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ORIGINAL ARTICLE

Food and agriculture in Slavonia, Croatia, during the Late Middle Ages: the archaeobotanical evidence

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Abstract

This paper presents the results from archaeobotanical remains collected from ten medieval settlements and fort sites in the region of present-day Slavonia, Croatia. From the 12th century AD, Slavonia was part of the Kingdom of Hungary, although the region benefited from a certain amount of autonomy. Examining the archaeobotanical data from this period shows a diverse agricultural system, where crop fields, gardens, orchards, pastures and woodlands were all used to produce a range of cereals, fruits, nuts, vegetables and herbs, as well as fibre plants. The dataset is dominated by cereal remains, especially *Triticum aestivum/durum* (free-threshing wheat), *Panicum miliaceum* (broomcorn millet) and *Secale cereale* (rye). *Vitis vinifera* (grape pips) were the most common fruit recovered, which corresponds with the presence of vineyards and international trade in wine noted in the literature by the late Middle Ages. Also of significance was the recovery of *Cannabis sativa* (hemp) and *Linum usitatissimum* (flax), which suggest local cultivation, possibly for linen and hemp fibres, for oil or for medicinal purposes.

Keywords Plant macro-remains · Cereals · Trade · Hungary · Late Medieval · Croatia

Introduction

As grain was the chief component of human diets during the Middle Ages, whether it was consumed as bread, porridge, pottage (a thick soup or stew) or beer, it is surprising how little is known about cereal production and consumption in regions such as Croatia. We gain some insight into economic evidence from historical sources, yet very little archaeological evidence (archaeobotanical or zooarchaeological) has been recovered or analysed so far. Within Croatia as a whole, two published sites have yielded carbonised plant remains from the 12th to 16th century: Vrbovec castle (Šoštarić and Šegota 2010a) and Torčec (Šoštarić 2004; Šoštarić and Šegota 2010b). Both sites are located within continental Croatia; Vrbovec castle is near Klenovec Humski and Torčec near Koprivnica by the Hungarian border. From Vrbovec castle nearly 900 carbonised grains of *Triticum aestivum* (bread wheat) were recovered, along with a few grains of *Hordeum vulgare* (barley) and *Panicum miliaceum* (broomcorn millet). In addition, there were isolated finds of other food plants such as *Vitis vinifera* (grape) and *Cucumis melo/sativus* (melon/cucumber). At Torčec excavations largely revealed several settlements dating from the 7th to the 15th century (Šoštarić 2004; Šoštarić and Šegota 2010b). Several non-carbonised plant remains were identified, but the carbonised remains included bread wheat, *Triticum spelta* (spelt), barley and broomcorn millet, as well as *Linum usitatissimum* (flax), grape and *Prunus persica* (peach).

This paper therefore considerably expands on this sparse evidence by presenting new archaeobotanical data from ten sites located within present-day Slavonia, located in the northeastern continental region of Croatia. The sites range in

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date from the 8th to the 17th century, but to keep the discussion focused we will concentrate on feudal crop husbandry regimes during the Árpád, Anjou and the Habsburg dynasties of the 12th to 16th centuries AD. Preferences and availability of plants for food and other economic uses undoubtedly changed over time within the region. In this study we aim to explore to what extent these changes are traceable in the archaeobotanical record. We compare our data with available information from other archaeobotanical studies in Hungary and Croatia, located within the medieval Kingdom of Hungary, and examine information from written sources. This paper also gives us the opportunity to discuss present and future research on medieval agriculture in Croatia.

Historical background

Today Slavonia is located in the eastern part of northern (continental) Croatia (Fig. 1). However, in the Late Middle Ages, the name Slavonia referred to the western part of continental Croatia, an area that lies between the rivers Sava, Drava, Sutla and Dunav (Danube) and included some parts of modern northern Bosnia and Hercegovina (Fig. 2). The eastern part of continental Croatia has no clear historical data but would have come under the jurisdiction of the Kingdom of Hungary. During the 16th and 17th centuries the area of Slavonia moved further east to form present-day Slavonia as it has remained. At that time, the region of old medieval

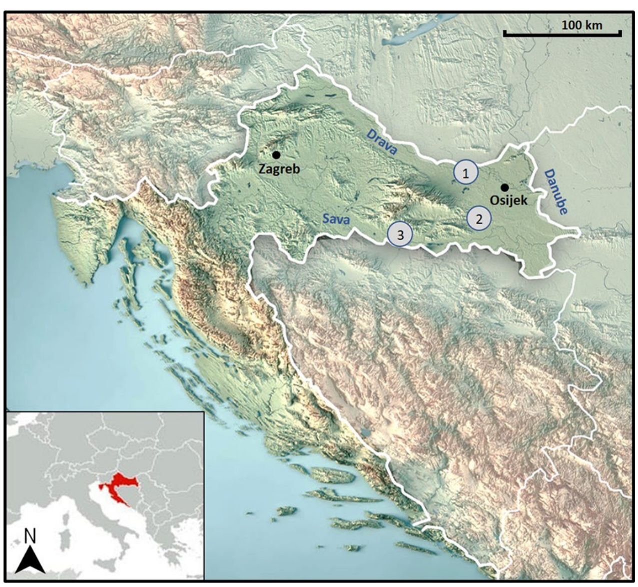

Fig. 1 Location of the medieval settlements; 1, Donji Miholjac-Đanovci (DM-D); 2, Đakovo–Franjevac (D–F), Tomašanci–Palača (T–P), Pajtenica–elike Livade (P–VL), Jurjevac–Stara Vodenica (J–SV), Ivandvor–Šuma Gaj (I–SG), Ivanovci Gorjanski–Palanka (IG–P); 3, Bijela Stijena, Rašaška, Sv. Ivan Trnava (adapted from Ramspott 2017)

Fig. 2 Map showing the Kingdoms of Hungary and of Slavonia (*Regnum Sclavoniae*) in the middle of the 14th century and divisions of Slavonia into *zupanija* (regions) (adapted from Regan 2003, pp 143–144, map 90–91)

Slavonia became incorporated within Croatia (present-day central Croatia) (Andrić 2001, pp. 60–61).

Medieval Slavonia had its own *ban* (governor), legal system, and administration, separate from the rest of Croatia (Fine 2006). This self-governing community is mentioned in the historical sources as the *Regnum Sclavoniae* (Kingdom of Slavonia) and was originally created by local landowners who united the medieval *županija* (regions/counties) of Križevci, Zagreb, Varaždin and Virovitica in the mid 13th century under the government of the *ban* (Fig. 2). The Hungarian feudal system was also introduced to medieval Slavonia, and almost certainly to the area of present-day Slavonia, with the crowning of King Coloman of Hungary in AD 1097. The Árpád dynasty, which King Coloman was a part of, lasted until the end of the 13th century. This period witnessed significant changes in the social structure of the ruling classes. *Županija* developed into institutions of noble autonomy, while the clergy increasingly separated themselves from the royal household to establish private monasteries and households outside the control of the *ispán/župan* (Hungarian/Croatian) county leaders (Rady 2000, pp. 32–33). Changes in land ownership also occurred when estates that had been owned collectively began to be broken up. The custom of partible inheritance, in which property was divided among many heirs, led to small parcels of land and even halves of villages ending up with different owners, leading to highly dispersed landholdings. This division was also matched amongst the peasantry with increased enclosure of the land (Klaić 1978, p. 224; Rady 2000, pp. 46–47). Population density is also thought to have been generally quite low throughout the Middle Ages, especially during periods of conflict such as the Mongol invasion in 1242 and plague, which first arrived in 1349 and then re-occurred periodically over the next few centuries (Schultheiss and Tardy 1966). Consequently, the Hungarian kings invited foreign settlers to their realm in large numbers and provided them with numerous privileges (Berend 2001; Petrovics 2017). In the 11th to 12th centuries many settlers came from Flanders, northern France, Lorraine and Lombardy, and from the 12th to the 13th century many Germans (*Teutonici* and *Saxones*) settled in the kingdom.

From the 14th century, and especially from the second half of the 15th century during the reign of king Matthias Corvinus, Hungary and Croatia (Slavonia) became Christendom's first line of defence against the east. When the Habsburg Ferdinand I was crowned king of Hungary, Dalmatia, Croatia and Slavonia in 1527, he soon began to defend the region from Turkish incursions. A military frontier was established and divided into two districts under special military administrations; the Croatian and the Slavonian military frontiers (Dávid and Fodor 2000; Holjevac and Moačanin 2007). Initially, the military frontier came under the jurisdiction of the Croatian *sabor* (parliament) and *ban* but, in 1627, it was placed under the direct control of the Habsburg military. Again, depopulation meant that landowners had to attract new settlers, but compulsory military service to the Habsburg empire meant that the population in the military frontier were free of serfdom and enjoyed considerable political autonomy. Significant upheavals beset Slavonia in the 16th century when the Ottoman empire expanded into most of present-day Slavonia, western Bosnia (then called Turkish Croatia) and Lika.

Within this context of war, migration, plague and general socio-economic changes, farmers also had to contend with climatic fluctuations. During the late Middle Ages the climate changed from the warmer Medieval Climatic Anomaly period to the Little Ice Age (Ferenczi et al. 2018; Kiss 2019; Vadas 2020). The water table also changed, being significantly lower in the Árpád period than in the late Middle Ages, with a major flood peak occurring in the late 15th or early 16th century (Vadas 2020). As well as flooding there are records of great droughts, documented in 1362, 1474, 1479, 1494 and 1507, resulting in significant shortages of crops, wine and hay (Kiss and Nikolić 2015; Kiss 2020). There is also documentary evidence of a 5 year long locust invasion dated to 1474, which spread into Hungary from Moldavia and reached as far as Bohemia and Linz in Austria (Kiss and Nikolić 2015). It was said that they consumed all green vegetation except the leaves of vines and trees.

Generally, sources dating from between the 12th and 16th centuries agree that the Kingdom of Hungary (including Slavonia) was a fertile land, rich in water, pastures and woods, where crops were grown and livestock raised (Fara 2017). At Berzence, a village on the Hungarian side of the river Drava, land records from 1377 show division into arable land and pastures, with mills and numerous fishponds located on the riverbanks (Kovács et al. 2014). While arable fields and pastures were listed on the northern, higher part of Berzence, only a few mentions of arable land can be found from the southern area that was prone to flooding, instead they refer to meadow management and fishponds. Land was therefore used in different ways depending on the location and elevation. Livestock was also an important element of the diet. However there have been few detailed studies of animal husbandry practices, and even fewer linking these with crop husbandry strategies. What we do know is usefully summarised by Tkalčec and Trbojević Vukičević (2021) who outline the archaeozoological evidence from medieval Slavonia and the rest of present-day Slavonia. Generally, pigs and cattle were commonly found, although sheep/goat, poultry and wild game were also identified. However, they found no clear patterns between regions or through time, which was probably due to the small numbers of bones identified from the different sites. The high percentages of pigs and wild animals at some of the sites would support the presence of woods in the local landscape. An increase in cattle trading, especially between Hungary and the west, and horse breeding is also noted in the later Middle Ages with a large-scale boom in trade in the 15th century (Bartosiewicz 1995; Varga 2007; Petrovics 2011; Szende 2011, p. 218). This probably led to an expansion in land used as pasture, as well as growing more crops as fodder.

Materials and methods

Over the last 10 years, archaeobotanical samples have been collected from 10 excavations at medieval settlement and defensive sites located within present-day Slavonia (Fig. 1; Table 1, ESM 1). This includes Đakovo–Franjevac (D–F), Ivandvor–Šuma Gaj (I–SG), Ivanovci Gorjanski–Palanka (IG–P), Jurjevac–Stara Vodenica (J–SV), Pajtenica–Velike Livade (P–VL), Tomašanci–Palača (T–P), Donji Miholjac–Đanovci (DM–D), Rašaška, Bijela Stijena and Sv. Ivan Trnava. In the Middle Ages only the sites DM–D and Bijela Stijena, and possibly Rašaška and Sv. Ivan Trnava would have belonged under the jurisdiction of medieval Slavonia.

Sample sizes were generally not recorded, but it is suggested that samples were usually one bucket full (ca. 11 L). At DM-D each sample was 6 L. Here 40 archaeobotanical samples were taken from a range of contexts, such as pits, hearths and house floors associated with the early and late medieval period at this multi-period site. The carbonised plant macro-remains were retrieved using water flotation and

Table 1 The archaeological sites located in present-day Slavonia, Croatia

Site name	Site type	No. of samples	Date range (AD)	References
Donji Miholjac–Đanovci (DM-D)	Multi-period settlement	39	8th–10th and 14th–15th cent	Tkalčec (2016)
Đakovo–Franjevac (D–F)	Multi-period settlement	1	11th–15th cent	Balen (2007a, 2011); Ivanković (2010)
Tomašanci–Palača (T–P)	Multi-period settlement	13	10th–13th cent	Balen (2008a, 2020); Balen and Gerometta (2011)
Pajtenica–Velike Livade (P–VL)	Multi-period settlement	8	11th–12th cent	Balen (2006)
Jurjevac–Stara Vodenica (J–SV)	Multi-period settlement	11	10th–13th cent	Balen (2008b); Bunčić (2012, 2016)
Ivandvor–Šuma Gaj (I–SG)	Multi-period settlement	7	8th–14th cent	Balen et al. (2009)
Ivanovci Gorjanski–Palanka (IG–P)	Multi-period settlement	13	10th–12th and 13th–14th cent	Balen (2007b); Šegvić (2010)
Rašaška	Fort	3	13th–15th cent	Matković (2013); Ivanušec and Mihaljević (2015)
Sv. Ivan Trnava	Fort	1	14th–15th cent	Mihaljević et al. (2014, 2015)
Bijela Stijena	Fort	3	14th–17th cent	Mihaljević (2011); Mihaljević and Ivanušec (2012a, 2012b, 2013); Matković (2013)

0.3 and 0.5 mm sieves to collect the flots and a 1 mm mesh sieve for the heavy residue.

Rescue excavations near Đakovo, on part of the Beli Manastir to Osijek and Svilaj motorway, provided 53 archaeobotanical samples from six multi-period sites; Đakovo–Franjevac (D–F), Tomašanci–Palača (T–P), Pajtenica–Velike Livade (P–VL), JurjevacStara Vodenica (JSV), Ivandvor–Šuma Gaj (I–SG) and Ivanovci Gorjanski–Palanka (IG–P). All samples were from pit features that contained material culture dated to the medieval period. The carbonised plant macro-remains were retrieved using water flotation, a 0.5 mm sieve to collect the flot and a 1 mm mesh for the heavy residue. The soil was clay rich, which hindered the flotation process, so the heavy residue was also sorted for charred plant remains.

Three further sites, Bijela Stijena, Rašaška and Sv. Ivan Trnava, located near Nova Gradiška, yielded seven archaeobotanical samples from medieval contexts. At Rašaška samples were collected from SJ (stratigraphic unit) 8, a floor layer within the building that contained collapsed stone, rubble and several fragments of pottery. At Sv. Ivan Trnava one archaeobotanical sample was collected from a 14/15th century well within the courtyard of the fort. At Bijela Stijena samples were collected from within the watchtower (SJ 53), which also contained much pottery, some metal finds and animal bones. All samples were processed with water flotation, using a 0.5 mm sieve to collect the flot and a 1 mm mesh for the heavy residue.

All samples were completely sorted, except sample 31 from IG-P, where only 5% of the sample was investigated. The data presented in ESM 2, Table S1 have been extrapolated up to 100%. Identification was done using a low power binocular microscope at 7–40×. Identifications were made using well-established morphological criteria and by comparison with modern reference material. The nomenclature of scientific plant names follows Zohary and Hopf (2000) for cultivated plants and the *Flora Croatica Database* for wild plants (Nikolić 2018). A standardised counting method was used, whereby each grain was counted as one and the minimum number of individuals (MNI) was estimated for fragments of grains. Glume base fragments were counted as one unless clearly representing part of another fragment, while whole spikelet forks were counted as two glume bases. The fruit and weed remains were counted as one, except where large item were broken and clearly represented the same parts of one seed.

Results

A total of 99 archaeobotanical samples were examined and of these, 17 samples either did not contain any carbonised macro-remains or only had unidentified fragments. Overall, just over 37,000 carbonised plant remains were recovered from the sites, along with five mineralised seeds of *Sambucus ebulus*, within three samples recovered from the 14th to 15th century settlement at DM–D. Approximately 90% of the remains were cereals, however, a large proportion are from sample 31 (SJ 73) at IG-P. Of the cereals, the largest number of grains (63%) were of *Triticum aestivum/durum* (free-threshing wheat) (Fig. 3; Table 2), followed by *Panicum miliaceum* (29%). Less than 2% of the cereals included *Secale cereale* (rye), with only a few grains of *Triticum dicoccum* (emmer) and *T. monococcum* (einkorn) and individual finds of *Hordeum vulgare* and *T. spelta* (spelt) being recovered. Just 12 chaff remains of *Avena sativa* (oat),

Table 2 Summary of the economic plant remains identified at each site

	Đakovo-Franjevac	Ivandvor – Šuma Gaj	Ivanovci Gorjanski – Palanka	Jurjevac – Stara Vodenica	Pajtenica-Velike Livade	Tomašanci – Palača	Donji Miholjac	Rašaška	Bijela Stijena
Cereal grains									
Hordeum vulgare			2				4		
Hordeum sp.							1	1	
Triticum aest./dur./rachis	12	4	15,920/1	6	11	9	71/1	97	
T. cf. *aestivum/durum*			4,820	2	1	2	2		
T. cf. *aest./dur./dicoccum*								13	
T. monococcum	2		20					4	
T. dicoccum				1	1			15	
T. (cf.) *spelta*						1	(4)	(4)	
Triticum spp.	4	7	1,838	10		3	10	25	
(cf.) *Secale cereale*/rachis	5	3	526	2	2	3	32 (4)/(2)	77 (2)	
Avena (cf.) *sativa*/rachis	(5)		(21)	(4)	(4)		13 (47)/3		
(cf.) *Panicum miliaceum*	22	1	8,895	23	8		54 (7)	433	
Setaria italica								2	
Cerealia indet., frag/rachis	42	20	20,202/4	37	36	29	89	180	
Straw	1	1					10		
Pulses									
(cf.) *Vicia faba*	7	1		3			(1)		(1)
Lathyrus sativus							1		
(cf.) *Lens culinaris*	1			2	1	1	(1)		
Pisum sativum				1		1	1		
Large legumes indet	8	2	5	2			2		3
Oil and fibre plants									
(cf.) *Linum usitatissimum*			3				2 (1)		
Cannabis sativa							1		
Papaver somniferum							6		
Fruits and nuts									
Cornus mas			2				1		
Corylus sp., frag		7	1	8	2				
Fragaria sp.							4		
Malus/Pyrus sp.							3		
Olea sp., wild			1						
Physalis alkekengi			2			1			
Prunus avium (sp.)			2 (2)					(1)	(1)
Rosa sp.						4			
Rubus fruticosus/idaeus (sp.)	(1)						4 (2)	(1)	
Rubus fruticosus (*R. idaeus*)							1 (1)		
Vitis vinifera			2				18	16	
Quercus sp.			1						
Indet fruit	3		2	2					
Herbs									
Brassica sp.	1			1			1		
cf. *Daucus* sp.							1		
Mentha arvensis			1						
Portulaca oleracea							11		
Solanum nigrum							24		
Sisymbrium sp.							5		
Verbena officinalis			13	3			26	2	

See ESM 2 for the full list of taxa per sample

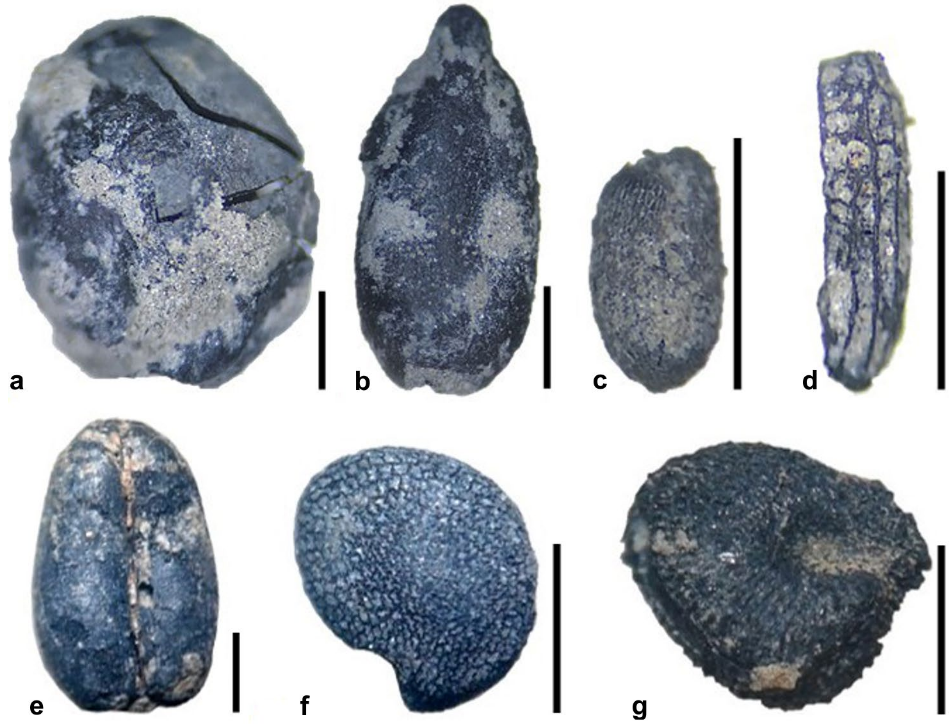

Fig. 3 Carbonised plant remains from medieval Donji Miholjac–Đanovci (DM–D); **a** *Cannabis sativa*; **b** *Linum usitatissimum*; **c** *Sisymbrium* sp.; **d** *Verbena officinalis*; from medieval layers at Tomašanci–Palača T–P; **e** *Triticum aestivum/durum*; **f** *Physalis alkekengi*; **g** *Agrostemma githago*; scale bar = 1 mm, images by K. Reed

free-threshing wheat and possibly rye were recovered from DM–D, I–SG and IG–P. Similarly, only 23 pulse remains were recovered, mostly of *Vicia faba* (broad bean) and *Lens culinaris* (lentil), but *Pisum sativum* (pea) and *Lathyrus sativus* (grass pea) were also noted. A small number of oil and fibre plants were recovered, including three *Linum usitatissimum* (flax) seeds identified from IG–P and DM–D, as well as one *Cannabis sativa* (hemp) achene from within the burnt remains of a hearth (SJ 397) dated to the 14th–15th century settlement at DM-D (Fig. 3). *Papaver somniferum* (opium poppy) was also recovered from two samples (313/SJ1201 and 280/SJ61) at DM-D.

A small number of fruit remains and nuts were identified, including 36 *Vitis vinifera* pips, mainly from DM-D and Rašaška, although two pips were also recovered from sample 49 (SJ 13) at IG-P. A small number of other taxa were found, including *Cornus mas* (cornelian cherry), *Physalis alkekengi*, (Chinese lantern, Fig. 3), *Prunus avium* (wild cherry), *Malus/Pyrus* sp. (apple/pear), *Rubus fruticosus* (blackberry) and *R. idaeus* (raspberry), as well as one *Olea* sp. (olive) fruit stone from IG-P. The second largest group of remains (10%) were weeds and other wild plants, and over 80 different genera of these were recorded. The main taxa identified included *Agrostemma githago* (corncockle), which had a large concentration in sample 31 (SJ 73) at IG–P, grasses, such as *Bromus, Lolium* and *Poa*, small seeded Fabaceae (*Trifolium/Medicago*), *Chenopodium* spp. (goosefoot) and *Polygonum* spp. (knotweeds). Some possible herbs or medicinal plants were also identified, including *Verbena officinalis* (vervain), *Solanum nigrum* (black nightshade), *Brassica* sp. (mustard/cabbage), *Sisymbrium* (hedge mustard) and *Mentha arvensis* (wild mint).

Taphonomy

Determining seed density at the sites was difficult except at DM–D, as there are no records from the other sites of the volume of sediment collected per sample (see above). Overall, the estimated density of plant items (excluding unidentified fragments) is relatively low for most samples, with an average of 4.7 seeds per litre from all the sites (excluding the large deposit found at IG–P; sample 31/SJ 73). Generally, densities of remains were less than 2/L at D–F, I–SG, J–SV, P–VL, T–P and Bijela Stijena. The highest densities came from Rašaška (average 29.3 plant items/L) and IG–P (average 502.5/L). The most significant find was the large deposit of cereals, mainly *T. aestivum/durum* and *P. miliaceum*, recovered from a pit (sample 31/SJ 73) at IG–P (Fig. 4). The weed taxa in this sample are limited, with only *A. githago* being found in any significant numbers, suggesting that the grain had been almost completely processed before being burnt and deposited in the context. There is no evidence of burning in the pit, so it is likely that the charred remains, along with lumps of charcoal, were deposited either as part of one activity, or over a short period of time from several activities. In contrast, the samples with low densities of remains probably derive from different charring events and were subsequently deposited in a secondary or even tertiary

Fig. 4 Excavation of the pit at Ivanovci Gorjanski–Palanka (IG–P) and a closer view of context SJ73, where sample 31 was collected; (image by J. Balen)

context. Thus, the plant remains from D–F, I–SG, J–SV, P–VL, T–P and Bijela Stijena probably represent settlement scatter that has been moved around the site before being deposited in the context from which it was recovered. The fact that many of the sites are multi-period also means that caution should be attached to unusual or singular finds of particular taxa, as they could have been moved from prehistoric to medieval contexts (Pelling et al. 2015). The results will therefore be discussed based on cumulative evidence rather than on a site-by-site basis.

Discussion

To discuss the archaeobotanical remains within their wider context, we examine all available archaeobotanical data collected from medieval settlements in continental Croatia (the region of medieval Slavonia and present-day Slavonia) and Hungary (Hungarian data from Gyulai 2010). The list of taxa presents only the carbonised remains of plants that could represent food, fibre or have medicinal properties (ESM 2; Table S2). A few sites also provided uncarbonised remains, however these have been excluded here to allow like for like comparison (as the taphonomic processes are different for carbonised and waterlogged remains). Any uncertain (cf.) identifications were removed, and some categories were condensed, so that, for example, subspecies of barley were recorded as simply *Hordeum vulgare*. The data are separated into the Árpád period (10th–13th century AD), from which 22 sites with archaeobotanical remains are recorded, and the Anjou and Habsburg period (14th–16th century AD), from which 18 sites are recorded.

Cereal cultivation in the Kingdom of Hungary and Slavonia

Overall, cereals are the most dominant plant remains in the assemblages. If we look at the two periods in Hungary as well as the data collected from the region of continental Croatia, free-threshing wheat, broomcorn millet and rye are present at over 60% of the sites (Table 3). The quantity of free-threshing wheat is also extremely high with several pits containing thousands of grains, as at Győr ECE and Vác, Széchenyi. In contrast, the quantity of broomcorn millet is

Table 3 The frequency (%) of cereal grains per site within present-day Hungary and northern Croatia and the total number of carbonised grains recovered for each species

	N-Croatia 8th–15th c. (n = 12)		Hungary 10th–13th c. (n = 22)		Hungary 13th–16th c. (n = 18)	
	Freq	*n*	Freq	*n*	Freq	*n*
Triticum aestivum/durum	92	17,032	73	14,515	67	26,421
Panicum miliaceum	83	9,474	68	219	78	3,179
Secale cereale	67	659	64	8,059	61	2,677
Avena sativa	50	94	27	128	44	1,679
Hordeum vulgare	42	14	73	5,212	72	7,115
Triticum monococcum	25	26	23	6	11	4
Triticum dicoccum	25	17	32	50	–	–
Triticum spelta	17	12	5	2	6	8
Setaria italica	17	3	5	1	6	1

relatively low from early medieval Hungarian sites, compared to the few thousand grains found in Croatia and from the later medieval period in Hungary. However, this may simply be a recovery bias rather than an indication of more limited millet growing in this period. Barley is also present in over 70% of the sites from Hungary, representing over 12,000 grains, but for Croatia only 14 grains were recovered from 42% of the sites. The frequency of oat increases from the Árpád to the Habsburg period, from 27 to 44% of the sites, while it was present in 50% of the sites in Croatia.

The dominance of free-threshing wheat and rye corresponds with both archaeological and literary sources that indicate these were the main crops grown in medieval Hungary and generally in Europe, although regional differences exist (for example, Gyulai 1995, p. 97; Ruas 2005; Kočár et al. 2010; Rottoli 2014). From historical sources we know that rye was one of the principal cereals exported from east to western Europe from the 12th century (Hybel 2002). This included Hungarian merchants, who are mentioned in records of grain imports into Bruges and Flanders around the 13th century (Hybel 2002). Wheat, barley and oats are also noted as imports to numerous ports and towns across Europe. In terms of cultivation, some suggest that free-threshing wheat would have required greater inputs of labour and of manure and the provision of better drainage compared to barley and rye. Thus, its dominance as a crop is believed to have reflected more labour intensive farming methods as well as agrarian organisation (Hamerow 2002, p. 153). Bakels (2005) examining medieval sites in the Netherlands also noted that soil types clearly made a difference to the crops grown, with rye, oats and barley being grown on sandy soils, while on loess and loam wheat would have partly taken over from rye as a winter crop. She also concluded that changes in political authority and territories had no great impact on the crops grown during the medieval period.

The finding of both free-threshing wheat and rye together has been suggested by some as an indication of growing a mixture (maslin) of both together, and other mixed crops such as barley and oats or a cereal with a legume (Campbell 2000, p. 262; Blagojević 2004, p. 84; Gyulai 2014a, b). Pretty (1990) suggests that the mixtures were probably intended as smother crops, in which strong competition between the two different species helped to outcompete weeds as well as helping to reduce risk of complete crop failure. In England, manorial accounts show a range of growing regimes, where some would grow only wheat and oats on their own but mixed the other crops (Pretty 1990). However, identifying maslin crop practices is notoriously difficult from archaeobotanical remains, especially from sites such as these where the samples represent mixed settlement debris (Jones and Halstead 1995). The extremely large deposit of cereal grains recovered from IG–P is probably the only sample from Slavonia that could indicate a cleaned or at least semi-cleaned crop. The sample contained ca. 67% free-threshing wheat, ca. 28% broomcorn millet and a small proportion of rye (if the unidentified grains are excluded). However, it is unlikely that this represents a maslin crop as broomcorn millet, as a summer crop, has a different growing cycle to free-threshing wheat, and the presence of rye could have arisen from a previous rye crop, making it a weed within the wheat. However, millet could have been stored with the larger wheat grains filling voids and optimising storage and potentially improving preservation (Castiglioni and Rottoli 2013).

Broomcorn millet is present at most of the sites and in large quantities within the region of continental Croatia and Hungary. Its popularity may have been linked to its short growing cycle and tolerance of bad weather and poor soils. The Cumans, Turkic nomadic people who settled in Hungary from the 13th century onwards, are thought to have brought *boza*, a fermented drink originally made with millet, to the region (Hosszú 2013, p. 154). However, there has been very little discussion about millet in literature from this period. At Tiszaörvény a large deposit of broomcorn millet grains and panicles was found in the corner of a house that would suggest a food store for human consumption (Gyulai 2010, p. 197). Stable isotope analyses of bones have also allowed us to identify the consumption of millet at this time. For example, analysis of human remains dating to the 13th century at Solt-Tételhegy suggested that most of their diets consisted of over 70% of C_3 plants, such as wheat, while C_4 plants, such as millet, on average constituted around 21% of adult diets (Gugora et al. 2018). Although this isotope value could result from eating livestock that were fed millet, it is probable that it was consumed at this time in Hungary.

Interestingly, spelt remains are relatively rare during both periods in Hungary and continental Croatia, yet it became a dominant crop in areas of Germany and Switzerland (Rösch 2008; Kühn and Brombacher 2014). Very small quantities of emmer and einkorn were also identified, probably showing a regional preference for these crops that has survived in certain parts of southeast Europe until today (Hajnalová and Dreslerová 2010). This is seen in Spain, where historical records indicate the presence of glume wheats in the medieval period and ethnographic surveys have found areas where they are still cultivated today (Peña-Chocarro and Zapata Peña 1998). Historical records suggest that einkorn was consumed occasionally by humans but was mostly grown for animals, depending on the region and cultural preference (Zaharieva and Monneveux 2014). Environmental factors may have also been a factor as, compared to free-threshing wheat, these species are somewhat more tolerant of less fertile soils and adverse weather conditions, which could have been useful for avoiding risk of crop failure.

Oat is generally present in low quantities at only a few sites in continental Croatia and Hungary, although there was one large find of over 1,500 *Avena* grains from Vác-Széchenyi. In contrast, barley is present in large quantities and high frequencies in both periods. As well as being consumed by people, oats and barley could also be used for fodder, especially to feed horses (Langdon 1982; Banerjea et al. 2020) and could have supplemented hay or other fodder. At 13th century Veselí nad Moravou, Czech Republic, evidence suggests that horses were fed meadow grasses as well as woody vegetation, millet, oat and less commonly *Cannabis*, wheat and rye (Dejmal et al. 2014). In Hungary, hay meadows are noted in various documents linked with settlements and castles in the 15th–16th century (Gyulai 2014a, b). In Slavonia, oats and barley were found at most of the settlement sites in low quantities and could have been consumed by humans, animals or both.

Very few chaff remains were identified from the majority of the sites, suggesting that cereal processing was probably not done within the settlements or forts. There are however two exceptions, the Árpád period settlement of Cegléd 4, where nearly 900 rachis fragments of bread wheat were recovered and also from the cellar of a building in the town of Vác (Széchenyi), where 125 barley rachis fragments were identified. No germinated grains were identified from continental Croatia, but in Hungary two sites yielded germinated free-threshing wheat grains; early medieval Cegléd 4, with a few hundred grains and late medieval Muhi with only 40, as well as one germinated barley grain (ESM 2; Table S2). Without further contextual information it is unclear whether these finds might indicate malting for brewing. However, we do know that ale or beer was brewed during this period elsewhere in Europe, especially in monasteries during the early Middle Ages (Poelmans and Swinnen 2011; Łużyniecka 2019). It seems that all types of grain were used for brewing beer depending on what was available, and it was only by the 14th to 15th centuries that barley became more commonly used in the commercial breweries that emerged around this time (Meussdoerffer 2009). The brewing of beer in Hungary is also supported by the presence of non-carbonised remains of *Humulus lupulus* (hop), identified from a small number of archaeological sites of this period in Hungary (Gyulai 2010, p. 215), although other herbs could also have been used to add flavour to the beer (Verberg 2020).

Bread was an important component of the medieval diet, with wheat bread being the most expensive, while rye and maslin produced a cheaper darker loaf (Groebner 1994). Barley and oats were also milled and baked to produce coarser, cheaper breads and even dried and ground peas and beans were used in the cheapest of loaves. Thus, typically, free-threshing wheat has been identified as a high status food, while rye was more commonly eaten by the poor. However, archaeological and historical evidence suggests this is an oversimplification, especially as it can be difficult to distinguish between richer and poorer people living under the same roof (van Zeist et al. 1994; de Hingh and Bakels 1996; Bakels and Groen-Houchin 2017). It is hard to determine any evidence of social status from the settlements in Slavonia. The two forts and one castle would have had high status people resident, however the archaeobotanical remains are very limited, making it impossible to see if the plant remains are distinctly different from the rest of the sites.

In addition to carbonised plant remains, there is also evidence of carbonised food. Some amorphous lumps were identified in the Croatian assemblage, however under a stereo microscope most of them looked more like fruit flesh than remains of some sort of cereal based food, such as bread or porridge (Valamoti et al. 2019; González Carretero et al. 2017). However, to confirm this, SEM analyses should be done in the future. In the Hungarian material, various types of food remains were found, including some bread, porridge (gruel) or cake/dough type remains, some of which were recovered from within pots (Gyulai 2010, pp. 312–314). From these, bread wheat, rye and broomcorn millet have been identified, as well as fruit remains.

Oil and fibre producing plants

Among the oil and fibre producing plants, small numbers of *Linum usitatissimum* (flax), *Cannabis sativa*, *Camelina sativa* (gold-of-pleasure) and *Papaver somniferum* (opium poppy) remains have been found both from continental Croatia and Hungary. Small amounts of *Brassica* seeds might also suggest their use as a source of oil at the time, or even for feeding animals. Their low presence does not necessarily mean that they were not widely cultivated, especially as their high oil content makes them unlikely to become carbonised. Furthermore, the processing may result in few seeds being deposited within the settlement, for example flax is processed for its fibre before the seeds mature. Cultivation is confirmed from Budapest, Szent György tér volt Teleki palota where over 2,500 waterlogged hemp and 456,000 poppy seeds were recovered from a 14th to 15th century well, No. 8 (Gyulai 2010; Gyulai and Kenéz 2018). Pollen data also indicate high levels of *Cannabis*-type pollen in Hungary through the medieval period, which Willis (1997) attributed to the long history of hemp rope production, as well as cloth weaving. Although rare, a few historical sources, mostly from the late Middle Ages, also mention hemp being a remedy for various ailments (Aldrich 1997, p. 42). Alternative uses of *Cannabis* cannot therefore be ruled out at DM-D, especially as the achene was discovered within a hearth context.

In the written records, flax and hemp are mentioned in tax records from the 15th to 16th century in Slavonia, Hungary and Serbia (Mišić 1992, p. 57; Ivanović et al. 2015;

Krstić 2020). Across Europe throughout the medieval period the fibres from flax and hemp were used for making cloth or other items and have been identified from numerous archaeological contexts (Clarke and Merlin 2013; Huang 2021). Even in the more recent past the growing of flax for fibre has a long tradition in Croatia, being usually sown in lowlands and near rivers and almost all peasant holdings grew sufficient flax for use by the extended family (Cruickshank 2011). Access to water is therefore important as both flax and hemp are harvested before the seeds ripen and are soaked in water, often in rivers, to rot so that the fibres can be extracted, a process known as retting. Although local production occurred, western imports of wool and some linen textiles also increased into Hungary during the 15th–16th century (Pál 1971).

Fruit and nuts

The evidence of fruit and nut remains is generally low in the Hungarian and continental Croatian assemblages, probably due to preservation bias (Antolín and Jacomet 2015). Their frequency is low, except for the presence of *Rubus* spp. (blackberries and raspberries) and *Vitis vinifera*, which are present at about 40% of the Croatian sites. From the carbonised remains there is evidence of a slightly wider range of fruits and nuts from the Habsburg period in Hungary, including *Citrullus lanatus* (watermelon), *Juglans regia* (walnut), *Malus domestica* (apple) and *Pyrus* cf. *communis* (pear). In Slavonia, *Prunus avium* (wild cherry) and *Prunus persica* (peach) were also present. The evidence of fruit trees in the region from these finds probably indicates local cultivation in orchards and gardens, but a large number of the fruits could have been gathered in the surrounding area from the wild, including *Cornus mas* (cornelian cherry), *Fragaria vesca* (wild strawberry), *Rubus fruticosus* (blackberry), *R. idaeus* (raspberry), *Physalis alkekengi* (Chinese lantern), *Sambucus nigra* (elder), *Corylus* sp. (hazelnut) and *Prunus spinosa* (sloe), although cultivation of the last two cannot be excluded. At Pécs, documentary evidence suggests that part of the area lying south of the castle during the 15th century had extensive gardens, vineyards and orchards belonging to the dwelling houses (Petrovics 2011).

Urban settlements and their markets also drew in locally grown fruit and vegetables, of which an ever-wider range has been revealed by the contents of well fills in these towns. For example, over 90,000 *Citrullus lanatus* (watermelon), as well as over 35,000 *Cucumus melo* (melon) and 11,000 *Cucumis sativus* (cucumber) seeds came from the 14th to 15th century well (no. 8) at Budapest, Szent György (Gyulai 2010). Other fruits from this well include ca. 335,000 *Ficus carica* (fig) seeds, over 1 million *Fragaria vesca* (wild strawberry) seeds, over 54,000 *Malus* (apple) pips, a wide range of *Prunus persica* (peach), *P. domestica* (plum), *P. spinosa* (sloe), nearly 40,000 *Rubus caesius* (dewberry) pips, ca. 400,000 grape pips, a few thousand pear pips and even a few hundred *Punica granatum* (pomegranate) seeds. Many of these fruits are mentioned in written sources of the time, such as the 15th century law book of Buda (Rabb 2007). While melons are known from the Roman period in Europe, illustrations do not really appear in Italy or other parts of Europe until the 15th century onwards (Paris et al. 2012). With the Ottoman occupation in the 16th century onwards in Hungary, watermelon cultivation also seems to have flourished, thought to be due to well-developed gardening skills that spread with the arrival of Ottoman forces and population (Gyulai 2001, pp. 184–185; Gyulai et al. 2012).

The greatest quantity of carbonised fruit remains were of grape from the Habsburg period (65 pips from Nagyvázsony-Csepely) and a total of 43 pips from five sites in continental Croatia (ESM 2; Table S2). Various documents, including wills, contracts, sales etc. show the presence of vineyards in Slavonia throughout the Middle Ages (Ljubljanović 2006; Laszlovszky 2018). Two taxes on vineyards and wine were noted. The first, *gornica* (*terragium*), was collected from people who rented vineyards from the towns and was an important source of income for the urban population. The second tax was a wine tithe (*decima vini*) which was collected from every owner or producer (Ljubljanović 2006). Notably, wine produced in Srijem, a province between the Drava, Danube and the Sava, was the most famous wine of the continental parts of the Hungarian-Croatian kingdom and occupied an important place in the overall Hungarian wine exports to other countries in the 12th to 16th centuries (Andrić 2017). The earliest known wine press is identified from a document about the Hungarian-Croatian King Bela IV, who on October 3rd, 1253 confiscated the property, namely a wine press and vineyards, of Laurentius, the manager of the Srijem settlement of Beshenov, and his aides, for counterfeiting money (Hardi 2017). Hungarian wine was particularly sought after in other parts of Europe. Kraków, in particular, became one of the principal destinations of Hungarian merchants, where it was one of the main export markets of wine from the 13th to 16th century, with numerous royal court papers and special duties indicating its importance (Carter 1987). However, Hungarian fears of a Kraków monopoly led to various disputes and sale prohibitions on certain wines towards the end of the 15th century (Carter 1987). The wealth generated from the wine trade contributed to the rise of several towns in the 14th and 15th century in the areas of production, including Ilok in Croatia (Szende 2011, p. 220).

Pulses, vegetables and herbs

Remains of pulses, vegetables and herbs are relatively rare in the assemblages, again probably due to preservation bias. Only a few pulse remains were found, with the most common being *Pisum* (pea) and *Lens* and to a lesser extent *Vicia faba* (ESM 2; Table S2). In addition, only a small number of *Daucus carota* (wild carrot), *Cichorium intybus* (chicory), *Allium sativum* (garlic), *Mentha arvensis* (mint) and *Coriandrum sativum* (coriander) seeds were recovered. A range of other possible wild food plants could also have been used. For example, the young leaves and seeds of *Sinapis arvensis* (charlock) can be eaten (Łuczaj et al. 2013), however, it can also grow as a weed in crops. The frequencies of such taxa are also generally low except for *Verbena officinalis* (vervain) which was found from five of the continental Croatian sites, although in small numbers (ESM 2, Table S2). Vervain was a common weed but was also considered as a herb that had magical properties in medieval Europe (Tobyn et al. 2011, p. 327).

In Hungary, there was a large increase in market towns in the 14th and 15th centuries, and especially in the second half of the 15th century (Sárosi 2013). In Slavonia, sources show that following the arrival of the Bosnian bishop Ponsi in 1239, Đakovo began to quickly develop from a small village into a market centre (Mažuran 1995). According to Dyer (2006), medieval gardening was probably practised more intensively in English towns, close to the markets to sell the produce. This would make sense for Croatia and Hungary too. From the 15th century law book of Buda we get an idea of what was sold at these market towns (Blazovich 1994; Rabb 2007). According to the rules there, the women selling green vegetables could sell dry peas, beans, lentils, barley, hemp, poppy, coarse oats, coarse barley, coarse spelt, sweet fennel (*Foeniculum vulgare*), coarse millet, dried chives (*Allium schoenoprasum*), dried garlic (*Allium sativum*) and every kind of greens in their baskets (Rabb 2007). The vegetable market women were allowed to sell fresh and pickled cabbages (*Brassica*), parsley (*Petroselinum crispum*), beetroot (*Beta vulgaris*), pumpkins (*Cucurbita pepo*), radishes (*Raphanus sativus*), horseradish (*Armoracia rusticana*), onions (*Allium cepa*), chives (*A. schoenoprasum*), garlic (*A. sativum*), carrots, spinach (*Spinacia oleracea*) and every other kind of green plant (Rabb 2007). This wide variety of herbs and vegetables would probably also have been supplemented by wild plants, but these are rarely recorded in the literature. Instead, recent ethnographic studies in the region show what plants could have been used in the past. A study in Dalmatia identified 55 wild plants that were consumed in rural villages, with the most frequent including, *Cichorium intybus* (chicory), *Foeniculum vulgare* (fennel), *Sonchus oleraceus* (sow thistle), *Asparagus acutifolius* (wild asparagus), *Papaver rhoeas* (common poppy), *Rumex pulcher* (fiddle dock), *Daucus carota*, *Allium ampeloprasum* (wild leek) and *Silene latifolia* (white campion) (Łuczaj et al. 2013). A similar study in Hungary identified 236 wild plants which were used as food, spices, for drinks or occasional snacks (Dénes et al. 2012). Unfortunately, it is uncertain from the archaeological data, which wild plants were consumed in the past, yet it is clear that a wide range of suitable taxa were available for both rural and urban populations.

Other useful plants

Certain other plants could have been used for dyeing or for medicines, although again evidence is limited for this region. A few seeds of the dye plant *Reseda luteola* (dyer's greenweed) were identified, which gives a yellow colour. Although many of the wild plants could also have grown as common ruderals around the settlements, some may indicate possible evidence of medicinal plants, such as *Conium maculatum* (hemlock) and *Hyoscyamus niger* (henbane) which were used as powerful painkillers, as soporifics and for coughs and other ailments. *Papaver somniferum* (opium poppy) was also used for pain relief (Anderson 2004). One source we can examine is the *Chilandar Medical Codex*, which is one of the best-preserved medieval Serbian manuscripts that brings together documents on European medical science in the 12th–15th centuries (Jarić et al. 2011). Of the plants quoted there, the following were found in the archaeobotanical assemblage: *Vitis vinifera* (mentioned 120 times), *Hyoscyamus niger* (henbane, mentioned five times), *Papaver somniferum* (opium poppy, three times), *Portulaca oleracea* (purslane, mentioned twice), *Prunus persica* (peach, seven times) and *Sinapis arvensis* (charlock, three times). *Cannabis sativa* is also known for its ritual and medicinal properties (Benet 1975) and cannot be ruled out here as having been used for those purposes as well.

Conclusions

The Middle Ages in Croatia was a complex time when political power and alliances changed from century to century. There were periods of conflict and immigration, as well as the destructive forces of plague and climatic fluctuations that would have had a distinct impact on the lives of its farming inhabitants. The results from the ten new sites presented here considerably expand our knowledge about medieval agriculture in Croatia. The archaeobotanical evidence shows a wide variety of cultivated and wild plants that could have been consumed or used for other purposes, such as for medicine, fibre or dye. Unsurprisingly the assemblage is dominated by cereal remains, particularly free-threshing wheat, rye and broomcorn millet, which correspond with other contemporary sites in Hungary. Examining charred plant remains from both continental Croatia (medieval Slavonia and present-day Slavonia) and Hungary showed some changes in the presence of crops from the Árpád (10th–13th century AD) and Habsburg (14th–16th century) periods. This included a slight increase in the presence of oats and possibly a decrease in the presence of the glume wheats emmer and einkorn, although these had a generally low occurrence anyway. Local horticulture was also a significant part of village and town life, with a wide range of fruits, vegetables and herbs identified from both periods. Thus, the landscape would have integrated a variety of productive spaces, including cultivated land, gardens, orchards, pastures and woods.

From historical records we see that by the end of the Árpád period, areas of cultivated land and pasture had grown considerably. This expansion in agriculture corresponds with an increase in the population (including new migrants) as well as with the establishment of urban centres, such as Đakovo, and a greater market economy. The trading of food also increased, with a thriving economy based on grain, wine and cattle, which were exported throughout Europe by the late Middle Ages. However, whether crop husbandry practices changed or evolved with these developments is still unclear from the archaeobotanical evidence. Regardless, the limited dataset from Croatia and Hungary as a whole indicates potential areas for future research into the development of agriculture during the Middle Ages. With increased sampling and archaeobotanical analyses, studies could include further consideration of how farming was done, perhaps by investigating ecological characteristics of arable weeds to assess the management of cultivated fields as well as stable isotope analyses. Comparison of the archaeobotanical data in terms of regional specialisations and how food systems changed with the development of urban centres would also provide a more detailed understanding of agricultural change at this time.

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