of the 17th century were considered from the Ottoman and Habsburg Empire, the Kingdom of Hungary, and the Principality of Transylvania which was under the suzerainty of the Ottoman Empire as a semi-independent state.

Pollen analysis

The retrieved cores were also subsampled at 10-cm intervals for pollen analysis. Samples of 1 cm^3 (Berglund & Ralska-Jasiewiczowa 1986) wet sediment were prepared for pollen analysis in the pollen laboratory of the Department of Geology and Paleontology at University Szeged using standard HF methods (Faegri & Iversen 1989; Eskola et al. 2021). *Lycopodium* spore tablets of known volume were added to each sample (Stockmarr 1971) to identify pollen concentrations. A minimum count of 500 grains per sample (excluding exotics) was made to ensure a statistically treatable sample size (Maher 1981).

Table 1.: Written sources about the environment around the türbe from the 17th century (modified after Pap et al. 2015, sources: Molnár 1978; Vatin 2005; Sinan Bey oğlu eski Sadrazam Şehit Mehmet Paşa Vakfı 1574; Vass 1993; Dağlı et al. 2003; Wagner 1700; Hungarian National Archives, Urbaria et Conscriptiones, 50: 57; Hungarian National Archives, Urbaria et Conscriptiones, 136: 30; 3; Hungarian National Archives, Hoffinanz Ungarn, W2279; Szigetvár Presbytery, Prothocollum Parochia Magno Szigethana (1717-1734) No. 1774; Szigetvár Presbytery, Prothocollum Parochia Magno Szigethana (1738) No. 1774; Hungarian National Archives, Urbaria et Conscriptiones, 94: 30; 5)

1. táblázat: Írott források a türbe környezetére vonatkozóan a 17. századból (Pap et al. 2015 alapján módosítva, források: Molnár 1978; Vatin 2005; Sinan Bey oğlu eski Sadrazam Şehit Mehmet Paşa Vakfı 1574; Vass 1993; Dağlı et al. 2003; Wagner 1700; Magyar Nemzeti Levéltár, Urbaria et Conscriptiones, 50: 57; Magyar Nemzeti Levéltár, Urbaria et Conscriptiones, 136: 30; 3; Magyar Nemzeti Levéltár, Hoffinanz Ungarn, W2279; Szigetvár Plébánia, Prothocollum Parochia Magno Szigethana (1717-1734) No. 1774; Szigetvár Pébánia, Prothocollum Parochia Magno Szigethana (1738) No. 1774; Magyar Nemzeti Levéltár, Urbaria et Conscriptiones, 94: 30; 5)

Written source	Age	Location	Land use	Vegetation
Sámuel Budina	1566	Szemlőhegy	Near the vineyards	Grape
Ottoman written source	1573	Suleiman's campsite	No data	Memorial garden within fruit trees
Ottoman census (defter)	1574	Monastery for dervishes (*tekke*)	No data	Monastery garden
Ottoman census (defter)	1579	Suleiman's monastery	1 grape, 5 arable lands	Grape, cereals
Evliya (Kjátib) Çelebi	1664	Suleiman's memorial place (*türbe*)	Vineyards, orchards	Grape, cherry
Johann Christop Wagner	1685-1687	Turbe Daghi on a hill	Fortress, garden	Vineyards, orchards
Leandro Anguissola's map	1689	Suleiman's memorial place (*türbe*)	Monastery garden with palisade wall	Tracts of land within fruit trees, trees and pasturelands
Hungarian Kingdom census (*urbarium*)	1692	Turbék village, with stone chapel	Vineyards, arable lands, orchards	Grape, fruits, cereals
Hungarian Kingdom census (*urbarium*)	1692	An abandoned mosque with Suleiman's grave on the vineyard hill (Turbék)	Vineyards, orchards	Grape, fruits
Hoffinanz Ungarn	1693	Suleiman's memorial place within a tower with lead roof	No data	No data
Mars Hungaricus (*Pál Eszterházy*'s book)	1694	Ottoman memorial place (*türbe*)	Forest spots	Linden (*Tilia*)
Prothocollum	1717-1734	Turkish rampart	Vineyards, arable lands and former fortress' place	Maize (*Zea mays*), grape (*Vitis vinifera*)
Prothocollum	1738	Turkish rampart	Arable lands	Maize (*Zea mays*)
Hungarian Kingdom census (*urbarium*)	1747	Turkish rampart	Arable lands	Cereals
First Austrian map	1782	Turbék, vineyard hill	Arable lands, vineyards, forests	No data

the point count method (Clark 1982). Tablets with a known *Lycopodium* spore content (supplied by Lund University, Sweden) were added to each sample to enable the calculation of pollen concentrations and accumulation rates. The pollen types were identified and modified according to Dimbleby (1985); Moore et al. (1991), Beug (2004), Punt et al. (2003), Kozáková & Pokorny (2007), supplemented by examination of photographs in Reille (1992, 1995, 1998) and of reference material held in the Department of Geology and Paleontology at University Szeged. Percentages of terrestrial pollen taxa, excluding *Cyperaceae*, were calculated using the sum of all those taxa. Percentages of *Cyperaceae*, aquatics, and pteridophyte spores were calculated relative to the main sum plus the relevant sum for each taxon or taxon group. Calculations, numerical analyses and pollen diagrams were performed using the software package Psimpoll 4.26 (Bennett 1992, 2005). Local pollen assemblage zones (LPAZs) were defined using optimal splitting of information content (Birks & Gordon 1985), zonation being performed using the 20 terrestrial pollen taxa that reached at least 5% in at least one sample.

According to modelling and empirical studies for narrow moat with a diameter of ca. 5–10 m (Sugita 1994; Beneš et al. 2002; Penny et al. 2006; Soepboer et al. 2007; Brown & Pluskowski 2011), the correlation between pollen abundances and vegetation composition does not improve for vegetation found at a minimum distance less than 100 m. The regionally 'uniform' background pollen component representing the vegetation between 500 m and 1000 m from the moat system, accounts for ca. 5–15% of the total pollen spectrum (Beneš et al. 2002; Soepboer et al. 2007; Brown & Pluskowski 2011). Pollen data from the infilled moat thus provide us an integrated palaeovegetation record for the landscape around the presumed human settlement and the surrounding region, with pollen from predominantly extra-local and local sources (Jacobson & Bradshaw 1981; Prentice 1985). We followed the work of Behre (1981, 1986, 1988) regarding human impact since these works take into account the appearance of weeds that spread as a result of human activities (Jones 1992) and papers about Hungarian vegetation and weed analysis (Ujvárosi 1957; Fekete et al. 1987; Magyari et al. 2010, 2012). We used the works of Behre (1981, 1986, 1988, 1990, 1993, 2007, 2008) in the identification and evaluation of weeds since some weeds (such as *Plantago lanceolata*) that spread due to human impact are native to Central Europe and in the Carpathian Basin, so the presence of these weed species is not necessarily the indication of human impact.

Although major advances have been made in the identification of pollen, especially of cultivated plants and weeds since the work of Firbas (1937), the identification of cultivated plants in the pollen record still poses some difficulties (Beug 1961, 2004; Andersen & Bertelsen 1972; Andersen 1979; Dickson 1996; Tweddle et al. 2005; Joly et al. 2007).

Results

Anthracological remains

During the flotation of the macrobotanical material, a high number of charred and rotten wood residues were found in the moat filling of the tomb. A part of the charred wood remains was burnt and these residues occurred in three horizons: in the bedrock level between 235 and 250 cm, between 130 and 145 cm, and between 85 and 100 cm. In the burnt charcoal material pine fragments were identified (Greguss 1955; Jacquiot 1955; Stieber 1967; Marguerie & Hunot 2007; Pichler et al. 2013; Robin et al. 2013; Knapp et al. 2015). Besides the burnt, unidentifiable charcoal assemblage and the burnt pine fragments, four anthracological taxa were identified from the infilling of the moat (**Table 2.**). These were oak (*Quercus* sp.), maple (*Acer* sp.), alder (*Alnus* sp.), and poplar/willow (*Populus/Salix* sp.).

Table 2.: Charcoal remains from the profile of the moat (identified by Katalin Náfrádi)

2. táblázat: Szenült famaradványok a szigetvári türbe árkának szelvényéből (határozta: Náfrádi Katalin)

Depth (cm)	Taxa	Number of pieces
40-55	*Quercus* sp.	143
55-70	*Quercus* sp., burnt *Alnus* sp.	138
70-85	*Quercus* sp., *Acer* sp., *Alnus* sp.	317
85-100	*Quercus* sp.	352
100-115	*Quercus* sp., *Alnus* sp.	335
115-130	*Quercus* sp., *Populus/Salix* sp., overburnt fragments	140
130-145	*Quercus* sp., *Alnus* sp., *Acer* sp., overburnt fragments	388
145-160	*Quercus* sp., *Acer* sp., *Alnus* sp.	398
160-175	*Quercus* sp., *Alnus* sp., overburnt fragments	702
175-190	*Acer* sp., *Alnus* sp.	816
190-205	*Quercus* sp., *Acer* sp., *Alnus* sp.	687
205-220	coniferous	350
220-235	*Alnus* sp.	354
235-250	*Alnus* sp., *Populus/Salix* sp., overburnt fragments	325

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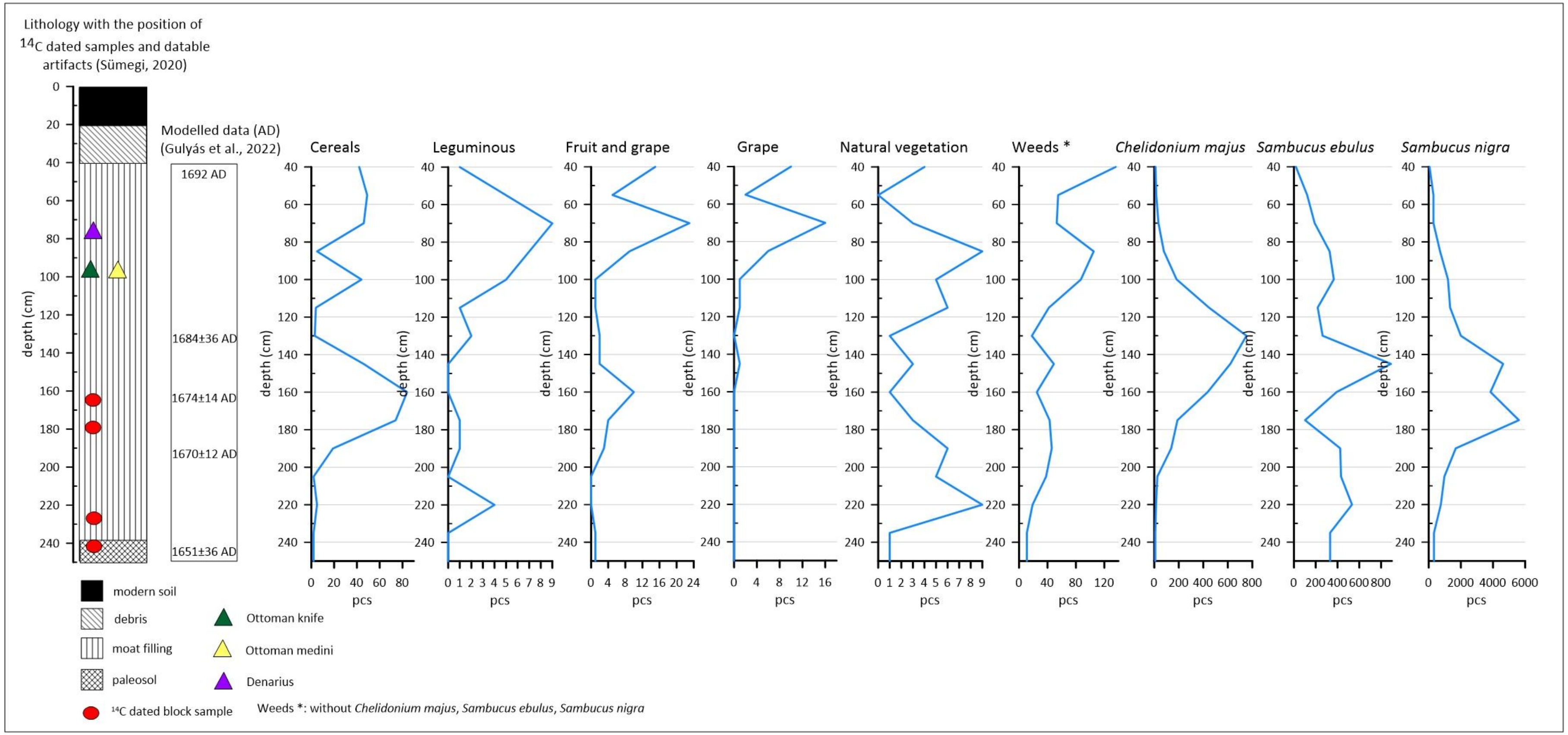

Fig. 1.: Main archaeobotanical indicator groups and the abundance and dominance of remains of the greatest volume of samples from the moat (lithology: Sümegi 2020, chronology: Gulyás et al. 2022)

(the number of *Sambucus nigra* (23 678 pieces), *Sambucus ebulus* (4 610 pieces) and *Chelidonium majus* (2 949 pieces) were not taken into account during the calculation of weed dominance)

1. ábra: Archeobotanikai fő indikátorcsoportok és a legnagyobb tömegben jelentkező maradványok gyakoriságának és dominanciájának változása a türbe árkából vett mintasorozatban (litológia: Sümegi 2020, kronológia: Gulyás et al. 2022 alapján)

(gyomok dominancia kiszámításánál nem vettük figyelembe a nagy tömegű *Sambucus nigra* (23 678 db), *Sambucus ebulus* (4 610 db) és *Chelidonium majus* (2 949 db) maradványokat)

Archaeobotanical remains

As a result of the archaeobotanical analysis, 77 taxa of 14 samples were found covering 32 057 remains (**Fig. 1.; Table 3., 4.**). In the archaeobotanical assemblage the remains of American black elderberry (*Sambucus nigra*) (23 678 pieces), European dwarf elderberry (*Sambucus ebulus*) (4 610 pieces), and greater celandine (*Chelidonium majus* (2 949 pieces) dominated; the number of these species (31 237) accounted for the ratio of 97.44% of the findings. These species belong to the same plant classification category indicating gardens, roads, human settlements and disturbance. Therefore, during quantitative evaluation, the number of these species was not considered, and we took the ratio of these three species to zero when assessing the dominance of each group/taxa, for better perspicuity. Thus, the indicator elements with a lower ratio and their quantitative change became more evident in the examined profile.

1. Cultivated plants

Approximately 20% of the analysed plant species are cultivated crops (17 species, 537 pieces of remains) including cereals, legumes, oil/fiber plants, and cultivated fruits and grapes. **Table 3.** shows the frequency of different categories.

Cereals

The majority of the residues of cultivated plants were poorly preserved. Five cereal species turned up in the samples (**Table 4.**). Barley (*Hordeum distichon/vulgare*) has the highest number; the majority is six-row barley (*Hordeum polystichum*). The number of rye (*Secale cereale*) is slightly lower. The number of common wheat/bread wheat (*Triticum aestivum*) and common millet (*Panicum miliaceum*) was nearly similar. And more than 200 cereal fragments were found that could not be identified as species.

Leguminous, oil and fiber plants, herbs

Lentil (*Lens culinaris*), pea (*Pisum sativum*), black mustard (*Brassica nigra*), turned up in more samples of the profile, while opium poppy (*Papaver somniferum*), flax (*Linum usitatissimum*) and wild parsnip (*Pastinac asativa*) in only one sample (**Table 3.**).

Cultivated fruits and grapes

The number of cultivated fruits was small in the samples of the moat filling; however, still indicative (**Table 3.**). All hard-shell fragments were burnt. Sour cherry/cherry (*Ceras usavium/vulgaris*) seeds were the most frequent. Unfortunately, the exact identification of the fragmented seeds was not possible; however, it certainly was a cultivated form (Necipoğlu 1997; Faust & Surányi 1999). In addition, the hard-shell fragments of plum (*Prunus domestica*) and walnut (*Juglans regia*) were identified. Fragments of hazelnut (*Corylus avellana*) were found in more samples. Common grape wine (*Vitis vinifera*) seeds turned up in half of the samples, and most of them were fragmented; however, undamaged seeds occurred as well, which may provide an opportunity to determine additional cultural varieties and types (Mravcsik et al. 2015). Most of the grape seeds were waterlogged, 10 pieces of burnt grape seeds turned up only in one sample.

Table 3. Cultivated plant remains from the profile of the moat (identified by Andrea Torma)

3. táblázat: Termesztett növénymaradványok a türbe árkának feltárásából (határozta: Torma Andrea)

Plant groups		Taxon	Number of seeds	Frequency in samples
Cultivated plants	Cereals	*Hordeum vulgare* L.	93	8
		Gramineae fragm.	241	8
		Panicum miliaceum L.	12	8
		Secale cereale L.	61	13
		Triticum aestivum L.	16	9
		Triticum sp.	2	2
	Leguminosea, oil and fiber plant, herbs	*Lens culinaris* Medik.	2	2
		Pisum sativum L.	4	3
		Brassica nigra (L.) Koch.	27	7
		Linum usitatissimum L.	1	1
		Papver somniferum L.	1	1
		Pastinaca sativa L.	1	1
	Fruits and grapes	*Cerasus avium/vulgaris* fragm.	32	7
		Corylus avellana L.fragm.	3	3
		Juglans regia L. fragm.	1	1
		Prunus cf. *domestica* L fragm.	3	2
		Vitis vinifera L.	37	7
Total number of seeds			537	

Table 4. Natural vegetation, ruderals, weeds and ornamental plant remains from the excavation of the moat (identified by Andrea Torma)

+: gathered fruits and flowers; *: plant species with one-piece remain (1-1 piece of the remains)

4. táblázat Természetes növények, ruderáliák, gyomok és dísznövények maradványai a türbe árkának feltárásából (határozta: Torma Andrea)

+: gyűjtögetett gyümölcsök és virágok; *: egy-egy növényi maradvánnyal jelentkező növényi taxon

Plant groups	Taxon	Number of seeds	Gathered
Field weeds and ruderals	*Agrostemma githago* L.	2	
	Bromus arvensis L.	3	
	Bromus secalinus L.	2	
	Carduus nutans L.	7	
	Centaurea cyanus L.	2	
	Chelidonium majus L.	2949	+
	Chenopodium album L.	302	
	Chenopodium hybridum L.	75	
	Chenopodium murale L.	7	
	Datura stramonium L.	150	
	Descurainia sophia (L.) Werb.	18	
	Fallopia convolvulus (L.) A. Löve	3	
	Galium spurium L.	4	
	Hyoscyamus niger L.	2	+
	Lolium temulentum L.	5	
	Picris hieracoides L.	16	
	Polygonum aviculare agg.	2	
	Portulaca oleracea L.	78	+
	Sambucus ebulus L.	4610	
	Sambucus nigra L.	23678	+
	Setaria glauca Beauv.	3	
	Setaria viridis/verticillata	3	
	Sinapis arvensis L.	10	
	Spergula arvensis L.	3	
	Stellaria media (L) Will.	17	+
	Urtica dioica L.	6	
	Malva pusilla Sm et Sow.	1	+
	Digitaria sanguinalis, Galium aparine, Leunurus cardiaca, Polygonum lapatifolium, Solanum nigrum, Stachys annua (total 33 taxa)	33	*
Natural vegetation	*Carex distans* L.	2	
	Carex flacca Schreb.	2	
	Carex vulpina L.	4	
	Chenopodium polyspermum L.	9	
	Eleocharis palustris (L.) R et Sch.	2	
	Myosoton aquaticum Mönch	5	
	Fragaria vesca L.	3	+
	Lamium ampexicaule L.	2	
	Prunus spinosa L.	1	+
	Rubus fruticosus L.	2	+
	Alisma plantago-aquatica, Barbarea stricta, Chrysanthemum leucanthemum, Ranunculus repens, Schoenoplectus lacustris, Solanum dulcamara, Calamintha acinos, Carex hirta, Medicago minima, Plantago lanceolata, Prunella vulgaris, Ranunculus bulbosus, Rumex crispus, Trifolium repens, Veronica hederifolia (total 25 taxa)*	25	*
Ornamental plants	*Betula pendula* Roth.	7	
	Picea abies (L.) Karsten	2	
Total number of seeds		32 057	

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2. Arable and ruderal weeds

The species list and the number of weed remain per sample depth are detailed in **Table 4**. As we mentioned above, American black elderberry, European dwarf elderberry, and greater celandine occurred with the highest values. Lamb's quarters (*Chenopodium album*), thorn apple (*Datura stramonium*), common purslane (*Portulaca oleracea*), and red goosefoot (*Chenopodium hybridum*) turned up in much smaller, but still significant quantities. Other species are represented in much smaller numbers, for example, corncockle (*Agrostemma githago*), field brome (*Bromus arvensis*), rye brome (*Bromus secalinus*), flixweed (*Descurainia sophia*), cornflower (*Centaurea cyanus*), false cleavers (*Galium spurium*) and wild mustard (*Sinapis arvensis*), darnel (*Lolium temulentum*) and corn spurry (*Spergula arvensis*).

3. Natural vegetation

Manyseed goosefoot (*Chenopodium polyspermum*), giant chickweed (*Myosoton aquaticum*) and true fox sedge (*Carex vulpine*) were the most frequent taxa among the natural vegetation elements (**Table 4.**). Common spikerush (*Eleocharis palustris*), blue sedge (*Carex flacca*), distant sedge (*Carex distans*), strawberry (*Fragaria vesca*), European blackberry (*Rubus fruticosus*) and common henbit (*Lamium amplexicaule*) turned up in few samples, while other taxa are in only one sample (**Table 4.**).

4. Ornamental plants

The residues of European white birch (*Betula pendula*) and the cone and pine needles of Norway spruce (*Picea abies*) were identified (**Table 4.**).

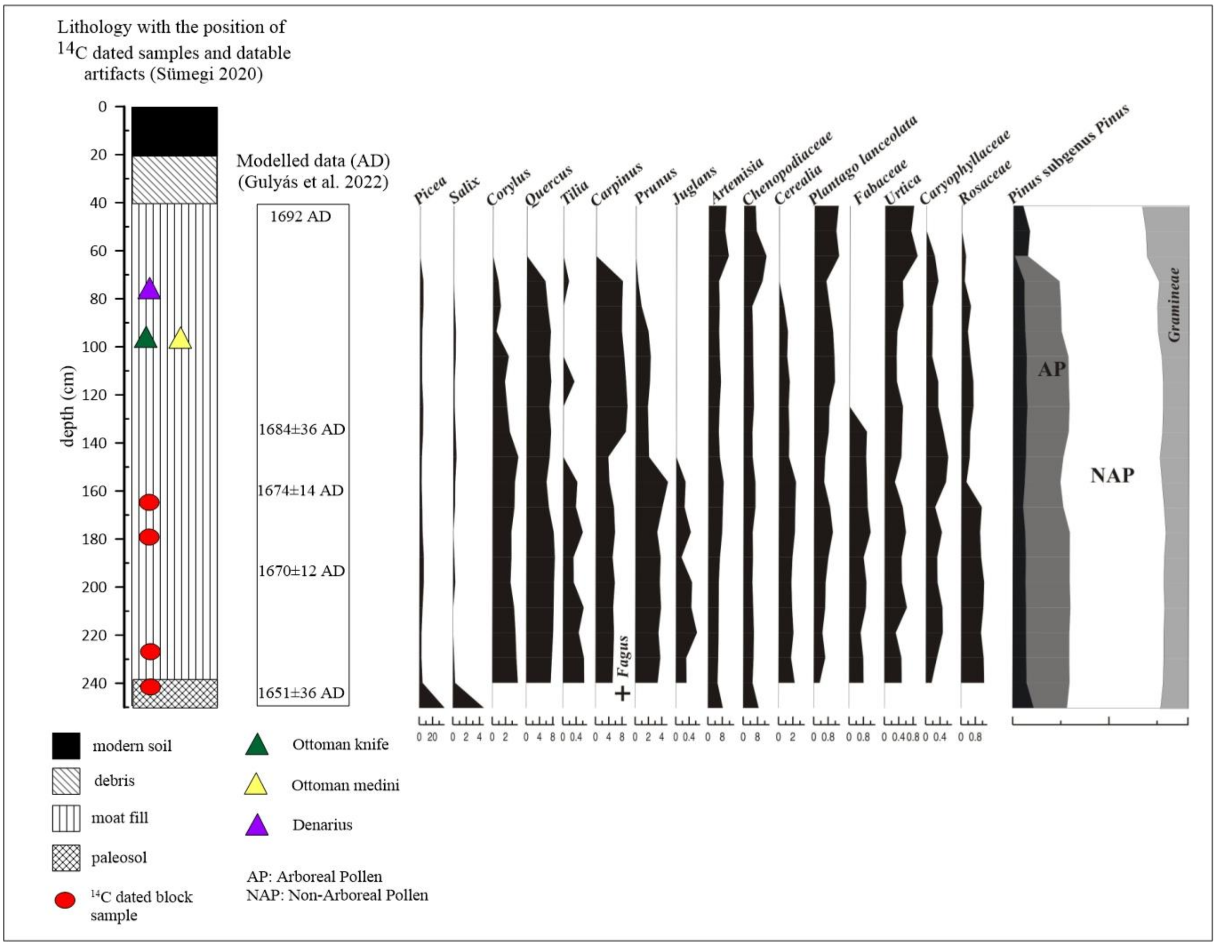

Fig. 2.: Pollen taxa (selected taxa) and main groups of samples taken from the moat at 10 cm intervals (lithology: Sümegi 2020, chronology: Gulyás et al. 2022)

2. ábra: Pollen taxonok és fő csoportok (szelektált taxonokkal) a türbe árkából vett 10 cm-es mintákból (litológia: Sümegi 2020, kronológia: Gulyás et al. 2022 alapján)

Pollen remains

The preservation of pollen samples was poor and medium. Only a low number of taxa (31) could be identified as a result of poor and selective pollen preservation (Dimbleby 1985). The samples of the near-surface part of the profile (the driest sediment layers) were pollen sterile. Apart from this, 500–500 pollen grains were counted from the samples taken at 10 cm intervals. The pollen material of the moat filling, formed in the 17th century, was based on the analysis of more than 10 thousand pollen grains belonging to 31 terrestrial taxa (**Fig. 2.**). The figure shows the most abundant arboreal (AP) and non-arboreal (NAP) taxa.

Discussion

The results of the drone surveys, the non-destructive geophysical and geoinformatics methods, furthermore, maps based on the analysis of historical sources, including the records of travellers (**Table 1**), were suitable for the localization of the site and the palaeo-hydrological, land use, and vegetation reconstruction of its surroundings (Gyenizse & Bognár 2014; Pap 2014; Pap et al. 2015; Pap 2019). The reconstructed land-use, vegetation, and palaeo-hydrological map (**Fig. 3.**), based on both the written sources (**Table 1**) and the maps of the 17th century, indicate that in the close vicinity of the türbe, on the Turbék vineyard hill gardens, vineyards and ploughed lands existed together with forest patches (natural vegetation patches) only beyond 1 km, predominantly in deeper areas.

We have Turkish and Latin sources (reports of Christian and Ottoman travellers, Ottoman and Christian tax forms, and censuses) about the tomb and its surroundings (**Table 1**) from 1526 until 1782 (Gyenizse & Bognár 2014). Based on these, following a political decision made under the leadership of the Ottoman Empire, according to a Sultan decree, the tomb and a small city (*Türbe kasabası*) were established, probably in 1575 (Pap et al. 2023), without any settlement background. It was maintained by the resources of the Ottoman Empire and destroyed after the recoiling of the Ottoman Empire. After the successful Habsburg siege of Szigetvár (1689) the tomb and the settlement were destroyed and demolished from 1691 onwards. We do not have information about another similar Ottoman-founded settlement in the Carpathian Basin so far, and it is unique in south-eastern Europe as well. Its distinctive character extends to its plant culture too, which was mentioned in historical sources. The written sources confirmed the archaeobotanical data; namely vineyards, orchards, and ploughed lands were mentioned from the 17th century. The most important archaeobotanical data was mentioned by Evlia Çelebi Ottoman traveller (Çelebi 1648; Karácson 1908), who mentioned grape (*Vitis vinifera*) and cherry (*Cerasus vulgaris*) by name concerning Suleiman's tomb and the area. Thus, the unidentifiable sour cherry/cherry stones that turned up most likely belong to cherry.

Another important written historical data that confirms the results of the archaeobotanical analysis, is that maize was only mentioned in the 18th century for the first time. It subsequently supports the lack of maize in the samples of the moat filling, even though maize production was detected in several places in the southern part of Transdanubia from the 17th century.

Based on the geochronological, sedimentological, geochemical (Gulyás et al. 2022), and malacological data (Sümegi 2023) the filling up of the moat was periodic, and its end by a single landscaping filling up at the turn of the 17th and 18th century. However, the horizon of the moat filling between 50 and 250 cm can be linked to the 17th century. According to the radiocarbon data, the filling up of the moat started at 1651+/-36 AD (Gulyás et al. 2022), while based on the malacological-palaeoclimatological data between 1624 and 1633 AD (Sümegi 2023). It should also be noted that the moat was most likely periodically cleaned.

A significant number (32 057 pieces) of plant remains covering 77 taxa were found, so a detailed archaeobotanical analysis could be performed. The comparative archaeobotanical database regarding cereals (**Fig. 4.**) of the Carpathian Basin of the 17th century enabled the interpretation of the archaeobotanical data of Szigetvár – Turbék vineyard hill.

Cereal cultivation decreased considerably in the Carpathian Basin in the 17th century, compared to previous centuries. Only one-third of cereal residues appeared in the 17th century; a large number of cereals was detected only in principality centers (Sárospatak: Gyulai et al. 2013), commercial centers (Vác: Gyulai 1995) and in the grain warehouses of Ottoman military centers (Dunaföldvár, Kaposvár, Székesfehérvár, Szolnok: P. Hartyányi et al. 1967/1968; P. Hartyányi & Patay 1970). In the 16th century, even in smaller settlements and communities, such as food provider villages (Sarvaly: Schkoflek 1985) and monasteries (Pogányszentpéter: Füzes 1972), the number of grains was very significant, exceeding 60% in the archaeobotanical material (**Tables 3,4.**).

Archaeobotanical data indicate a notable decline in cereal cultivation in the whole Carpathian Basin in the 17th century. Due to the conquest of the Ottoman army and the ongoing wars (Sümegi et al. 2016) the population decreased.

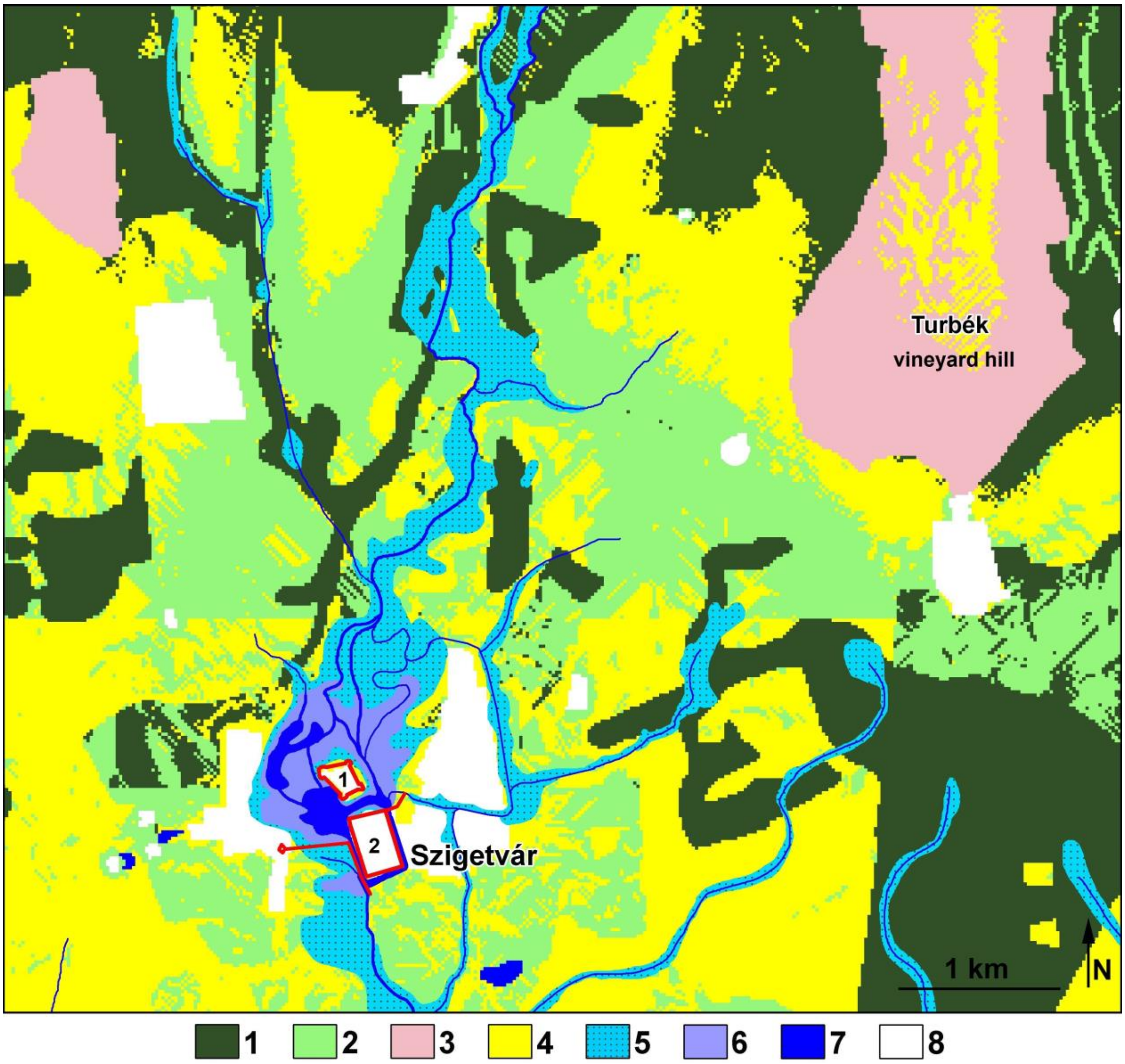

Fig. 3.: Reconstructed vegetation, land use and palaeohydrology map around Suleiman's türbe in the 17th century (Gyenizse & Bognár 2014)

1: forest; 2: meadow, pasturage; 3: vineyards and orchards; 4: arable field; 5: marshes and wetlands; 6: temporary wetlands; 7: lake, open water surface; 8: built-up, non-modellized area. Red line 1-2: the castle (1) and the fortress (2) around Szigetvár

3. ábra: A Szulejmán türbe környékének 17. századi földhasználati, növényzeti és paleohidrológiai rekonstrukciós térképe (Gyenizse & Bognár 2014)

1 = erdő; 2 = rét, legelő; 3 = szőlő és kertek; 4 = szántóföldek; 5 = mocsár és vizes élőhelyek; 6 = mocsarak; 7 = tavak; 8= beépített területek; vörös vonal 1-2 = a vár (1) és az erődített város (2) vonala.

Food production changed and animal husbandry became dominant in the second half of the 16th century (Bartosiewicz 1996; Nyerges & Bartosiewicz 2006).

Due to the long ripening period of cereals and the unpredictable growing and harvesting conditions through wartime, it certainly became secondary during these chaotic times. In addition to these factors, climate deterioration in the entire Carpathian Basin, as well as the extension of wet floodplain areas (Pinke et al. 2017) promoted the reduction of crop production and the spread of livestock farming. At the same time, compared to the dominance of wheat at the end of the medieval period, grain production shifted and barley (*Hordeum*), which is less sensitive to the production site, and rye (*Secale*), which provides a higher yield in a cooler climate, became dominant in the archaeobotanical assemblage of the study site and through the entire Carpathian Basin in the 17th century. This change in dominance may also be related to the deterioration of climatic conditions according to written resources and the changes observed in agricultural production and nutrition (Rácz 2020).

Surprisingly, the cultivation of maize (*Zea mays*), which is sensitive to production conditions, began in the Carpathian Basin in the 17th century, characterized by the Little Ice Age (LIA) cold maximum. Based on historical sources, maize appeared and spread in the Carpathian Basin from two directions: south-western (Italian and Dalmatian) and south-eastern (Ottoman) mediation (Horváth 1811; Berényi 1945; Enyedi 1957; Imreh 1999; Balassa 2001; Gyulai et al. 2014a,b). References of maize plant appeared in Latin-Hungarian dictionaries (Szikszai Fabricius 1590, 24: *Frumentum turcicü* = Turkish wheat) and herbariums (Beythe 1595) in the Carpathian Basin as early as the end of the 16th century. Nevertheless, the first written sources related to crop (maize) production and management appeared in the eastern part of the Carpathian Basin, in the Transylvanian estates of György Rákóczi prince in 1611 (Schwantner 1798), and then in 1639 in Transylvania (Schwantner 1798), in the valley of the Maros (Mureş) River (Horváth 1811; Berényi 1945; Enyedi 1957; Balassa 1960; Imreh 1999).

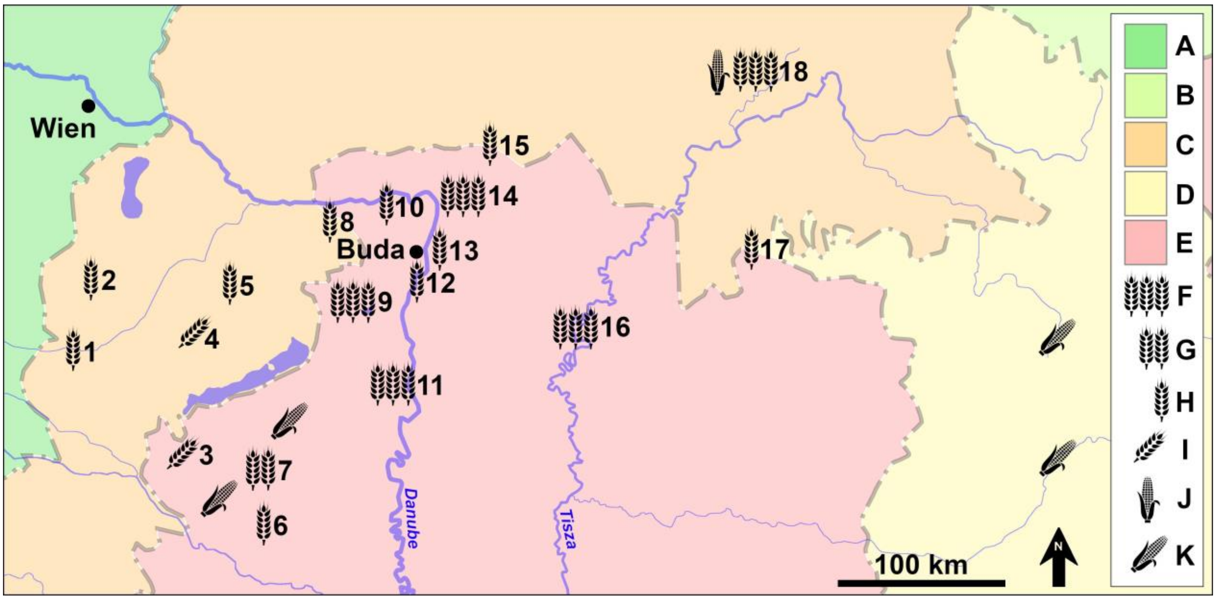

Fig. 4.: Archaeobotanical database for cereals in the Carpathian Basin during the 17th century 1.Szentgotthárd castle - Ilon et al. 2007, 2. Kőszeg castle - P. Hartyányi et al. 1967/1968, 3. Pogányszentpéter (monastery – 16th century, destroyed between 1526 and 1566) – Füzes 1972, 4. Sümeg – Sarvaly village – 16th century, destroyed in 1536) - Skoflek 1985, 5. Pápa castle - Torma 1996b, 6. Szigetvár – Turbék vineyard hill site (in this manuscript), 7. Kaposvár - P. Hartyányi et al. 1967/1968, 8. Tata castle - P. Hartyányi et al. 1967/1968, 9. Székesfehérvár - P. Hartyányi et al., 1967/1968 10. Esztergom castle - P. Hartyányi et al. 1967/1968, 11. Dunaföldvár castle - P. Hartyányi & Patay 1970, 12. Budapest – 1. site - P. Hartyányi & Patay 1967/1968, 13. Budapest – 2. site (Rácfürdő) - P. Hartyányi & Patay 1967/1968, 14. Vác city (trade center) - P. Hartyányi et al. 1967/1968, 15. Szécsény castle - Torma, 1996a 8. Sárospatak castle - Gyulai et al. 2013, 16. Szolnok castle - P. Hartyányi & Patay 1967/1968, 17. Debrecen city - P. Hartyányi et al. 1967/1968, 18. Sárospatak castle - Gyulai et al. 2013.Writtendata: Lászlófalvi Velics & Kammerer 1886; Lászlófalvi Velics & Kammerer 1890; Szilágyi 1895; Imreh 1999; Rácz 2020

4. ábra: Gabonafélék archeobotanikai adatbázisa a Kárpát-medencében a 17. századra vonatkozóan 1. Szentgotthárdi vár - Ilon et al. 2007, 2. Kőszegi vár - P. Hartyányi et al. 1967/1968, 3. Pogányszentpéter (kolostor– 16. század, 1526-1566 között rombolták le) - Füzes 1972, 4. Sümeg – Sarvaly falu – 16. század, 1536-ban rombolták le) - Skoflek 1985, 5. Pápai vár – Torma 1996b, 6. Szigetvár – Turbék Szőlőhegy lelőhely (ebben a cikkben), 7. Kaposvár - P. Hartyányi et al. 1967/1968, 8. Tatai vár - P. Hartyányi et al. 1967/1968, 9. Székesfehérvár - P. Hartyányi et al., 1967/1968 10. Esztergomi vár - P. Hartyányi et al. 1967/1968, 11. Dunaföldvári vár - P. Hartyányi & Patay 1970, 12. Budapest – 1. lelőhely - P. Hartyányi & Patay 1967/1968, 13. Budapest – 2. lelőhely (Rácfürdő) - P. Hartyányi & Patay 1967/1968, 14. Vác város (kereskedelmi centrum) - P. Hartyányi et al. 1967/1968, 15. Szécsényi vár - Torma, 1996a 8. Sárospataki vár - Gyulai et al. 2013, 16. Szolnoki vár - P. Hartyányi & Patay 1967/1968, 17. Debrecen város - P. Hartyányi et al. 1967/1968, 18. Sárospataki vár - Gyulai et al. 2013. Írott források: Lászlófalvi Velics & Kammerer 1886; Lászlófalvi Velics & Kammerer 1890; Szilágyi 1895; Imreh 1999; Rácz 2020

Moreover, in 1686, the independent Transylvanian parliament, as a result of the change in the military situation in the Carpathian Basin, the retake of the Castle in Buda (1686), the political situation of the Ottoman and the Habsburg Empire, banned the cultivation of maize, as an Ottoman tradition (Szilágyi 1895; Berényi 1945; Enyedi 1957). At the same time, the first maize archaeobotanical remains in the Carpathian basin (Gyulai et al. 2014a,b) derive from the Rákóczi property in Sárospatak from the 17th century (**Fig. 4.**).

A very important botanical question regarding maize is why this plant was not grown around the türbe in the 17th century. Based on product and property censuses (Gyenizse & Bognár 2014) it was cultivated in the wider area of the türbe, in the southern part of Transdanubia in the 1650s, and it was present in the Ottoman memorial place in Szigetvár in the 18th century, which was already transformed into an agricultural area.

So environmental factors could not be the reason for the lack of cultivation. What is more, taking into account the microclimatic and pedological conditions of the area, they were particularly favourable for the cultivation of maize. Based on these, it is likely, that maize was not grown in the vicinity of the türbe for its religious nature and traditions of it.

The earliest evidence of grape and fruit production dates back to the Iron Age in the Carpathian Basin (Gyulai 2010; Gyulai et al. 2011). During the Roman Empire, and surprisingly in the Ottoman period fruit and grape production reached its maximum (Gyulai 2010), even though it (especially grape production) declined during the 17th century as a result of climate deterioration and wars, particularly in the Little Hungarian Plain and Hungarian Upland (Gecsényi 1988; Kalesny 1993). In particular, many cultivated fruit remains are known from the Ottoman era (Torma 1996a,b, 1997, 2003); unfortunately, only a part of these was found in the samples of the moat. It cannot be ruled out that the main reason for the low number of fruit residues may have been the stone wall surrounding the tomb, which could have hindered the remains from entering the moat (**Fig. 4.** and **Table 3,4.**).

During the Ottoman period, grape production was important in the Carpathian Basin, as dried fruits were very popular by that time (Árendás 1982). In addition, the Rácz ethnic group that fled to the Hungarian Kingdom introduced a new grape vine, called Kadarka between the Danube-Tisza Interfluve and along the Danube River (Katona & Dömötör 1963) during the Ottoman period. So, the Ottoman Empire and the spreading Islamic customs, which prohibit the consumption of wine according to the Qur'an, did not restrict (Fodor 1998) the development of viticulture in the conquered territories and wine consumption for Christian communities if they paid the must and wine tax (Égető 1993; Hegyi 1976; Káldy-Nagy 1985). This later, together with the wine trade tax, could have been a very significant amount based on written sources of taxation (Szakály 1981; Fekete 1993; Pákay 1984) and, of course, Ottoman communities also paid tax for growing grapes (Káldy-Nagy 1985). In addition, the sweet must, consumed frequently by the Ottoman communities, is also made of grapes, and this drink, called petymez/peszmeg/saba (must honey), has become one of the favourite drinks of the Christian Hungarian communities (Andrásfalvy 1961). Grape seeds appeared in the profile at 160 cm which corresponds to 1674+-14 AD years according to Gulyás et al. 2022. Based on the wine grape remains of the moat filling of the 17th century, probably must honey was made in the pilgrim town (*Türbe kasabası*) near the tomb. Grape remains (**Fig. 5.**) have been found in almost all of the 17th century Ottoman sites in the Carpathian Basin processed so far. These remains confirm written sources, such as tax sheets (Szakály 1981; Fekete 1993; Pákay 1984) and the reports of Ottoman travellers (Çelebi 1684; Karácson 1908) about the well-developed grape production that subsisted despite wars (Andrásfalvy 1961).

Besides the remains of cereal (**Fig. 5.**) production and horticulture, the residues of opium poppy, lentil, pea, black mustard, flax, and parsnip indicating horticulture appeared (**Fig. 5.**). All of the plant remains that were found in the tomb are ancient crops (Behre 1988; Jacomet & Kreuz 1999; Gyulai 1995, 2010; Hajnalová 2007), and the characteristic plants of the Islam horticulture including spices, herbs, and fruits occur as well (Jacquart 2008). The remains (**Fig. 5.**) of fruit seeds (for example cherry, plum, and walnut) indicate fruit gardens. Based on Evlia Çelebi's notes (Çelebi 1684; Karácson 1908) cherry production (*Cerasus vulgaris*) was likely in the vicinity of the tomb. These plants are typical in medieval Islamic gardens (Ruggles 2011) but have also been an integral part of Christian garden cultures (Davies 2019; Peña-Chocarro & Pérez-Jordà 2019; Sánchez-Pardo et al. 2020). The gathering of strawberry, European blackberry, blackthorn, and hazelnut were present in the Islamic grape-fruit and horticulture. These plants indicate that gardening was present in different parts of Europe and the Carpathian basin in the 17th century (Gyulai 1995, 2010; Torma 1996a,b, 1997, 2003; Sánchez-Pardo et al. 2020).

In addition to orchards, vegetable gardens, and cereal fields, the presence of flower gardens or flower strips could also be inferred based on the pollen material, with the presence of carnations (*Caryophyllaceae*), roses (*Rosaceae*), and lilies

Fig. 5.: Archaeobotanical remains from the moat of Szigetvár – Turbék vineyard hill from the 17th century (pictures taken by Andrea Torma). 1./ *Triticum aestivum* 2./ *Hordeum vulgare* (2a. dorsal, 2b. ventral). 3./ *Secale cereale* (3a dorsal, 3b. ventral). 4./ *Vitis vinifera*. 5./ *Juglans regia* fragment of the endokarp (shell). 6./ *Pisum sativum*. 7./ *Cerasus avium/vulgare* fragment of fruit-stone. 8./ *Brassica nigra*. 9./ *Panicum miliaceum*. 10./ *Lens culinaris*. 11./ *Betula pendula* scale. 12./ *Sambucus nigra*. 13./ *Sambucus ebulus*. 14./ *Bromus secalinus* (14a. dorsal, 14b. ventral). 15./ *Picris hieracoides*. 16./ *Carduus nutans*. 17./ *Centaurea cyanus*. 18./ *Carex hirta*. 19./ *Datura stramonium*. 20./ *Veronica hederifolia*. 21./ *Urtica dioica*. 22./ *Stachys annua*. 23./ *Solanum nigrum*. 24./ *Sinapis arvensis*. 25./ *Chenopodium hybridum*. 26./ *Hyoscyamus niger*. 27./ *Portulaca oleracea*. 28./ *Picea abies* needle.

5. ábra: Archeobotanikai növénymaradványok a Szigetvár – Turbék szőlőhegy lelőhelyen feltárt 17. századi árokból (képeket Torma Andrea készítette).1./ *Triticum aestivum*. 2./ *Hordeum vulgare* (2a: dorsalis, 2b: ventralis). 3./ *Secale cereale* (3a: dorsalis, 3b: ventralis). 4./*Vitis vinifera*. 5./ *Juglans regia* (terméshéj). 6./ *Pisum sativum*. 7. *Cerasus avium/vulgare* magvak. 8./ *Brassica nigra*. 9./ *Panicum miliaceum*. 10./ *Lens culinaris*. 11./ *Betula pendula* (terméspikkely). 12./ *Sambucus nigra*. 13./ *Sambucus ebulus*. 14./ *Bromus secalinus* (14a: dorsalis, 14b: ventralis). 15./ *Picris hieracoides*. 16./ *Carduus nutans*. 17. *Centaurea cyanus*. 18./ *Carex hirta*. 19./ *Datura stramonium*. 20./ *Veronica hederifolia*. 21./ *Urtica dioica*. 22./ *Stachys annua*. 23./ *Solanum nigrum*. 24./ *Sinapis arvensis*. 25./ *Chenopodium hybridum*. 26./ *Hyoscyamus niger*. 27./ *Portulaca oleracea*. 28./ *Picea abies* tűlevél töredék.

(*Liliaceae*) based on pollen data. However, a more specified determination is not possible by pollen analysis (Ueda & Tomita 1989; Kosenko 1999; Özhatay & Koçyiğit 2009; Ullah et al. 2018; Hu et al. 2021). The presence of gardens, inhabited areas, roads, orchards, fields, meadows, and pastures is supported by the diverse weed vegetation with goosefoot (*Chenopodiaceae*), plantain (*Plantago media/major, Plantago lanceolate*), knotweed (*Polygonum aviculare*), nettles (*Urtica*) and bedstraw (*Galium*) (**Fig. 2.**). Weeds of cereals indicate their local cultivation (Bogaard et al. 2001, 2016; Marinova & Atanassova 2006; Hyvönen & Huusela-Veistola 2008; Kreuz & Schäfer 2011; Lodwick 2018), while weeds indicating ruderal areas appeared as well, such as *Bromus arvensis, Bromus secalinus, Carduus nutans, Digitaria sanguinalis* and *Galium aparine* (Bakels 1999; Beneš et al. 2002; Kohler-Schneider & Caneppele 2009; Bosi et al. 2017).

Chenopodiaceae and *Setaria* taxa are also considered to be weeds nowadays but have been used for feeding and grazing animals and as green manure (Magyar 2013). Thus, their appearance raises several land use possibilities in the study site, from horticulture to ploughed lands and trampled, ruderal areas (Bakels 1999; Charles et al. 2002; Bieniek 2002; Latałowa et al. 2003; Hajnalová 2007; Behre 2008; Wallace & Charles 2013). Regarding the number of weed seeds, the mass of seeds belongs to ruderal species (**Fig. 1**) indicating trampled areas, roads, and settlements (Ellenberg 1974, 1988; Lososová et al. 2011; Lapteva & Korona 2012; Kenéz et al. 2014; McPartland & Hegman 2018), for example, *Leorunus cardiaca, Polygonum aviculare*, and *Picris hieracoides*.

The largest amount, thousands of remains of greater celandine (*Chelidonium majus*), dwarf elderberry (*Sambucus ebulus*), and black elderberry (*Sambucus nigra*) turned up that prefers nutrient-rich, fresh habitats, such as the banks of the moat of the tomb (**Fig. 1.**). In addition, black elderberry (*Sambucus nigra*) and greater celandine (*Chelidonium majus*) were gathered as well. Greater celandine was a known herbal drug (Sárközi et al. 2006), while the fruit and flower of black lace were consumed as herbal tea (Akbulut et al. 2009; Porter & Bode 2017).

Weed species indicating vineyards and orchards (*Digitaria sanguinalis, Portula caoleracea, Stellari media*, and *Malva pusilla*) appeared in the archaeobotanical assemblage (Poldini et al. 1998; Beneš et al. 2002; Weiss & Kislev 2004; Bosi et al. 2015; Koszałka & Strzelczyk 2015; Mariotti Lippi et al. 2015; Dunseth et al. 2019). In addition to being habitat markers (Lososová et al. 2003), they have also been used for feeding poultry (Melius Juhász 1578; Guarrera et al. 2005) and as green manure.

The archaeobotanical remains of natural vegetation elements indicate waterfront areas, floodplains and wet ditches, such as *Eleocharis palustris, Carex vulpina, Schoenoplectus lacustris, Alisma plantago* aquatic, and *Carex flacca*, or ruderal areas, for example *Myosoton aquaticus* or *Barbarea stricta* (Hosch & Jacomet, 2001; Šoštarić & Küster, 2001) (**Table 3,4.**). *Chenopodium polystichum, Chrysanthemum leucathemum* and *Ranunculus repensindicate* floodplain, ruderal, and inhabited areas (Gyulai et al. 1992; Henriksen & Robinson 1996; Latałowa et al. 2003; Sillasoo 2006; Tserendorj et al. 2021).

The remains of *Betula pendula* and *Picea abies* needles (**Fig. 5.**) may indicate the presence of planted and artificially maintained forest patches or groves, possibly rows of trees or scattered trees near the moat (Liu & Hytteborn 1991; Atkinson 1992; Kovačić & Nikolić 2005; Wistuba et al. 2013; Beck et al. 2016; Lachowicz et al. 2018; Šímová et al. 2019). The presence of both species is not typical on south-facing slopes at low elevation, which is warmer during summer and is in contradiction to their ecological needs. Moreover, spruce favours altitudes of 800 meters above sea level and exist on the northern hillsides in the Carpathian Basin (Latałowa & van der Knaap 2006; Beck et al. 2016; Tóth et al. 2017; Šímová et al. 2019). As a result, both plants were probably planted in the Szigetvár – Turbék vineyard hill site in the 17th century, and it cannot be ruled out that their presence may have been related to the function of the memorial place and the pilgrim town (Alavijeh 2012). Namely, spruce (usually the evergreen pine) is the eternal tree of life in the middle of Paradise (Eden) (Wheeler 2006), but long before the formation of state religions, it also had a magical significance in shamanism (Paul 1944). In shamanism, the pine tree was celebrated as a symbol of warmth and light that returns after the winter solstice, including the oldest evergreen pine tree on Earth (Öberg & Kullman 2011). It can be assumed that in the life of the tomb, pines, including the evergreen spruce (Adiloglu & Uludas 2011) symbolize the Islamic approach to Paradise and the appearance of eternal life. As a result, the Ottoman memorial garden of the tomb (Adiloglu & Uludas 2011) could symbolize eternal life and the Garden of Eden. Birch (*Betula*) might symbolize post-war reconciliation and peace in Islamic gardens (Ware 2017), where Islamic warriors could rest and meditate on the question of life and death. At the same time, both spruce and birch are excellent construction wood (Yildiz 2006; Hart et al. 2016), they might have had significance in traditional medicine (Aabel 2001; Keating et al. 2016) and were very good firewood as well (Fine et al. 2004; Salthammer et al. 2014). However, these properties are mainly exploited in the higher elevations of mountains and the boreal forests north of the Carpathian Basin (Jalonen & Vanha-Majamaa 2001; Helfferich 2004).

Unfortunately, pine charcoals could not be identified at the species level; however, their presence in the charcoal assemblage may support our hypothesis that planted pine (and *Betula*) trees existed in the garden of the türbe, or the vicinity of the memorial place. Oak trees may have been used as construction wood (Papp & Grynaeus 2011; Bertus-Barcza 2012; Papp 2018) in buildings or provided the wood material for the bridge (Bertus-Barcza 2012). Maple trees could be utilized during the construction of the tomb as well (Yeşilada et al. 1999; Deforce 2017; Cywa 2018). Both species were used as columns, beams, furniture, or firewood (Hæggström 1992; Willis et al. 1998; Rinaldi et al. 2013). Alder and poplar/willow trees are mainly used for making wattle fences, partitioning rooms, the construction of the walls of adobe houses and wells (Engelhardt et al. 1999; Murray et al. 2009; Cywa 2018; Mighall et al. 2018). Legs and piles of oak and maple trees were probably formed (that are hardwoods with high and medium density), and between them, a wattle fence using alder, poplar, and/or willow branches was made. This structure (hardwood legs and wattle fence) unambiguously had a protective function. Since the türbe was surrounded by a palisade (Pap et al. 2023), the oak charcoal found may be the remains of this or the bridge. A part of the identified and the burnt (thus unidentifiable) charred wood remains occurred in three horizons: in the bedrock level between 235 and 250 cm, between 130 and 145 cm, and between 85 and 100 cm. We cannot exclude that the formation of the upper two sediment levels of the moat filling might be related to the occupation of the tomb in 1664, after which it was rebuilt, and its final destruction in 1689.

So based on the archaeobotanical, anthracological data and pollen composition it is probable that fruit, vegetable, and flower gardens were established near the türbe and the settlement, with pastures, forests, and arable lands on the edges of the garden area. So, the first agricultural zone (von Thünen 1826) was established around the medieval settlement center according to the results. It is probable that the natural conditions such as the micro-topographical, pedological, and micro-climatic features of the area also played a role in the development of this economic zone and the mosaic land use, somewhat amplifying the social and environmental impact of the settlement (**Table 3,4**).

Summary

Recent investigations of historical geographical and environmental historical sources (Pap et al. 2023) complemented by geoarchaeological (Gulyás et al. 2022) analyses managed to identify the location of the burial place of Sultan Suleiman I the “Magnificent”. Following the successful discovery and excavation of the archaeological site, a moat system was revealed by boreholes. The moat was located north of the former türbe and was 4 m long, 120 cm wide, and 250 cm deep. Fourteen 30-liter samples were taken from the filling sediment wall of the 250 cm deep moat for anthracological and macrobotanical analyses at 15 cm intervals, and 10 cm intervals for pollen analysis. Radiocarbon data (Gulyás et al. 2022) suggest that the soil and sediment material of the moat accumulated during the 17th century. A mass of pollen, charcoal, and macrobotanical remains were identified from the samples of the excavated moat system. We aimed to explore the natural and artificial vegetation of the türbe and to provide information on the food habits and plant use of the former human communities. Based on the pollen and macroplant remains, arable and pasture lands, orchards, gardens and vineries, natural forest spots, and park spots were able to reconstruct, and flattened areas related to active human activity around the moat during the 17th century (**Figs. 1, 2.** and **Table 3, 4.**).

In the vicinity of the moat and at the time of its filling up, an open, human-influenced grassland dominated by gardens, and smaller arable lands; patches of deciduous forest (with oak, elm, linden, hornbeam, and beech trees) existed further from the moat. Scots pine (*Pinus sylvestris*) did not exist in the area; its higher ratio in the pollen assemblage can be explained by its significant pollen-releasing ability and its air-sacks in the pollen grain, therefore it can spread to considerable distances by the wind (Willis 1994; Willis et al. 1995, 1997, 1998, 2000). On the other hand, based on the ratio of *Picea* (spruce) pollen, there may have been planted spruce trees near the moat filling, or a smaller grove (Fredskild 1984), but this issue may have been better explored by the macrobotanical material and clarify the pollen analytical results. However, charred pine remains turned up in the charcoal assemblage, unfortunately, their identification was not possible due to the overburning of the wood material. The number of cereal pollen grains and the locally accumulated cereal seeds indicate cereal cultivation of barley (*Hordeum*) – rye (*Secale*) – oat (*Avena*) – wheat (*Triticum*) order by quantity. The low number of wheat may be related to the cultural habits of the staff working in the türbe (Gostin & Bougeva 2021) and/or to climatic factors (Sümegi et al. 2016). In the case of this latter, there is clear evidence of a cooler and wetter climate in the 17th century (Grove 1988; Pfister & Brázdil 2006; Rácz 2020), which favoured barley and rye production (Bonachela 1996; Sümegi et al. 2020). In addition to cereal cultivation, vegetation gardens, and orchards existed around the türbe based on the pollen material (Ganeshan et al. 2008). Fruit (*Prunus*) and walnut trees (*Juglans*), vegetable gardens, with peas, beans, and some sorts of celery (parsley, celery, dill, maybe anise) was grown, and flower gardens existed in the vicinity of Suleiman's türbe in the late 16thand during the 17th century.

Contribution of authors

Torma Andrea Writing – Original draft. **Náfrádi Katalin** Writing - Original Draft, Review & Editing. **Törőcsik Tünde** Writing – Original draft. **Sümegi Pál** Writing – Original draft, Supervision.

Acknowledgement

This research has been supported by the Hungarian Ministry of Human Capacities grant 20391-3/2018/FEKUSTRAT and the European Regional Development Fund grant GINOP-2.3.2-15- 2016-00009 'ICER'.

References

AABEL, S. (2001): Prophylactic and acute treatment with the homeopathic medicine Betula 30c for birch pollen allergy: a double-blind, randomized, placebo-controlled study of consistency of VAS responses. *British Homeopathic Journal* **90/02** 73–78. https://doi.org/10.1054/homp.1999.0471

ULUDAS, B. & ADILOGLU, F. (2011): Islamic gardens with a special emphasis on the Ottoman paradise gardens: The sense of place between imagery and reality. *Online Journal of Communication and Media Technologies* **1/4** 44–96. https://doi.org/10.29333/ojcmt/2345

AKBULUT, M., ERCISLI, S. & TOSUN, M. (2009): Physico-chemical characteristics of some wild grown European elderberry (Sambucus nigra L.) genotypes. *Pharmacognosy magazine* **5/20** 320-323. https://doi.org/10.4103/0973-1296.58153

ALAVIJEH, A.Z. (2012): Manifestation of Plant, Tree and Human in Asian Mythology. International Conference on Humanity, History and Society, *International Proceedings of Economics Development and Research IPEDR* **34** 180–183.

ANDERSEN, S.T. (1979): Identification of wild grass and cereal pollen. *Danmarks Geologiske Undersøgelse Årbog* **1978** 69–92.

ANDERSEN, S.T. & BERTELSEN, F. (1972): Scanning electron microscope studies of pollen of cereals and other grasses. *Grana* **12** 79–86.

ANDRÁSFALVY, B. (1961): Pekmez. Adatok törökkori szőlőkultúránk megismeréséhez. *Dunántúli Tudományos Intézet Kiadványa, Kisebb tanulmányok* 87–95.

ATKINSON, M.D. (1992): Betula pendula Roth (B. verrucosa Ehrh.) and B. pubescens Ehrh. *Journal of Ecology* **80/4** 837–870. https://doi.org/10.2307/2260870

ATCHISON, J., HEAD, L. & FULLAGAR, R. (2005): Archaeobotany of fruit seed processing in a monsoon savanna environment: evidence from the Keep River region, Northern Territory, Australia. *Journal of Archaeological Science* **32/2** 167–181. https://doi.org/10.1016/j.jas.2004.03.022

ÁRENDÁS, V. (1982): A magyarországi archeobotanikai adatok összehasonlító értékelése. *Agrártörténeti Szemle* **24** 1–52.

BAKELS, C. (1999): Archaeobotanical investigations in the Aisne valley, northern France, from the Neolithic up to the early Middle Ages. *Vegetation History and Archaeobotany* **8/1-2** 71–77. https://doi.org/10.1007/BF02042844

BALASSA, I. (1960): *A magyar kukorica*. Akadémiai Kiadó, Budapest, pp. 525.

BALASSA, I. (2001): Gabonatermesztés. In: PALÁDI-KOVÁCS, A., SZILÁGYI, M., ÉGETŐ, M. & KUPÓ, J. eds., *Magyar Néprajz* **II.**, Akadémiai Kiadó, Budapest, 295–433.

BALÉE, W. (2006): The research program of historical ecology. *Annual Review of Anthropology* **35** 75–98.

BARTOSIEWICZ, L. (1996): Medieval and Turkish period animal bones from Segesd, Southwestern Hungary. *Somogyi Múzeumok Közleményei* **12** 183–222.

BECK, P., CAUDULLO, G., DERIGO, D., TINNER, W. (2016). Betula pendula, Betula pubescens and other birches in Europe: distribution, habitat, usage and threats. In: SAN-MIGUEL-AYANZ, J., DERIGO, D., CAUDULLO, G., DURRANT, T.H. & MAUSI, A. eds., *European Atlas of Forest Tree Species.* Publication Office of the European Union, Luxembourg, 70–73.

BEHRE, K.E. (1981): The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores* **23** 225–245.

BEHRE, K.E. (1986): *Anthropogenic indicators in pollen diagrams*. Balkema, Rotterdam, pp. 232.

BEHRE, K.E. (1988): The role of man in European vegetation history. In: HUNTLEY, B. & WEBB III., T. eds., *Vegetation history*. Springer, Dordrecht, 633–672.

BEHRE, K.E. (1990): Some reflections on anthropogenic indicators and the record of prehistoric occupation phases in pollen diagrams from the Near East. In: BOTTEMA, S., ENTJES-NIEBORG, G. & VAN ZEIST, W. eds., Man´s Role in the Shaping of the Eastern Mediterranean

Landscape). Balkema, Rotterdam, Netherlands, 219–230.

BEHRE, K.E. (1993): Die tausendjährige Geschichte des Teesdalio-Arnoseridetums. *Phytocoenologia* **23** 449–456. https://doi.org/10.1127/phyto/23/1993/449

BEHRE, K.E. (2007): Evidence for Mesolithic agriculture in and around central Europe? *Vegetation History and Archaeobotany* **16** 203–219. https://doi.org/10.1007/s00334-006-0081-7

BEHRE, K.E. (2008): Collected seeds and fruits from herbs as prehistoric food. *Vegetation History and Archaeobotany* **17** 65–73. https://doi.org/10.1007/s00334-007-0106-x

BENEŠ, J., KAŠTOVSKÝ, J., KOČÁROVÁ, R., KOČÁR, P., KUBEČKOVÁ, K., POKORNÝ, P. & STAREC, P. (2002): Archaeobotany of the Old Prague Town defence system, Czech Republic: archaeology, macro-remains, pollen, and diatoms. *Vegetation History and Archaeobotany* **11/1** 107–120. https://doi.org/10.1007/s003340200012

BENNETT, K.D. (1992): PSIMPOLL: a quickBASIC program that generates PostScript page description files of pollen diagrams. *INQUA Commission for the study of the Holocene: working group on data handling methods, Newsletter* **8** 11–12.

BENNETT, K.D. 2005. PSIMPOLL manual. Available at http://www.kv.geo.uu.se/psimpoll.html (accessed 12 February 2008).

BERÉNYI, D. (1945): A kukorica termelése és összefüggése az időjárással. *Alföldi Magvető* **II/4** Tiszántúli Mezőgazdasági Kamara (Debrecen) 9–33.

BERGLUND, B.E. & RALSKA-JASIEWICZOWA, M. (1986): Pollen analysis and pollen diagrams. In: BERGLUND, B.E. ed., *Handbook of Holocene Palaeoecology and Palaeohydrology*. J. Wiley & Sons Ltd., Chichester-Toronto, 455–484.

BERTUS-BARCZA, P. (2012): Egy török kori híd maradványai. *National Geographic* 2012.09.16. https://ng.24.hu/kultura/2012/09/16/egy_torok_kori_hid_maradvanyai_/

BEUG, H-J. (1961): *Leitfaden der Pollenbestimmung*. Gustav Fischer Verlag, Stuttgart, pp. 61.

BEUG, H-J. (2004): *Leitfaden der Pollenbestimmung für Mitteleuropa und angrenzende Gebiete*. Verlag Dr. Friedrich Pfeil, München. pp. 542.

BEYTHE, I. (1595): *Füves könüv. [Herbarium]*. Manlius János kiadása, Németújvár (Güssing). (in Hungarian). pp. 134.

BIENIEK, A. (2002): Archaeobotanical analysis of some early Neolithic settlements in the Kujawy region, central Poland, with potential plant gathering activities emphasised. *Vegetation History and Archaeobotany* **11/1-2** 33–40. https://doi.org/10.1007/s003340200004

BIRKS, H.J.B. & GORDON, A.D. (1985): *Numerical methods in Quaternary pollen analysis*. Academic Press, London. pp. 317.

BOGAARD, A., JONES, G., CHARLES, M., & HODGSON, J.G. (2001): On the archaeobotanical inference of crop sowing time using the FIBS method. *Journal of Archaeological Science* **28/11** 1171–1183. https://doi.org/10.1006/jasc.2000.0621

BOGAARD, A., HODGSON, J., NITSCH, E., JONES, G., STYRING, A., DIFFEY, C., POUNCETT, J., HERBING, C., CHARLES, M., ERTUG, F., TUGAY, O., FILIPOVIC, D. & FRASER, R. (2016): Combining functional weed ecology and crop stable isotope ratios to identify cultivation intensity: a comparison of cereal production regimes in Haute Provence, France and Asturias, Spain. *Vegetation History and Archaeobotany* **25/1** 57–73. https://doi.org/10.1007/s00334-015-0524-0

BONACHELA, S. (1996): Root growth of triticale and barley grown for grain or for forage-plus-grain in a Mediterranean climate. *Plant and Soil* **183/2** 239–251.

BOSI, G., MERCURI, A.M., MAZZANTI, M. B., FLORENZANO, A., MONTECCHI, M.C., TORRI, P., RINALDI, R. (2015): The evolution of Roman urban environments through the archaeobotanical remains in Modena–Northern Italy. *Journal of Archaeological Science* **53** 19–31. https://doi.org/10.1016/j.jas.2014.09.020

BOSI, G., MAZZANTI, M.B., MONTECCHI, M. C., TORRI, P., LABATE, D. & RINALDI, R. (2017): The life of a Roman colony in Northern Italy: Ethnobotanical information from archaeobotanical analysis. *Quaternary International* **460** 135–156. https://doi.org/10.1016/j.quaint.2016.08.008

BRECHER, GY. (1960): *A magismeret atlasza.* Mezőgazdasági Kiadó, Budapest. pp. 323.

BROOKS, D.R. (1985): Historical ecology: a new approach to studying the evolution of ecological associations. *Annals of the Missouri Botanical Garden* **72** 660–685. https://doi.org/10.2307/2399219

BROWN, A. & PLUSKOWSKI, A. (2011): Detecting the environmental impact of the Baltic Crusades on a late-medieval (13^{th}–15^{th} century) frontier landscape: palynological analysis from Malbork Castle and hinterland, Northern Poland.

Journal of Archaeological Science **38/8** 1957–1966. https://doi.org/10.1016/j.jas.2011.04.010

CAPPERS, R.T.J. (2006). The reconstruction of agricultural practices in ancient Egypt: an ethnoarchaeobotanical approach. *Palaeohistoria* **47-48** 429–446.

ÇELEBI E (1684): The book of the travells [Szejáhatnáme - Müntahabat-i Evlia Çelebi] IV. (1664-1666), Ikdám, Istanbul, (1896) Hungarian translation by KARÁCSON, I. (1908): Evlia Cselebi török világutazó Magyarországi utazásai, 1664-1666. Magyar Tudományos Akadémia, Budapest, pp. 278.

CHARLES, M., BOGAARD, A., JONES, G., HODGSON, J. & HALSTEAD, P. (2002): Towards the archaeobotanical identification of intensive cereal cultivation: present-day ecological investigation in the mountains of Asturias, northwest Spain. *Vegetation History and Archaeobotany* **11/1-2** 133–142.

CLARK, R.L. (1982): Point count estimation of charcoal in pollen preparations and thin sections of sediments. *Pollen et Spores* **24** 523–35.

CYWA, K. (2018): Trees and shrubs used in medieval Poland for making everyday objects. *Vegetation History and Archaeobotany* **27/1** 111–136. https://doi.org/10.1007/s00334-017-0644-9

DAVIES, W. (2019): Gardens and gardening in early medieval Spain and Portugal. *Early Medieval Europe* **27/3** 327–348. https://doi.org/10.1111/emed.12342

DEFORCE, K. (2017): Wood use in a growing medieval city. The overexploitation of woody resources in Ghent (Belgium) between the 10th and 12th century AD. *Quaternary International* **458** 123–133. https://doi.org/10.1016/j.quaint.2016.09.059

DELACY, I.H., BASFORD, K.E., COOPER, M., BULL, J.K. & MCLAREN, C.G. (1996): Analysis of multi-environment trials – an historical perspective. In: COOPER, M. ed., *Plant adaptation and crop improvement.* CBA International, Wallingford (UK), 39–124.

DICKSON, C. (1996): Food, medicinal and other plants from the 15th century drains of Paisley Abbey, Scotland. *Vegetation history and Archaeobotany* **5/1** 25–31.

DIMBLEBY G.W. (1985): *The palynology of archaeological sites.* Academic Press, London. pp. 176.

DUNSETH, Z.C., FUKS, D., LANGGUT, D., WEISS, E., MELAMED, Y., BUTLER, D.H., YAN, X., BOARETTO, E., TEPPER, Y., BAR-OZ, G. & SHAHACK-GROSS, R. (2019): Archaeobotanical proxies and archaeological interpretation: A comparative study of phytoliths, pollen and seeds in dung pellets and refuse deposits at Early Islamic Shivta, Negev, Israel. *Quaternary Science Reviews* **211** 166–185. https://doi.org/10.1016/j.quascirev.2019.03.010

ÉGETŐ, M. (1993): *The history of peasant viticulture and winemaking on the Great Hungarian Plain from Middle Age to until the middle of the last century.* Akadémiai Kiadó, Budapest, pp. 265.

ELLENBERG, H. (1974): Zeigerwerte der Gefässpflanzen Mitteleuropas. *Scripta Geobotanica* **9** 1–97.

ELLENBERG, H. (1988): Vegetation ecology of central Europe. Cambridge University Press, Cambridge. pp. 731.

ENGELHARDT, B., HERZIG, F., KOBYLIŃSKI, Z., KRASNODĘBSKI, D., KUPRYJANOWICZ, M., & MICHNIEWICZ, M. (1999): Early Medieval wells from Pfettrach, Bavaria: cultural ecology of an early Bavarian village. *Archaeologia Polona* **37** 87–118.

ENYEDI, GY. (1957): A kukorica Magyarországon. *Földrajzi Közlemények* **131** 17–32.

ESKOLA, T., KONTIO, R. & LUNKKA, J.P. (2021): Comparison between modified LST Fastfloat and conventional HF methods for pollen preparation in highly minerogenic sediments. *Bulletin of the Geological Society of Finland* **93/1** 5–18. https://doi.org/10.17741/bgsf/93.1.001

EVANS, J.G. (1978): *An Introduction to Environmental Archaeology*. Paul Elek Press, London. pp. 154.

EVANS, J.G. & O'CONNOR, T. (1999): *Environmental Archaeology: principles and methods.* Shutton Publishing, Stroud. pp. 242.

FAEGRI, K. & IVERSEN, J. (1989): *Textbook of pollen analysis.* John Wiley and Son, Chichester. pp. 328.

FAUST, M. & SURÁNYI, D. (1999): Origin and dissemination of plums. *Horticultural Reviews* **23** 179–231.

FEKETE, L. (1993): *A hódoltság török levéltári forrásai nyomában.* Budapest Oriental Reprints, Körösi Csoma Társaság – MTA Könyvtára, Budapest, pp. 498.

FEKETE, G., VIRÁGH, K. & HORÁNSZKY, A. (1987): Facies and their response to perturbation in a turkey oak-sessile oak wood. *Acta Botanica Hungarica* **33** 19–40.

FIRBAS, F. (1937): Der pollenanalytische Nachweis des Getreidebaus. *Zeitschrift für Botanik* **31** 447–478.

FIGUEIRAL, I., BOUBY, L., BUFFAT, L., PETITOT, H., TERRAL, J.F. (2010): Archaeobotany, vine growing and wine producing in Roman Southern France: the site of Gasquinoy (Béziers, Hérault). *Journal of Archaeological Science* **37** 139–149.

FINE, P.M., CASS, G.R. & SIMONEIT, B.R. (2004): Chemical characterization of fine particle emissions from the fireplace combustion of wood types grown in the Midwestern and Western United States. *Environmental Engineering Science* **21/3** 387–409. https://doi.org/10.1089/109287504323067021

FODOR, P. (1998): Török politika Magyarországon (1520–1541). In: TÓTH, G.P. ed., Veszprém a török korban. Felolvasóülés Veszprém török kori emlékeiről. *Veszprémi Múzeumi Konferenciák* **9**. Veszprém Megyei Múzeumok Igazgatósága, Laczkó Dezső Múzeum Kiadványa, Veszprém, 7–16.

FREDSKILD, B. (1984): Holocene palaeo-winds and climatic changes in West Greenland as indicated by long-distance transported and local pollen in lake sediments. In: MÖRNER, N-A. & KARLÉN, W. eds., *Climatic changes on a yearly to millennial basis*. Springer, Dordrecht, 163–171.

FÜZES, F.M. (1972): Előzetes jelentés az 1967. évi pogányszentpéteri kolostor-ásatás XVI. század eleji gabonaleletéről. *Thúry György Múzeum Évkönyve,* Nagykanizsa, 285–290.

GANESHAN, S., RAJASEKHARAN, P.E., SHASHIKUMAR, S. & DECRUZE, W. (2008): Cryopreservation of pollen. In: REED, B.M. ed., *Plant cryopreservation: a practical guide*. Springer, New York, 443–464. https://doi.org/10.1007/978-0-387-72276-4_17

GECSÉNYI L. (1988): Data on the history of viticulture around Győr between 12. and 17. century. *Győri Tanulmányok* **9** 19–38.

GOSTIN, A.I. & BOGUEVA, D. (2021): History of eating habits in the Balkans. In: GOSTIN, A.I., BOGUEVA, D. & KOKURINOV, V. eds., *Nutritional and Health Aspects of Food in the Balkans*. Academic Press, London, pp. 9–20. https://doi.org/10.1016/B978-0-12-820782-6.00012-8

GREGUSS, P. (1945): *A középeurópai lomblevelű fák és cserjék meghatározása szövettani alapon.* Országos Magyar Természettudományi Múzeum Kiadó, Budapest. pp. 159.

GREGUSS, P. (1955): *Identification of living gymnosperms on the basis of xylotomy*. Akadémiai Kiadó, Budapest, pp. 667.

GROVE, J.M. (1988): *The little ice age*. Routledge, London, pp. 498.

GUARRERA, P.M., FORTI, G. & MARIGNOLI, S. (2005): Ethnobotanical and ethnomedicinal uses of plants in the district of Acquapendente (Latium, Central Italy). *Journal of Ethnopharmacology* **96/3** 429–444. https://doi.org/10.1016/j.jep.2004.09.014

GULYÁS, S., TORMA, A., PAP, N., FODOR, P., KITANICS, M., GYENIZSE, P., MOLNÁR, M. & SÜMEGI, P. (2022): Tackling erosion-accumulation events in a moat sequence from an unique Ottoman memorial place (Szigetvár, SW Hungary) using ^{14}C and geoarcheological data. *Archaeological and Anthropological Sciences* **14/1** 1–12. https://doi.org/10.1007/s12520-021-01479-x

GYENIZSE, P. & BOGNÁR, Z. (2014): Szigetvár és környéke 16–17. századi tájrekonstrukciója kartográfiai és geoinformatikai módszerekkel. In: PAP, N. ed., Szülejmán szultán emlékezete Szigetváron/Kanuni Sultan Süleyman'ın Sigetvar'daki Hatırası. *Mediterrán és Balkán Fórum* **8**, 73–90.

GYULAI, F. (1995): Natural environment and climate. Plant explotation and agriculture. In: BARTOSIEWICZ, L. ed., Animals in the Urban Landscape in the Wake of the Middle Ages. A case study from Vác, Hungary. *BAR International Series*, **609**, 93–110.

GYULAI, F. (2010): *Archaeobotany in Hungary. Seed, fruit, food and beverages remains in the Carpathian basin: an archaeobotanical investigation of plant cultivation and ecology from the Neolithic until the late Middle Ages*. Archaeolingua, Budapest. pp. 479.

GYULAI, F., EMŐDI, A., MRAVCSIK, Z., & PÓSA, P. (2013): Az újkori mezőgazdasági kultúrkörnyezet rekonstrukciója a sárospataki ásatások példáján. *Gesta*, **13** 67–71.

GYULAI, F. (2014a): The history of broomcorn millet (Panicum miliaceum L.) in the Carpathian-Basin in the mirror of archaeobotanical remains I. From the beginning until the Roman Age. Columella: *Journal of Agricultural And Environmental Sciences* **1** 29–38. https://doi.org/10.18380/SZIE.COLUM.2014.1.1.29

GYULAI, F. (2014b): The history of broomcorn millet (Panicum miliaceum L.) in the Carpathian-Basin in the mirror of archaeobotanical remains II. From the Roman Age until the Late Medieval Age. Columella: *Journal of Agricultural And Environmental Sciences* **1** 39–48. https://doi.org/10.18380/SZIE.COLUM.2014.1.1.39

GYULAI, F., HERTELENDI, E. & SZABÓ, I. (1992): Plant remains from the early medieval lakeshore settlement Fonyód-Bélatelep (Lake Balaton, Hungary) with especial emphasis on the history of fruit cultivation in Pannonia. *Vegetation history and archaeobotany* **1/3** 177–184. https://doi.org/10.1007/BF00191557

GYULAI, G., MALONE, R.P., WATERS, L., HESZKY, L. & KISS, E. (2011): Morphogenetics of ancient Vitis seeds (3rd and 11th-15th c., Hungary) – a genotype reconstruction. In: GYULAI, G. ed., *Plant Archaeogenetics*. Nova Science Publishers, New York, 41–48.

HÆGGSTRÖM, C.A. (1992): Wooded meadows and the use of deciduous trees for fodder, fuel, carpentry and building purposes. Protoindustries et histoire des forêts. GDR ISARD-CNRS Les *Cahiers de l'Isard* **3** 151–162.

HAJNALOVÁ, M. (2007): Early farming in Slovakia: an archaeobotanical perspective. In: COLLEDGE, S. & CONOLLY, J. eds., *The origins and spread of domestic plants in southwest Asia and Europe*, Routledge Press, London, 295–314.

HART, J.P., SHAFIE, T., BIRCH, J., DERMARKAR, S. & WILLIAMSON, R.F. (2016): Nation building and social signaling in southern Ontario: AD 1350–1650. PloS One **11/5** e0156178. https://doi.org/10.1371/journal.pone.0156178

HEGYI, K. (1976): Egy világbirodalom végvidékén. Gondolat Kiadó, Budapest, pp. 292.

HELFFERICH, D. (2004): Birch: white gold in the boreal forest. *Agroborealis* **35** 4–12.

HENRIKSEN, P.S., & ROBINSON, D. (1996): Early Iron Age agriculture: archaeobotanical evidence from an underground granary at Overbygård in northern Jutland, Denmark. *Vegetation History and Archaeobotany* **5/1-2** 1–11. https://doi.org/10.1007/BF00189430

HORVÁTH, M. (1811): Az ipar és kereskedés története Magyarországon a három utolsó század alatt. Magyar Királyi Nyomda, Buda. pp. 391.

HOSCH, S. & JACOMET, S. (2001): New aspects of archaeobotanical research in central European Neolithic lake dwelling sites. *Environmental archaeology* **6/1** 59–71. https://doi.org/10.1179/env.2001.6.1.59

HU, Z., ZHAO, C., ZHAO, Y. & LIU, J. (2021): Pollen morphology of Liliaceae and its systematic significance. *Palynology* **45/3** 531–568. https://doi.org/10.1080/01916122.2021.1882601

Hungarian National Archives, Urbaria et Conscriptiones: 50: 57; 8. –136: 30; 3. – 94: 30; 5 (historical source in Table 1).

Hungarian National Archives: Hoffinanz Ungarn, W2279 (historical source in Table 1**)**.

HYVÖNEN, T. & HUUSELA-VEISTOLA, E. (2008): Arable weeds as indicators of agricultural intensity–a case study from Finland. *Biological Conservation* **141/11** 2857–2864. https://doi.org/10.1016/j.biocon.2008.08.022

IMREH, I. (1999): Erdélyi eleink emlékezete (1550–1850). Telek László Alapítvány, Budapest, pp 371.

JACOBSON, G.L. & BRADSHAW, R.H.W. (1981): The selection of sites for palaeovegetational studies. *Quaternary Research* **16** 80–96.

JACOMET, S. (2006): *Identification of cereals remains from archaelogical sites*, 2nd edition, Archaeobotany Lab, Integrative Prehistoric and Archaeological Science (IPAS), Basel University. pp. 61.

JACOMET, S., KREUZ, A. & RÖSCH, M. (1999): *Archäobotanik: Aufgaben, Methoden und Ergebnisse vegetations- und agrargeschichtlicher Forschung*. Ulmer, Stuttgart. pp. 368.

JACQUART, D. (2008): Islamic pharmacology in the middle ages: theories and substances. *European Review* **16/2** 219–227. https://doi.org/10.1017/S1062798708000215

JACQUIOT, C. (1955): *Atlas d'anatomie des bois des coniferes*. Centre Technique du Bois, Paris. pp. 133.

JALONEN, J. & VANHA-MAJAMAA, I. (2001): Immediate effects of four different felling methods on mature boreal spruce forest understorey vegetation in southern Finland. *Forest Ecology and Management* **146/1-3** 25–34. https://doi.org/10.1016/S0378-1127(00)00446-1

JOLY, C., BARILLÉ, L., BARREAU, M., MANCHERON, A. & VISSET, L. (2007): Grain and annulus diameter as criteria for distinguishing pollen grains of cereals from wild grasses. *Review of Palaeobotany and Palynology* **146/1-4** 221–233. https://doi.org/10.1016/j.revpalbo.2007.04.003

JONES, G. (1992): Weed phytosociology and crop husbandry: identifying a contrast between ancient and modern practice. *Review of Palaeobotany and Palynology***73/1-4** 133–143.

KALESNY, F. (1993): Über den Weinbau und den Weinverkauf in Preßburg bis Ende des 15. Jahrhunderts. In: MARSINA, R. ed., *Städte im Donauraum*. Bratislava-Preßburg, Slovenská historická spoločnosť, Bratislava, 184–193.

KARÁCSON, I. (1908): Evlia Cselebi török világutazó Magyarországi utazásai, 1664-1666. Magyar Tudományos Akadémia, Budapest, pp. 278.

KATONA, J. & DÖMÖTÖR, J. (1963): Magyar borok – borvidékek. Mezőgazdasági Kiadó, Budapest, pp. 205.

KÁLDY-NAGY, GY. (1985): A budai szandzsák 1546-1590. évi összeírása. Demográfiai és gazdaságtörténeti adatok - Pest Megye Múltjából 6. Pest Megyei Levéltár kiadványa, Budapest, pp. 756.

KEATING, J., TCHOU, J., OKUSANYA, O., FISHER, C., BATISTE, R., JIANG, J., KENNEDY, G., NIE, S. & SINGHAL, S. (2016): Identification of breast cancer margins using intraoperative near‐infrared imaging. *Journal of surgical oncology* **113/5** 508–514. https://doi.org/10.1002/jso.24167

KENÉZ, Á., MALATINSZKY, Á. & PETŐ, Á. (2014): The first archaeobotanical evidence of Dasypyrum villosum in Hungary: an archaeophyte weed or a native grass? *Vegetation history and archaeobotany* **23/6** 841–849. https://doi.org/10.1007/s00334-014-0468-9

KNAPP, H., NELLE, O. & KIRLEIS, W. (2015). Charcoal usage in medieval and modern times in the Harz Mountains Area, Central Germany: Wood selection and fast overexploitation of the woodlands. *Quaternary International* **366** 51–69. https://doi.org/10.1016/j.quaint.2015.01.053

KOHLER-SCHNEIDER, M. & CANEPPELE, A. (2009): Late Neolithic agriculture in eastern Austria: archaeobotanical results from sites of the Baden and Jevišovice cultures (3600–2800 bc.). *Vegetation History and Archaeobotany* **18/1** 61–74. https://doi.org/10.1007/s00334-007-0129-3

KOSENKO, V.N. (1999): Contributions to the pollen morphology and taxonomy of the Liliaceae. *Grana* **38/1** 20–30.

KOSZAŁKA, J. & STRZELCZYK, J. E. (2015): Archaeobotanical reconstructions of field habitats and crops: the grange in Pomorzany near Kutno, 18th/19th c. *Biodiversity Research and Conservation* **37/1** 75–81. https://doi.org/10.1515/biorc-2015-0006

KOVAČIĆ, S. & NIKOLIĆ, T. (2005): Relations between Betula pendula Roth (Betulaceae) leaf morphology and environmental factors in five regions of Croatia. *Acta Biologica Cracoviensia Series Botanica* **47/2** 7–13.

KOZÁKOVÁ, R. & POKORNÝ, P. (2007): Dynamics of the biotopes at the edge of a medieval town: pollen analysis of Vltava river sediments in Prague, Czech Republic. *Preslia* **79** 259–281.

KÖRÖSI, A. (2009): Szentkirály (Bács-Kiskun megye) késő középkori falu 2. gödöróljának állatcsontleletei. *Studia Caroliensia* **7** 353–382.

KREUZ, A. & SCHÄFER, E. (2011): Weed finds as indicators for the cultivation regime of the early Neolithic Bandkeramik culture? *Vegetation History and Archaeobotany* **20/5** 333-348. https://doi.org/10.1007/s00334-011-0294-2

LAPTEVA, E.G. & KORONA, O.M. (2012): Holocene vegetation changes and anthropogenic influence in the forest-steppe zone of the Southern Trans-Urals based on pollen and plant macrofossil records from the Sukharysh cave. *Vegetation history and archaeobotany* **21/4-5** 321–336. https://doi.org/10.1007/s00334-011-0333-z

LACHOWICZ, H., SAJDAK, M., PASCHALIS-JAKUBOWICZ, P., CICHY, W., WOJTAN, R. & WITCZAK, M. (2018): The influence of location, tree age and forest habitat type on basic fuel properties of the wood of the silver birch (Betula pendula Roth.) in Poland. *BioEnergy Research* 11/3 638–651. https://doi.org/10.1007/s12155-018-9926-z

LATAŁOWA, M., BADURA, M. & JAROSIŃSKA, J. (2003): Archaeobotanical samples from non-specific urban contexts as a tool for reconstructing environmental conditions (examples from Elbląg and Kołobrzeg, northern Poland). *Vegetation History and Archaeobotany* 12/2 93–104. https://doi.org/10.1007/s00334-003-0011-x

LÁSZLÓFALVI VELICS, A. & KAMMERER, E. (1886): *Magyarországi török kincstári defterek I.* 1543-1635. Akadémiai Kiadó, Budapest. pp. 526.

LÁSZLÓFALVI VELICS, A. & KAMMERER, E. (1890): *Magyarországi török kincstári defterek II.* 1543-1635. Akadémiai Kiadó, Budapest. pp. 526.

LIU, Q. & HYTTEBORN, H. (1991): Gap structure, disturbance and regeneration in a primeval Picea abies forest. *Journal of Vegetation Science* **2/3** 391–402.

LODWICK, L.A. (2018): Arable weed seeds as indicators of regional cereal provenance: a case study from Iron Age and Roman central-southern Britain. *Vegetation History and Archaeobotany* **27/6** 801–815. https://doi.org/10.1007/s00334-018-0674-y

LOSOSOVÁ, Z., DANIHELKA, J. & CHYTRÝ, M. (2003): Seasonal dynamics and diversity of weed vegetation in tilled and mulched vineyards. *Biologia* **58/1** 49–57.

LOSOSOVÁ, Z., HORSÁK, M., CHYTRÝ, M., ČEJKA, T., DANIHELKA, J., FAJMON, K., HÁJEK, O., JUŘICKOVÁ, L., KINTROVÁ, K., LÁNÍKOVÁ, D., OTÝPKOVÁ, Z., ŘEHOŘEK, V. & TICHÝ, L. (2011): Diversity of Central European urban biota: effects of human‐made habitat types on plants and land snails. *Journal of Biogeography* **38/6** 1152–1163. https://doi.org/10.1111/j.1365-2699.2011.02475.x

MAGYAR, L. (2013): Historical review of the research on the germination biology of weeds in Hungary. *Magyar Gyomkutatás és Technológia* **14/1** 4–25.

https://doi.org/10.3390/agronomy12040891

MAGYARI, E.K., CHAPMAN, J.C., PASSMORE, D.G., ALLEN, J.R. M., HUNTLEY, J.P. & HUNTLEY, B. (2010). Holocene persistence of wooded steppe in the Great Hungarian Plain. *Journal of Biogeography* **37/5** 915–935. https://doi.org/10.1111/j.1365-2699.2009.02261.x

MAGYARI, E.K., CHAPMAN, J., FAIRBAIRN, A.S., FRANCIS, M. & DEGUZMAN, M. (2012): Neolithic human impact on the landscapes of North-East Hungary inferred from pollen and settlement records. *Vegetation History and Archaeobotany* **21/4-5** 279–302. https://doi.org/10.1007/s00334-012-0350-6

MAHER Jr., L.J. (1981): Statistics for microfossil concentration measurements employing samples spiked with marker grains. *Review of Palaeobotany and Palynology* **32/2-3** 153–191.

MARGUERIE, D. & HUNOT, J.Y. (2007): Charcoal analysis and dendrology: data from archaeological sites in north-western France. *Journal of Archaeological Science* **34/9** 1417–1433. https://doi.org/10.1016/j.jas.2006.10.032

MARINOVA, E. & ATANASSOVA, J. (2006): Anthropogenic impact on vegetation and environment during the Bronze Age in the area of Lake Durankulak, NE Bulgaria: Pollen, microscopic charcoal, non-pollen palynomorphs and plant macrofossils. *Review of Palaeobotany and Palynology* **141/1-2** 165–178. https://doi.org/10.1016/j.revpalbo.2006.03.011

MARIOTTILIPPI, M., BELLINI, C., MORISECCI, M., GONNELLI, T. & PALLECCHI, P. (2015): Archaeobotany in Florence (Italy): landscape and urban development from the late Roman to the Middle Ages. *Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology* **149/1** 216–227. https://doi.org/10.1080/11263504.2013.822433

MCPARTLAND, J.M., & HEGMAN, W. (2018): Cannabis utilization and diffusion patterns in prehistoric Europe: A critical analysis of archaeological evidence. *Vegetation History and Archaeobotany* **27/4** 627–634. https://doi.org/10.1007/s00334-017-0646-7

MELIUS JUHÁSZ, P. (1578): Herbarium. Az fáknak, füveknek nevekről, természetükről és hasznairól. Heltai Gáspárné Műhelye, Kolozsvár. *Bibliotheca Hungarica Antiqua* **37** Országos Széchenyi Könyvtár, Balassi Kiadó, Magyar Tudományos Akadémia Irodalom-tudományi Intézet, Budapest, 2002, pp. 188.

MIGHALL, T., TIMPANY, S., WHEELER, J., BAILEY, L., BAMFORTH, M., GRAY, L. & TAYLOR, M. (2018): Vegetation Changes and Woodland Management Associated with a Prehistoric to Medieval Burnt Mound Complex at Ballygawley, Northern Ireland. *Environmental Archaeology* **23/3** 267–285. https://doi.org/10.1080/14614103.2017.1370856

MOORE, P.D., WEBB, J.A. & COLLINSON, M.E. (1991): *Pollen Analysis.* Blackwell Scientific, Oxford, pp. 2016.

MOLNÁR, I. (1978): Budina Sámuel históriája, magyarul és latinul Szigetvár 1566. évi ostromáról. – *A Szigetvári Várbaráti Kör Kiadványai* **6**. – Szigetvár, pp. 45.

MRAVCSIK, Z., GYULAI, F., VINOGRADOV, S., EMŐDI, A., ROVNER, I. & GYULAI, G. (2015): Digital seed morphometry for genotype identification–Case study of seeds of excavated (15th century Hungary) and current vinegrape (Vitis v. vinifera) varieties. *Acta Botanica Hungarica* **57/1-2** 169–182. https://doi.org/10.1556/ABot.57.2015.1-2.13

MURRAY, H., MURRAY, J.C. & LINDSAY, W. (2009): Medieval timber-lined wells in Elgin. *Proceedings of the Society of Antiquaries of Scotland* **139** 213–227.

NÁFRÁDI, K. (2011): Identification and evaluation of charred wood remains derived from archaeological sites in geoarcheological research. *PhD Thesis*, University of Szeged? Szeged, pp. 138.

NECIPOĞLU, G. (1997): The suburban landscape of sixteenth-century Istanbul as a mirror of classical Ottoman garden culture. In: PETRUCCIOLI, A. ed., *Gardens in the Time of the Great Muslim Empires: Theory and Design*. E.J. Brill, Leiden, New York, pp. 32–71.

NIXON, S., MURRAY, M.A. & FULLER, D.Q. (2011): Plant use at an early Islamic merchant town in the West African Sahel: the archaeobotany of Essouk-Tadmakka (Mali). *Vegetation History and archaeobotany* **20/3** 223–239. https://doi.org/10.1007/s00334-010-0279-6

NYERGES, É. & BARTOSIEWICZ, L. (2006): Animal keeping at Szentkirály in light of archaeozoological data from the Middle Ages. *Studia Caroleinsia* **3-4** 331–351.

ÖBERG, L. & KULLMAN, L. (2011): Ancient subalpine clonal spruces (Picea abies): sources of postglacial vegetation history in the Swedish Scandes. *Arctic* **64/2** 183–196. https://doi.org/10.14430/arctic4098

ÖZHATAY, N. & KOÇYIĞIT, M. (2009). Pollen morphology of Allium species (Liliaceae) in European Turkey and around Istanbul. *Phytologia Balcanica* **15/2** 199–208.

PAP, N. (2014): Szülejmán szultán emlékezete Szigetváron. / Kanuni Sultan Süleyman'ın

Sigetvar'daki Hatırası. *Mediterrán és Balkán Fórum* **8**, pp. 135.

PAP, N. (2019): The Pilgrime Town (Türbe kasabasi) of Sultan Süleyman at Szigetvár. In: FODOR, P., ed., *The battle for Central Europe: The Siege of Szigetvár and the Death of Süleyman the magnificient and Nicholas Zrínyi (1566).* Hungarian Academy of Sciences, Research Centre for the Humanities, Budapest, pp. 539–552. https://doi.org/10.1163/9789004396234_028

PAP, N., KITANICS, M., GYENIZSE, P., HANCZ, E., BOGNÁR, Z., TÓTH, T. & HÁMORI, Z. (2015): Finding the Tomb of Suleiman the Magnificent in Szigetvár, Hungary: Historical, Geophysical and Archeological Investigations. *Die Erde* **146/4** 289–303. https://doi.org/10.12854/erde-146-22

PAP, N., FODOR, P., KITANICS, M., GYENIZSE, P. & HANCZ, E. (2023): Introduction. Historical and archaeological data for integrated multiproxy environmental historical analyses on the moat profile of the türbe complex of Sultan Suleiman I at Szigetvár – Turbék vineyard hill site (Hungary). *Archeometriai Műhely* **XX/3** 195–200. https://doi.org/10.55023/issn.1786-271X.2023-016

PAPP, A. (2018): The Turk baths of Hungary. Archaeological remains of the Ottoman era. Archaeolingua Press, Budapest, pp. 153.

PAPP, A. & GRYNAEUS, A. (2011): Chronological Determination of the turk Baths in Budapest. *Budapest Régiségei* **44** 259–273.

PAUL, F. (1944): Spruce root basketry of the Alaska Tlingit. *Ethnographic Art Publication*, Washington, pp. 80.

PÁKAY, Zs. (1984): Adalékok a tapolcai és sümegi járás török kori történetéhez a rovásadó-összeírások alapján (1531–1696). *Veszprém Megyei Múzeumok Közleménye* **17** 233–271.

PEÑA - CHOCARRO, L. & PÉREZ - JORDÀ, G. (2019): Garden plants in medieval Iberia: the archaeobotanical evidence. *Early Medieval Europe* **27/3** 374–393. https://doi.org/10.1111/emed.12348

PENNY, D., POTTIER, C., FLETCHER, R., BARBETTI, M., FINK, D. & HUA, Q. (2006): Vegetation and land-use at Angkor, Cambodia: a dated pollen sequence from the Bakong temple moat. *Antiquity* **80/309** 599–614. https://doi.org/10.1017/S0003598X00094060

PFISTER, C. & BRÁZDIL, R. (2006): Social vulnerability to climate in the "Little Ice Age": an example from Central Europe in the early 1770s. *Climate of the Past* **2** 115–129. https://doi.org/10.5194/cp-2-115-2006

P. HARTYÁNYI, B., NOVÁKI, GY. & PATAY, Á. (1967/1968): Növényi mag- és termésleletek Magyarországon az újkőkortól a XVIII. századig. I. *Magyar Mezőgazdaság Múzeum Közleményei* **1967/1968** 5–84.

P. HARTYÁNYI, B. & PATAY, Á. (1970): A dunaföldvári öregtoronynál előkerült régészeti növények vizsgálata. *Szekszárdi Balogh Ádám Múzeum Évkönyve* **1** 209–222.

PICHLER, T., NICOLUSSI, K., GOLDENBERG, G., HANKE, K., KOVÁCS, K. & THURNER, A. (2013). Charcoal from a prehistoric copper mine in the Austrian Alps: dendrochronological and dendrological data, demand for wood and forest utilisation. *Journal of Archaeological Science* **40/2** 992–1002. https://doi.org/10.1016/j.jas.2012.09.008

PINKE, Z., FERENCZI, L., ROMHÁNYI, B. F., GYULAI, F., LASZLOVSZKY, J., MRAVCSIK, Z., PÓSA, P., LASZLOVSZKY, J. & GÁBRIS, G. (2017): Zonal assessment of environmental driven settlement abandonment in the Trans-Tisza region (Central Europe) during the early phase of the Little Ice Age. *Quaternary Science Reviews* **157** 98–113. https://doi.org/10.1016/j.quascirev.2016.12.010

POLDINI, L., ORIOLO, G. & MAZZOLINI, G. (1998): The segetal vegetation of vineyards and crop fields in Friuli-Venezia Gulia (NE Italy). *Studia Geobotanica* **16** 5–32.

PORTER, R. S. & BODE, R.F. (2017): A review of the antiviral properties of black elder (Sambucus nigra L.) products. *Phytotherapy Research* **31/4** 533–554. https://doi.org/10.1002/ptr.5782

PRENTICE, I.C. (1985): Pollen representation, source area, and basin size: toward an unified theory of pollen analysis. *Quaternary Research* **23** 76–86. https://doi.org/10.1016/0033-5894(85)90073-0

PUNT, W., BLACKMORE, S., HOEN, P.P. & STAFFORD, P.J. (2003): The Northwest European Pollen Flora: Reprinted from *Review of Palaeobotany and Palynology* 123/1-2 Elsevier, Amsterdam, pp. 194.

RAPP, G.R., HILL, C.L. & HILL, M.C.L. (2006): Geoarchaeology: the earth-science approach to archaeological interpretation. Yale University Press, New Haven, pp. 339.

RÁCZ, L. (2020): Carpathian basin–the winner of the little ice age climate changes: long-term time-series analysis of grain, grape and hay harvests between 1500 and 1850. *Economic- and Ecohistory* **16/1** 81–96.

REILLE, M. (1992): *Pollen et Spores d'Europe et d'Afrique du Nord.* Laboratoire de Botanique Historique et Palynologie, Marseille, pp. 543.

REILLE, M. (1995): *Pollen et Spores d'Europe et d'Afrique du Nord. Supplement 1*. Laboratoire de Botanique Historique et Palynologie, Marseille, pp. 331.

REILLE, M. (1998): *Pollen et Spores d'Europe et d'Afrique du Nord. Supplement 2*. Laboratoire de Botanique Historique et Palynologie, Marseille, pp. 521.

RINALDI, R., MAZZANTI, M.B. & BOSI, G. (2013): Archaeobotany in urban sites: the case of Mutina. *Annali di Botanica* **3** 217–230. https://doi.org/10.4462/annbotrm-10292

ROBERTS, N. (2013): *The Holocene: an environmental history*. John Wiley & Sons, London, pp. 328.

ROBIN, V., KNAPP, H., BORK, H. R., NELLE, O. (2013): Complementary use of pedoanthracology and peat macro-charcoal analysis for fire history assessment: illustration from Central Germany. *Quaternary International* **289** 78–87. https://doi.org/10.1016/j.quaint.2012.03.031

RUGGLES, D.F. (2011): *Islamic gardens and landscapes*. University of Pennsylvania Press, Philadelphia (USA), pp. 312.

SALTHAMMER, T., SCHRIPP, T., WIENTZEK, S. & WENSING, M. (2014): Impact of operating wood-burning fireplace ovens on indoor air quality. *Chemosphere* **103** 205–211. https://doi.org/10.1016/j.chemosphere.2013.11.067

SÁNCHEZ-PARDO, J.C., MARRON, E.H. & ȚIPLIC, M.C. (2020): *Ecclesiastical Landscapes in Medieval Europe*. Archaeopress, Oxford, pp. 246.

SÁRKÖZI, Á., JANICSAK, G., KURSINSZKI, L. & KERY, A. (2006): Alkaloid composition of Chelidonium majus L. studied by different chromatographic techniques. *Chromatographia* **63/13** S81–S86. https://doi.org/10.1365/s10337-006-0728-7

SCHERMANN, SZ. (1966): *Seed knowledge I-II*. Akadémiai Kiadó, Budapest, pp. 869, 212.

SKOFLEK I. (1985): Remains of seeds and fruits from Sümeg-Sarvaly in 16. century. *Magyar Mezőgazdasági Múzeum Közleményei,* **1984/85** 33–44.

SCHWANTNER, M. (1798): *Statistik des Königreichs Ungarn*. Matthias Trattner nyomda, Pest, pp. 622.

SCHWEINGRUBER, F.H. (1990): *Anatomy of European woods: An Atlas for the Identification of European Trees, Shrubs and Dwarf Shrubs / Anatomie Europäischer Hölzer: Ein Atlas zur Bestimmung Europäischer Baum-, Strauch- und Zwergstrauchhölzer.* Verlag Paul Haup, Birmensdorf, pp. 800.

SILLASOO, Ü. (2006): Medieval plant depictions as a source for archaeobotanical research. *Vegetation History and Archaeobotany* **16/1** 61–70. https://doi.org/10.1007/s00334-006-0036-z

ŠÍMOVÁ, A., PÁNEK, T., GAŁKA, M., ZERNITSKAYA, V., HÁJKOVÁ, P., BRODSKA, H., JAMRICHOVÁ, E. & HAJEK, M. (2019): Landslides increased Holocene habitat diversity on a flysch bedrock in the Western Carpathians. *Quaternary Science Reviews* **219** 68–83. https://doi.org/10.1016/j.quascirev.2019.07.009

"Sinan Bey oğlu eski Sadrazam Şehit Mehmet Paşa Vakfı", evahir-i Zilhicce/981.; 1574.03.24-04.22 (h.sz. 981). 572 numaralı defter 27 sayfa ve 20. sıra (historical source in Table 1).

SOEPBOER, W., SUGITA, S., LOTTER, A.F., VANLEEUWEN, J.F.N. & VANDERKNAAP, W.O. (2007): Pollen productivity estimates for quantitative reconstruction of vegetation cover on the Swiss Plateau. *The Holocene* **17** 65–77. https://doi.org/10.1177/0959683607073279

Somogy County Archive Contracts 1789 (1604-1891), without page number (historical source in Table 1).

ŠOŠTARIĆ, R. & KÜSTER, H. (2001): Roman plant remains from Veli Brijun (island of Brioni), Croatia. *Vegetation History and Archaeobotany* **10/4** 227–233. https://doi.org/10.1007/PL00006934

STEWART, J. (1955): The theory of cultural change - The methodology of multilinear evolution University of Illinois Press, Urbana-Chicago, pp. 244.

STIEBER J. (1967): A magyarországi felső-pleisztocén vegetáció-története az anthrakotómiai eredmények (1957-ig) tükrében. *Földtani Közlöny* **97** 308–317.

STOCKMARR, J. (1971): Tablets with spores used in absolute pollen analysis. *Pollen et Spores* **13** 614–621.

SUGITA, S. (1994): Pollen representation of vegetation in Quaternary sediments: theory and method in patchy vegetation. *Journal of Ecology* **82** 881–897. https://doi.org/10.2307/2261452

SÜMEGI, B.P. (2020): A szigetvári Szulejmán türbe palánk északi árkának feltárása és üledékföldtani elemzése. In: TÖRŐCSIK, T., GULYÁS, S., MOLNÁR, D. & NÁFRÁDI, K. eds., *Környezettörténet. Tanulmányok Sümegi Pál professzor 60 éves születésnapi köszöntésére. Geolitera*, Szeged, 449–456.

SÜMEGI, P., MOLNÁR, D., NÁFRÁDI, K., PÁLL, D.G., PERSAITS, G., SÁVAI, SZ. & TÖRŐCSIK, T. (2016): The environmental history of Southern Transdanubia during the Medieval and the Ottoman Period in the light of palaeoecological and geoarcheological research. In: KOVÁCS, Gy. & ZATYKÓ, Cs. eds., *Per sylvam et per lacus nimios.* The Medieval and Ottoman Period in Southern Transdanubia. Southwest Hungary the Contribution of the Natural Sciences. Institute of Archaeology Research Centre for the Hungarian Academy of Sciences, Budapest, 15–73.

SÜMEGI, P., NÁFRÁDI, K., TÖRŐCSIK, T., JAKAB, G., BODOR, E., MOLNÁR, M., SÜMEGI, B.P., TAPODY, R.O., KNIPL, I., KUSTÁR, R. & BÁNFFY, E. (2020): Prehistoric environment of the Sárköz region in the Danube Valley, southern Hungary. Case studies from infilled oxbow lakes. In: BÁNFFY, E. ed., *The Environmental History of the Prehistoric Sárköz Region in Southern Hungary.* Confinia et Horizontes, Harrassowitz Verlag, Darmstadt, 83–158.

SÜMEGI, P. (2023): Results of the malacological assemblage of the memorial tomb's moat of Sultan Suleiman I, at Szigetvár (Hungary). *Archeometriai Műhely* **XX/3** 243–250. https://doi.org/10.55023/issn.1786-271X.2023-019

SZIKSZAI FABRICIUS, B. (1590): Nomenclatura seu dictionarium Latino Ungaricum. Csáktornyaj János kiadása, Debrecen, pp. 181.

SZILÁGYI S. (1895): *Erdélyi országgyűlési emlékekek. 18. rész, 1683-1686. Transylvanian parliamentary memories. 18. part, 1683-1686.* Magyar Tudományos Akadémia Kiadványa, Budapest, pp. 606.

SZABÓ, P. (2015): Historical ecology: past, present and future. *Biological Reviews* **90/4** 997–1014. https://doi.org/10.1111/brv.12141

SZAKÁLY F. (1981): *Magyar adóztatás a török hódoltságban.* Akadémiai Kiadó, Budapest, pp. 485.

Szigetvár Presbytery: Prothocollum Parochia Magno Szigethana 1717-34; 1738, No.1774 (historical source in Table 1).

TORMA A. (1996a): Szentkirály archeobotanikai leletei. In: PÁLÓCZI-HORVÁTH A., SOMHEGYI T. & TORMA A. eds., *Élet egy középkori faluban, 25 év régészeti kutatása a 900 éves Szentkirályon. Kiállítási katalógus* Magyar Mezőgazdasági Múzeum kiadványa, Budapest, 37–45.

TORMA A. (1996b): Botanikai leletek a középkori Pápáról. *Pápai Múzeumi Értesítő* **6** 325–328.

TORMA A. (1997): Archeobotanikai maradványok a középkorból *Agrártörténeti Szemle* **38** 317–342.

TORMA, A. (2003): Palaeobotanical assembleges from Mediaeval wells in Hungary. *Anthaeus* **26** 245–255.

TÓTH, E.G., VENDRAMIN, G.G., BAGNOLI, F., CSEKE, K. & HÖHN, M. (2017): High genetic diversity and distinct origin of recently fragmented Scots pine (Pinus sylvestris L.) populations along the Carpathians and the Pannonian Basin. *Tree Genetics & Genomes* **13/2** 47. https://doi.org/10.1007/s11295-017-1137-9

TÖRŐCSIK, T. & SÜMEGI, P. (2019): Pollen-based reconstruction of the plant cultivation in the Carpathian basin from the Migration Age to the end of the Medieval Age. *Archeometriai Műhely* **XVI/3** 245–270.

TSERENDORJ, G., MARINOVA, E., LECHTERBECK, J., BEHLING, H., WICK, L., FISCHER, E., SILLMANN, M., MÄRKLE, T. & RÖSCH, M. (2021): Intensification of agriculture in southwestern Germany between the Bronze Age and Medieval period, based on archaeobotanical data from Baden-Würtenberg. *Vegetation History and Archaeobotany* **30/1** 35–46. https://doi.org/10.1007/s00334-020-00814-x

TWEDDLE, J.C., EDWARDS, K.J. & FIELLER, N.R. (2005): Multivariate statistical and other approaches for the separation of cereal from wild Poaceae pollen using a large Holocene dataset. *Vegetation history and archaeobotany* **14/1** 15–30. https://doi.org/10.1007/s00334-005-0064-0

UEDA, Y. & TOMITA, H. (1989): Morphometric analysis of pollen exine patterns in roses. *Journal of the Japanese Society for Horticultural Science* **58/1** 211–220. https://doi.org/10.2503/jjshs.58.211

UJVÁROSI, M. (1957): Gyomnövények, gyomirtás. Mezőgazdasági Kiadó, Budapest, pp. 786.

ULLAH, F., ZAFAR, M., AHMAD, M., DILBAR, S., SHAH, S.N., SOHAIL, A., ZAMAN, W., IQBAL, M., BAHADUR, S. & TARIQ, A. (2018): Pollen morphology of subfamily Caryophylloideae (Caryophyllaceae) and its taxonomic significance. *Microscopy Research and Technique* **81/7** 704–715. https://doi.org/10.1002/jemt.23026

VASS, E. (1993): Szigetvár város és a szigetvári szandzsák jelentősége az Oszmán-Török Birodalomban 1565-1689. – In: SZITA, L. ed., *Tanulmányok a török hódoltság és a felszabadító háborúk történetéből.* Baranya Megyei Levéltár és a Magyar Történelmi Társulat Dél-dunántúli Csoportja, Pécs, 193–217.

VATIN, N. (2005): Un türbe sans maître. Note sur la foundation de la destination du türbe de Soliman-le-Magnifique à Szigetvár. *Turcica* **37** 9–42. https://doi.org/10.2143/TURC.37.0.2011699

VERNET, J.L. (2006): History of the Pinus sylvestris and Pinus nigra ssp. salzmanni forest in the Sub-Mediterranean mountains (Grands Causses, Saint-Guilhem-le-Désert, southern Massif Central, France) based on charcoal from limestone and dolomitic deposits. *Vegetation History and Archaeobotany* **16/1** 23–42. https://doi.org/10.1007/s00334-005-0032-8

VON THÜNEN, J. (1826): *Der Isolierte Staat in Beziehung auf Landwirtschaft und National-ökonomie.* Perthes, Hamburg, pp. 678.

WAGNER, J.CH. (1700): *Johann Christoph Wagners Christlichund Türckischer Staedt- und Geschicht-Spiegel. Vorweisend Eine eigentliche Beschreibung aller der vornehmsten Städte, Vestungen und Schlösser der Christenheit und Türckey,* Koppmayer, Augsburg, pp. 147.

WALLACE, M. & CHARLES, M. (2013): What goes in does not always come out: the impact of the ruminant digestive system of sheep on plant material, and its importance for the interpretation of dung-derived archaeobotanical assemblages. *Environmental Archaeology* **18/1** 18–30. https://doi.org/10.1179/1461410313Z.00000000022

WARE, V. (2017): From war grave to peace garden: Muslim soldiers, militarized multiculture, and cultural heritage. *Journal of War & Culture Studies* **10/4** 287–304. https://doi.org/10.1080/17526272.2017.1396069

WEISS, E. & KISLEV, M.E. (2004): Weeds & seeds. *The Biblical archaeology review* **30/6** 32–37.

WHEELER, B. (2006): Mecca and Eden: Ritual, relics, and territory in Islam. University of Chicago Press, Chicago, pp. 333.

WILLIS, K.J. (1994): The vegetational history of the Balkans. *Quaternary Science Reviews* **13/8** 769–788. https://doi.org/10.1016/0277-3791(94)90104-X

WILLIS, K.J., SÜMEGI, P., BRAUN, M. & TÓTH, A. (1995): The late Quaternary environmental history of Bátorliget, NE Hungary. *Palaeogeography, Palaeoclimatology, Palaeoecology* **118/1-2** 25–47. https://doi.org/10.1016/0031-0182(95)00004-6

WILLIS, K.J., BRAUN, M., SÜMEGI, P. & TÓTH, A. (1997): Does soil change cause vegetation change or vice versa? A temporal perspective from Hungary. *Ecology* **78/3** 740–750. https://doi.org/10.1890/0012-9658(1997)078[0740:DSCCVC]2.0.CO;2

WILLIS, K.J., SÜMEGI, P., BRAUN, M., BENNETT, K.D. & TÓTH, A. (1998): Prehistoric land degradation in Hungary: who, how and why? *Antiquity* **72/275** 101–113. https://doi.org/10.1017/S0003598X00086312

WILLIS, K.J., RUDNER, E. & SÜMEGI, P. (2000): The full-glacial forests of central and southeastern Europe. *Quaternary Research* **53/2** 203–213. https://doi.org/10.1006/qres.1999.2119

WISTUBA, M., MALIK, I., GÄRTNER, H., KOJS, P. & OWCZAREK, P. (2013): Application of eccentric growth of trees as a tool for landslide analyses: The example of Picea abies Karst. in the Carpathian and Sudeten Mountains (Central Europe). *Catena* **111** 41–55. https://doi.org/10.1016/j.catena.2013.06.027

YEŞILADA, E., SEZIK, E., HONDA, G., TAKAISHI, Y., TAKEDA, Y. & TANAKA, T. (1999): Traditional medicine in Turkey IX: Folk medicine in north-west Anatolia. *Journal of ethnopharmacology* **64/3** 195–210. https://doi.org/10.1016/S0378-8741(98)00133-0

YILDIZ, U.C. (2006): Mechanical and chemical behavior of spruce wood modified by heat. *Building and environment* **41/12** 1762–1766. https://doi.org/10.1016/j.buildenv.2005.07.017

ZOHARY, D., HOPF, M., WEISS, E. (2012): *Domestication of Plants in the Old World: The origin and spread of domesticated plants in Southwest Asia, Europe, and the Mediterranean Basin.* Oxford University Press, Demand, pp. 264.