Acta Palaeobotanica 62(2), 108–122, 2022
https://doi.org/10.35535/acpa-2022-0008

e-ISSN 2082-0259
ISSN 0001-6594

Settlements and cemeteries in Bronze Age Croatia: The archaeobotanical evidence

KELLY REED[1*], TOMISLAV HRŠAK[2], MARIJA MIHALJEVIĆ[3] and JACQUELINE BALEN[4]

[1]Oxford Martin School, University of Oxford, 34 Broad Street, Oxford, OX1 3BD, UK;
e-mail: kellyreed@hotmail.co.uk; ORCID: https://orcid.org/0000-0002-7460-8057

[2]Arheološki Muzej Osijek, Osijek, Croatia

[3]Gradski Muzej Nova Gradiška, Nova Gradiška, Croatia

[4]Archaeological Museum in Zagreb, Croatia

Received 3 February 2022, accepted for publication 5 September 2022

ABSTRACT. The Bronze Age in Europe is a dynamic time characterised by an increase in long-distance mobility and interaction, changes in social organisation, technological advancements and evolving agricultural practices. In particular, we see an increase in the range of crops grown from the middle Bronze Age, including the introduction of new crops, such as broomcorn millet and broad bean. However, evidence of agricultural practices in Croatia is limited. This paper presents new archaeobotanical data collected from ten Bronze Age settlements and cemeteries in continental Croatia. Overall, the density of plant remains was low and consisted of either cereal grains or wild taxa, with the majority coming from Mačkovac-Crišnjevi. Oats (*Avena* sp.) and broomcorn millet (*Panicum miliaceum*) are the most dominant cereals, followed by small numbers of barley (*Hordeum vulgare*), emmer (*Triticum dicoccum*) and free-threshing wheat (*Triticum aestivum/durum*). The composition of the botanical remains are comparable to neighbouring regions, although the occurrence of millet and especially oats are not seen in any significance until the Iron Age.

KEYWORDS: crop agriculture, millet, diversification, Carpathian Basin

INTRODUCTION

Croatia is a country situated in south Central Europe and the Mediterranean region, and is positioned at the heart of ancient migration routes through Europe, where the movement of people, ideas and materials can be observed in prehistory. From the beginning of the Bronze Age technological advancements, such as ship building, chariots and horse breeding, expanded the potential for long-distance mobility and interaction, connecting new regions (Harding, 2013; Kristiansen, 2016: 158; Kristiansen and Sørensen, 2019). From a political economy perspective, Earle et al. (2015) suggests long-distance trade in metals and other commodities, such as salt and wool, created a shift from local group ownership towards increasingly individual strategies to obtain wealth from macro-regional trade. This in turn transformed the institutional formation of societies across Europe. In the Carpathian Basin, which includes present day Hungary, eastern Slovenia, eastern Croatia, northern Serbia, northern Bosnia and Herzegovina, western Romania and south-western Ukraine, clear changes in society are observed during the Bronze Age (~2500 to 800 cal. BC). Settlements by the middle Bronze Age become larger, more diverse and complex, with the re-emergence of (fortified) tell sites in the eastern part of the basin (e.g. Gogâltan, 2008, 2019; Fischl and Reményi, 2013). In agriculture, this period is characterised by the spread and adoption of new crops

* Corresponding author

Table 1. Summary of previously published sites with archaeobotanical remains in Croatia

Site name	Period	Type	Date	No. of samples	Reference
Okruglo	Bronze Age	Settlement		1	Smith et al., 2006
Torčec-Gradić	Bronze Age	Settlement		1	Šoštarić, 2004
Grapčeva	Early to middle Bronze Age	Cave	2565–2144 cal. BC – 1879–1529 cal. BC	11, 4	Borojević et al., 2008
Monkodonja	Early/Middle Bronze Age	Hillfort	~1800–1200 cal. BC	64	Kroll, 2015
Čauševica	Late Bronze Age	Settlement		2	Huntley, 1996
Nova Bukovica-Sjenjak	Late Bronze Age	Settlement		3	Šoštarić, 2001
Kalnik-Igrišče	Late Bronze Age	Settlement		158	Mareković et al., 2015; Reed et al., 2021

into the farming repertoire, such as broomcorn millet (*Panicum miliaceum*), broad bean (*Vicia faba*), gold of pleasure (*Camelina sativa*) and Safflower (*Carthamus tinctorius*) (Kroll, 1990; Medović, 2002; Akeret, 2005; Gyulai, 2010: 105; Filipović et al., 2020). In particular, broomcorn millet is a clear example of trans-Eurasian exchange, where it was first domesticated in modern-day China in the Neolithic and spread to Europe (Filipović et al., 2020). Agricultural tools began to be made with bronze, such as sickles and ploughs, making them more robust and probably more efficient (e.g. Arnoldussen and Steegstra, 2016). By the late Bronze Age settlements once again change, moving away from large complex sites to smaller dispersed and more open types. Instead, large cemeteries linked with the Urnfield phenomenon become widespread (Staniuk, 2021).

In addition to these cultural developments, climatic changes are also observed. The Carpathian Basin is generally characterised by fertile chernozem soils with Continental and Sub-Mediterranean forest-steppe elements and regional climatic variability (Zólyomi et al., 1997; Magyari et al., 2010). In the Bronze Age a cooler and wetter climate of the early Sub-Boreal, contemporary with the early Bronze Age, was replaced between 2000 BC and 1500 BC by a relatively warm climate (Fischl et al., 2013). Climatic deterioration is then observed at the beginning of the late Sub-Boreal period ~1500/1450 BC, which has been linked to evidence of societal collapse in parts of Europe, including the move away from tell sites and possible depopulation in the Carpathian Basin, although debate continues (Fischl et al., 2013; Demény et al., 2019; Duffy et al., 2019). Palynological evidence is patchy, with inherent methodological problems, but most studies from lower altitudes in the Carpathian Basin suggest a general shift from mixed oak to first hornbeam, then beech forests during the Copper and Bronze Age, with a rise in oak seen in the late Bronze Age, possibly linked with their economic significance (Willis et al., 1997; Magyari et al., 2010, 2012; Grindean et al., 2014; Feurdean et al., 2015; Gumnior et al., 2020). Human impact on the landscape is also a contested topic with some studies suggesting that large scale human impact on the environment is not seen until the middle Bronze Age (Willis, 1994; Andrič and Willis, 2003; Sümegi et al., 2012). However, others suggest a more complex picture with varying levels of human impact seen from site specific studies in pre-Bronze Age landscapes in the Carpathian Basin (Magyari et al., 2012; Chapman, 2018). For example, in Slovenia episodes of burning of forests for clearance is seen through much

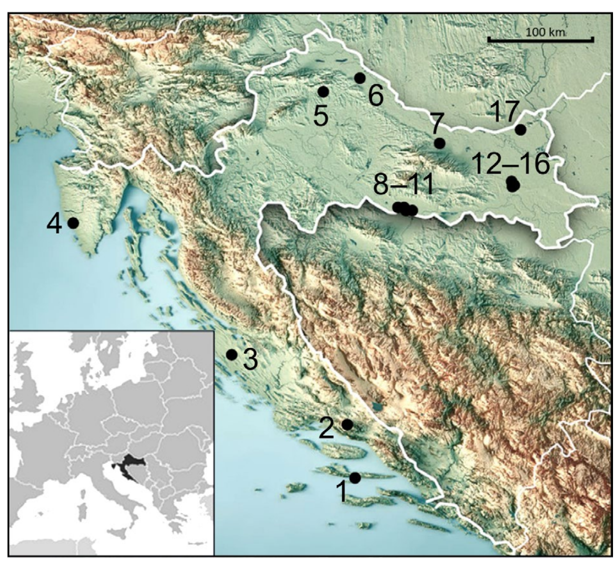

Figure 1. Map of Croatia showing the location of Bronze Age sites with archaeobotanical remains. 1 – Grapčeva, 2 – Okruglo, 3 – Ĉauševica, 4 – Monkodonja, 5 – Kalnik-Igrišče, 6 – Torčec-Gradić, 7 – Nova Bukovica-Sjenjak, 8 – Mačkovac-Crišnjevi, 9 – Mačkovac-Oštrovi, 10 – Orubica-Veliki Šeš, 11 – Zapolje, 12 – Tomašanci-Palača, 13 – Viškovci-Gradina, 14 – Kuševac-Topolina, 15 – Đakovo-Ciglana, 16 – Đakovo-Štrosmajerovac, 17 – Beli Manastir-Sudaraž. Map adapted from Ramspott (2017)

of the Holocene, with the strongest human impact being associated with *Fagus* decline and an increase in taxa characteristic of meadows, fields and pastures ~4000 BC (Andrič, 2007). How landscape changes link with the development of agriculture, including agricultural expansion, in the Bronze Age is therefore still unclear.

In comparison to other regions little is known about the development of agriculture in Bronze Age Croatia and how it relates to other socio-economic developments. What we do know is that agriculture arrived in Croatia ~6000 BC and involved the cultivation of einkorn (*Triticum monococcum*), emmer (*Triticum dicoccum*), barley (*Hordeum vulgare*), pea (*Pisum sativum*), lentil (*Lens culinaris*) and flax (*Linum usitatissimum*) (Reed, 2015; Gaastra et al., 2022). Little seems to change during the Copper Age and it is not until the middle Bronze Age that we start to see evidence of other crops such as broomcorn millet (Reed, 2017; Reed et al., 2022). The current archaeobotanical evidence is sporadic, as the recovery of the plant remains is not regularly undertaken during excavations. To date, only seven sites have published evidence of plant remains dating to the Bronze Age (Tab. 1). This paper therefore considerably expands on this sparse evidence by presenting archaeobotanical data from ten Bronze Age sites located in continental Croatia (Fig. 1). These sites will then be compared to the wider Carpathian Basin region to explore the development of Bronze Age agriculture.

MATERIALS AND METHODS

Over the last 15 years archaeobotanical samples have been collected from ten Bronze Age sites within continental Croatia (Tab. 2). The region is roughly bordered by the river Drava to the north, the Sava to the south and the Danube to the east, and is characterised by relatively flat and extremely fertile loess plains. The sites of Tomašanci-Palača (Balen, 2020) and Viškovci-Gradina (Balen, 2013, 2014, 2015, 2016) date to the early Bronze Age Vinkovci culture (2500–2200 cal. BC). Đakovo-Ciglana (Hršak, 2009, 2010), Đakovo-Štrosmajerovac (Hršak and Bojčić, 2007), Kuševac-Topolina (Bojčić and Hršak, 2008), Mačkovac-Crišnjevi and Mačkovac-Oštrovi (Karavanić et al., 2002; Mihaljević and Kalafatić, 2007a, 2008, 2014), Orubica-Veliki Šeš (Mihaljević and Kalafatić, 2007b), Zapolje (Mihaljević and Radović, 2018) and Beli Manastir-Sudaraž (Hršak, 2015) are all dated to the late Bronze Age Urnfield culture (~1300 BC–800 BC).

Each sampling method was determined and implemented by the directors of the excavation in relation to their own aims and objectives. Sample sizes were not recorded, but the archaeologists estimate that samples were usually one bucket full (~11 L). Flotation was conducted either by bucket flotation or using a flotation machine with 500 µm sieves used for the flots and 1 mm for the heavy residue (some sieves were homemade, so the size is estimated). The floated remains were completely sorted for plant remains at all sites and in most cases the charcoal volume for each flot was recorded. All plant remains were carbonised and were identified using a stereo zoom microscope with 7 × to 45 × magnification. Identifications were made using the modern reference collection held at the department of Archaeology and Ancient History, University of Leicester and the Institute of Archaeology, UCL, as well as with reference to Cappers and Neef (2006) and Jacomet (2006). The nomenclature of scientific plant names follows Zohary and Hopf (2000) for cultivars and the Flora Croatica Database (Nikolić, 2018) for wild plants. A standardised counting method was used, whereby each grain counts as one and 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 seeds were counted as one, even when only a fragment was found, except where large seeds were broken and clearly represented the same parts of the same one for example, *Cornus mas*.

At Mačkovac-Crišnjevi oat florets were recovered (Fig. 2b, c), but black oat (*Avena strigosa*), wild oat (*Avena fatua*) and common oat (*Avena sativa*) could not be reliably distinguished from one another. Grains identified as *Avena* sp. are subsequently referred to as oats within this paper without specification between wild and cultivated oat, as such distinction cannot be made. Furthermore, the size-range of the oat grains recovered from Mačkovac-Crišnjevi did vary considerably therefore it is probable that more than one species of oat is present, as seen at Iron Age Pod (Kučan, 1984).

RESULTS

A total of 145 samples were sorted from the ten Bronze Age sites, but only 90 samples contained carbonised plant remains (Tab. 2). Overall, the density of plant remains was low, less than three seeds per litre, except at Mačkovac-Crišnjevi where two samples contained a high number of oats (*Avena* sp.), and one sample contained a high number of broomcorn millet (*Panicum miliaceum*). Similarly, charcoal density was relatively low, less than 1 cm^3/l, except at Mačkovac-Crišnjevi.

Overall, the settlement sites had 1155 identified plant remains, while the cemeteries had only 129. Most of the remains were

Table 2. Summary of the ten Bronze Age sites and their archaeobotanical assemblage

	Tomašanci-Palača	Viškovci-Gradina	Kuševac-Topolina	Mačkovac-Crišnjevi	Orubica-Veliki Šeš	Beli Manastir-Sudaraž	Đakovo-Ciglana	Đakovo-Štrosmajerovac	Mačkovac-Oštrovi	Zapolje	Total
Bronze Age phase	Early		Late								
No. of samples	27	4	7	31	2	10	17	31	5	9	
Site type	Settlement						Cemetery				
Estimated sample vol (l)	308	44	88	429	22	110	187	341	77	99	
Average seed density	0.12	1.57	0.49	2.49	0.18	0.98	0.11	0.07	0.62	0.33	
GRAIN											
Hordeum vulgare [cf.]	[2]	1	1	2			5				9 [2]
Triticum dicoccum [cf.]	1	8 [3]		3							12 [3]
Triticum monococcum [cf.]		1 [2]						[1]			1 [3]
Triticum mono/dicocc	1										1
T. aestivum/durum	1		1				3	1			6
cf. *Triticum spelta*										1	1
Triticum spp.		11		3		3	3	2			22
Avena sp.		21		343							364
Cerealia indet.	25		3	8			7	4	2	1	50
Panicum miliaceum			4	213	1		1	1	17		237
CHAFF											
Avena sativa/strigosa floret				2							2
Avena sativa/fatua floret				6							6
Avena sp. floret				6							6
Triticum dicoccum g/b		2				2					4
Triticum sp. g/b		1		6		9					16
Rachis indet				1		1					2
Straw	1										1
PULSES											
Lathyrus/Vicia sp.				1							1
Lens culinaris				1							1
Pisum sativum		1									1
Indet pulse frag		1	4								5
FRUITS											
Cornus mas	1				1			1			3
Physalis alkekengi [cf.]			2			1 [1]					3 [1]
Vitis vinifera	1										1
Fruit shell frags				5		1		1			7
WILD/WEED TAXA	2	17	28	298	2	90	1	13	33	31	515
Total	35	69	43	898	4	108	20	24	52	33	1,286

either cereal grains or wild taxa (Fig. 3), with the majority coming from Mačkovac-Crišnjevi. Oats and broomcorn millet are the most dominant cereals in terms of quantity of remains, followed by small numbers of barley (*Hordeum vulgare*), emmer (*Triticum dicoccum*) and free-threshing wheat (*Triticum aestivum/durum*). However, barley and free-threshing wheat are found most frequently, at five and four of the sites respectively (Tab. 2). One einkorn (*Triticum monococcum*) and one tentatively identified spelt (cf. *Triticum spelta*) grain were also identified. Chaff remains were rare and only present at the settlement sites. Pulses were also rare and only present at the settlement sites, with one lentil (*Lens culinaris*) from Mačkovac-Crišnjevi and one pea (*Pisum sativum*) from Viškovci-Gradina. Individual finds of cornelian cherry (*Cornus mas*), Chinese lantern (*Physalis alkekengi*) were predominantly found at the settlement sites.

Wild plants were recovered from all the sites and generally grouped under weeds of fields and gardens, weeds of ruderal places and grasslands, with a few wetland plants (Fig. 2d). Local woodland is also inferred from the recovery of hornbeam (*Carpinus betulus*) at Mačkovac-Crišnjevi, which could have been exploited for firewood by the inhabitants (Fig. 2e). Most of the remains were grasses, including *Echinochloa crus-galli, Digitaria sanguinalis, Bromus* sp., *Lolium* sp., *Poa* sp., and *Phleum* sp., *Chenopodium album, Polygonum persicaria* and *Trifolium* sp. are also found in relatively high quantities at the settlement sites. Interestingly, several samples

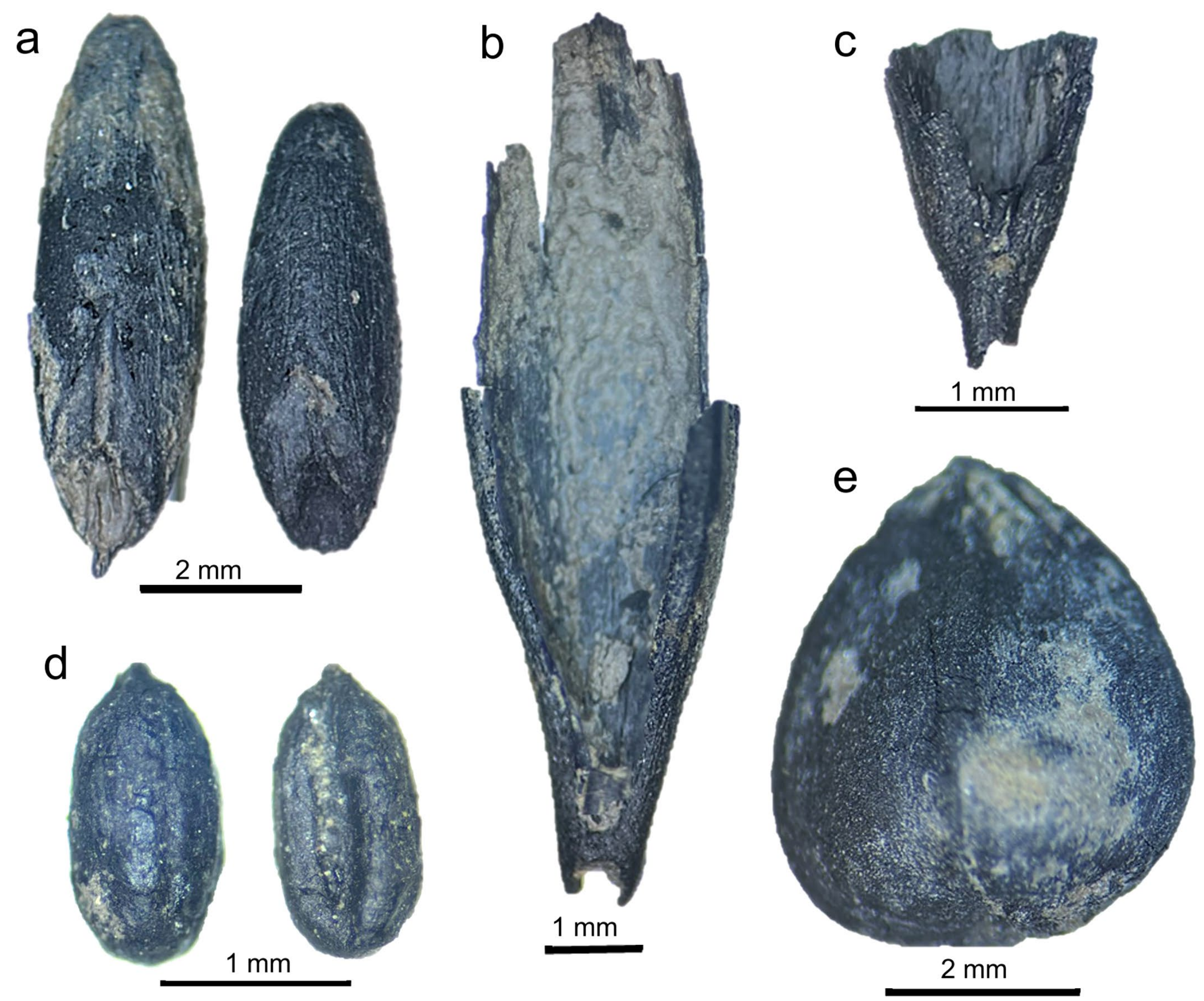

Figure 2. Carbonised remains of (**a**) *Avena* sp., (**b**) *Avena sativa/fatua*, (**c**) *Avena sativa/strigosa*, (**d**) cf. *Bupleurum rotundifolium*, (**e**) *Carpinus betulus*, from Mačkovac-Crišnjevi

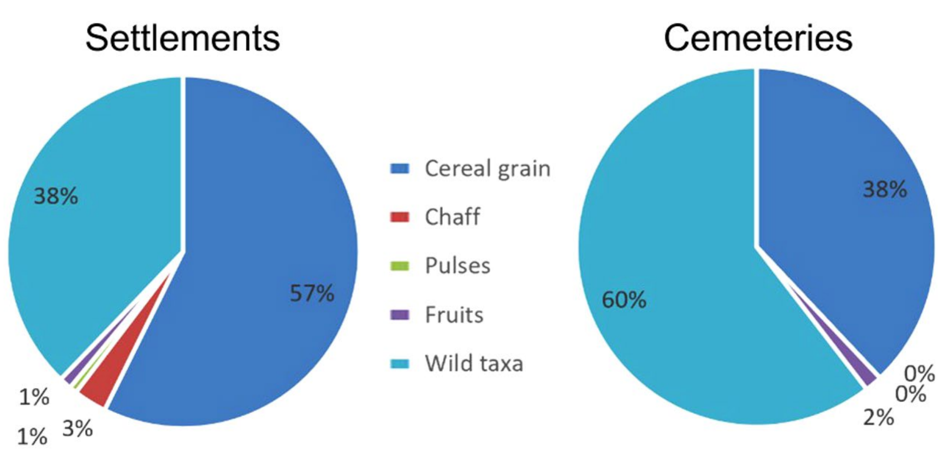

Figure 3. Percentage of plant remains per group for settlements (1155 plant remains) and cemeteries (129 plant remains)

contained poppy (*Papaver sominferum*) at Beli Manastir-Sudaraž, which may indicate collection/use by the inhabitants. Individual finds of other plants could also indicate purposeful collection, including elderberry (*Sambucus ebulus* and *S. nigra*), mint (*Mentha* sp.), and nettle (*Urtica dioica* and *U. urens*).

DISCUSSION

TAPHONOMY AT THE TEN CROATIAN SITES

Distinguishing routine activities and occasional accidental or deliberate burning episodes is particularly important not only to determine formation processes at a site but also when comparing different samples. Numerous scholars advocate the need to differentiate between regular routine activities and rare accidental or deliberate events in order to restrict their contribution to the overall pattern on a site or to assist in the detection of repeated episodes of accidental or deliberate burning that may signify a specific practice (e.g. Jones, 1991; Hubbard and Clapham, 1992; Van der Veen, 2007; Fuller et al., 2014). Differentiation between the samples also allows deposits of the same crop processing stage, and thus the same relative composition, to be compared. This is particularly important when exploring weed ecology, as weeds with different physical characteristics (e.g. size or shape) are removed through each processing stage and would therefore bias the assemblage towards certain species (Hillman, 1984; Jones, 1984; Van der Veen, 1992; Bogaard, 2004). Exploring the deposition of carbonised remains Van der Veen (2007) highlighted five 'routes of entry' on archaeological sites, the most common being: plant remains used as fuel, both intentionally and through casual discard, and foods accidentally burnt during food preparation, such as through cooking or roasting. The least common routes include, accidental or deliberate destruction of food and fodder stores, the use of fire to clean out grain storage pits, and the destruction of diseased or infested crop seeds (Van der Veen, 2007). Deposition of plant remains through ritual activities can also result in carbonised plant remains, such as from cremation burials or votive offerings (e.g. Megaloudi, 2005). The density of the plant remains in an archaeological deposit is also used to infer the rate of deposition, where a low density of plant remains indicates slow accumulation, while high densities suggest rapid deposition (Jones, 1991).

Examining the ten sites presented here we see several biases within the assemblages. First, at several sites the limited range of contexts sampled could impact the representativeness of the archaeobotanical data (Hillman, 1981; Jacomet and Brombacher, 2005). The dominance of pit features at the settlement sites, as well as the low seed density in most samples (Supplementary File: Table 1[1]), suggests that many of the remains represent the slow accumulation of secondary or tertiary deposits, which have little association with activities connected to the context (Hillman, 1984; Van der Veen, 2007). The only exception are the three samples (12, 18, 67) from Mačkovac-Crišnjevi, which contained high numbers of oat and broomcorn millet grains (Supplementary File: Table 1). The presence of broomcorn millet has also been contentious in prehistoric contexts, with studies showing intrusion within Neolithic and Copper Age contexts (Motuzaite-Matuzeviciute et al., 2013). The recent study by Filipović et al. (2020) dated broomcorn millet grains from Mačkovac-Crišnjevi and confirmed dates associated with the middle Bronze Age (Tab. 3).

Some of the sites, such as Tomašanci-Palača, were located near settlements dating to other periods. The presence of one grape pip in this early context should therefore be looked at with caution, especially as similarities between the seeds of the cultivated grape, *Vitis vinifera*, and the closely related woodland species, *Vitis vinifera* ssp. *silvestris,* means we cannot rule out the presence of the woodland variety (Smith and Jones, 1990). However, the presence of only one grape pip may also indicate contamination from a medieval settlement that is also found at the sites. Grape finds are also rare in Bronze Age Hungarian sites (Gyulai, 2010: 451).

Cremation and inhumation burials follow distinct internment activities and preserve environmental remains differently. Regarding cremations, the burning of the body can provide suitable conditions to allow food/plant remains to survive. In pre-Roman Italy the

[1] Supplementary File: Table 1. Number of species identified per sample for the ten Bronze Ages sites

Table 3. Carbon dates of broomcorn millet (*Panicum miliaceum*) from Mačkovac-Crišnjevi and Mačkovac-Oštrovi, Croatia (Reed et al. 2022)

Site name	Material	Sample number	Context	Calibrated age (cal. BC/AD, 95.4% / 2σ hpd range)	BP	Lab code	Dating funded by
Mačkovac-Crišnjevi	*Panicum miliaceum* grain	[SJ71]	Pit	1596–1135 BC	3120 ±70	Poz-104900	DFG (SFB1266)
Mačkovac-Oštrovi	*Panicum miliaceum* grain	30 [SJ55]	Fill of pot in a cremation burial	1411–1223 BC	3055 ±35	Poz-104921	DFG (SFB1266)

incorporation of plants within cremations was common, particularly cultivated, and uncultivated fruits and nuts such as grapes, acorns (*Quercus* sp.) and dogwood (*Cornus sanguinea*) (Rottoli and Castiglioni, 2011; Caracuta and Fiorentino, 2018). In the eastern Alps burnt offering sites dating to the Bronze and Iron Age regularly have remains of crops and fruits, although in low numbers, suggesting plant offerings were incorporated within ritual practices (Außerlechner, 2021).

At the four late Bronze Age cemetery sites presented here, the quantity of remains recovered is low. At Mačkovac-Oštrovi most of the remains were wild or weed taxa, mostly Polygonaceae and Poaceae, although 15 broomcorn millet (*Panicum miliaceum*) were recovered from sample 30 (Supplementary File: Table 1). Interestingly, the recent study by Filipović et al. (2020) dated broomcorn millet grains from sample 30 at Mačkovac-Oštrovi and confirmed dates associated with the middle Bronze Age (Tab. 3). Thus, it is possible that the plant remains from sample 30 are associated with the cremation burial and possibly the ceremonial act. At the other cemeteries, the taxa were generally found as singular finds per sample. This could suggest that these finds are intrusive, or represent accidental burning of plants within the cemetery, especially in the case of the wild taxa.

ASSESSING THE ARCHAEOBOTANICAL DATA FROM CROATIA

Overall, a total of 17 sites dated to the Bronze Age have archaeobotanical remains from Croatia. Four of the sites are located on the coast, while the others are situated in continental Croatia (Fig. 1; Supplementary File: Table 2[2]). The quantity and quality of the archaeobotanical remains vary, with at least 60% of the sites having less than 100 plant remains in the whole assemblage, which is unlikely to indicate a representative crop inventory. Further, the majority date to the late Bronze Age making comparisons across the period difficult. Examining the coastal evidence, we see a very limited repertoire of remains, with only Monkodonja providing any clear evidence of crop cultivation. Here emmer (*Triticum dicoccum*), barley (*Hordeum vulgare*) and grape pips (*Vitis vinifera*) dominate a small dataset, that included generally singular finds of einkorn (*Triticum monococcum*), oat (*Avena sativa*), broomcorn millet (*Panicum miliaceum*), broad bean (*Vicia faba*), pea (*Pisum sativum*), grass pea (*Lathyrus sativus*) and bitter vetch (*Vicia ervilia*) (Kroll, 2015). At Okruglo waterlogged remains of grape pips, acorn (*Quercus* sp.) nut fragments and a few wild taxa were recorded, while at Grapčeva cave the early Bronze Age samples were dominated by a few acorn fragments, and only a few unidentified wheat grains, a grape pip and weeds (Smith et al., 2006; Borojević et al., 2008). The last coastal site, Cauševica, was dominated by a few wild olive (*Olea* sp.) shell fragments and juniper (*Juniperus* sp.) (Huntley, 1996).

In continental Croatia, the site of Torčec-Gradić, yielded two *Alisma plantago-aquatica* seeds identified as 'pseudo fresh' making it unclear how these remains link to their Bronze Age contexts, while at Nova Bukovica-Sjenjak 183 broad beans and a few acorns were recovered (Šoštarić, 2001, 2004). The best Bronze Age site with archaeobotanical remains so far published is that of Kalnik-Igrišče, where a burnt down building allowed unique preservation of the crops stored within (Mareković et al., 2015; Reed et al., 2021). Here over 100 000 grains show a dominance in broomcorn millet, barley, free-threshing wheat (*Triticum aestivum*) and broad bean. Emmer, spelt (*Triticum spelta*) and lentil (*Lens culinaris*) were also found in relatively high quantities in the western side of the house, suggesting they were also

[2] Supplementary File: Table 2: Number of species identified per sample for published Bronze Age sites in Croatia

crops, although maybe in a more minor capacity. Within the house there was also numerous wild apples/pears (*Malus*/*Pyrus* sp.) and acorns that are likely to have been collected and stored specifically by the inhabitants.

The ten additional sites presented here add to this picture in continental Croatia, highlighting the dominance in broomcorn millet, found at six of the sites, as well as the relatively high frequency of barley and free-threshing wheat at four and five of the sites respectively (Tab. 1). In terms of quantities, the large number of oat and broomcorn millet grains at Mačkovac-Crišnjevi found as relatively clean grain deposits in three separate contexts may indicate their cultivation, although we cannot distinguish cultivated and wild oats from the archaeobotanical remains. It is worth noting that oat is rarely found in Central and Southeast Europe until the 1st millennium BC, when it is suggested to be a secondary crop to wheat and barley (Zohary and Hopf, 2000; Stika and Heiss, 2013). In Hungary, Gyulai (2010) does not record the presence of domestic oat until the late Iron Age. In Bosnia and Herzegovina, the earliest occurrence has been recorded at the Iron Age site of Pod (4th to 6th century BC), although most of the remains were the wild taxa *Avena sterilis* and *Avena fatua* (Kučan, 1984). If domestic oats can be dated at Mačkovac-Crišnjevi to the late Bronze Age this would be some of the earliest evidence in the region.

New research on the introduction and adoption of millet is also showing its arrival into Croatia by the middle Bronze Age (Filipović et al., 2020; Reed et al., 2022), but it is not until the late Bronze Age that we see clear evidence of its cultivation as a crop within the Croatian assemblage. Recent stable isotope analyses of humans and animal remains add to this evidence. In coastal Croatia, stable carbon and nitrogen isotope analyses were carried out on human and animal bones from three Bronze Age sites Gusica Gomila, Jukica Gomila and Brnjica (Miller, 2018). Only two individuals from Brnjica showed signs of low consumption of C4 plants and/or marine foodstuffs. While in the neighbouring region of Lika, Zavodny et al. (2017) examined the stable isotopes of 36 human and 30 faunal remains from 12 Bronze and Iron Age sites. They found no C4 signatures within the animal remains suggesting that millet was not regularly used for fodder (also Zavodny et al., 2019). Of the human remains they found that most individuals appear to have eaten comparable proportions of millet, approximately 20% of the overall diet, regardless of age or sex from the middle Bronze Age onwards (at Bezdanjača, 1430–1290 cal. BC and Veliki Vital, 1420–1295 cal. BC). As the Iron Age progresses, millet consumption increases to almost 40% of the diet at the sites of Mala Metaljka, Sultanov Grob and Trošmarija (Zavodny et al., 2017).

Overall, by the late Bronze Age there is a clear indication of broomcorn millet, barley, free-threshing wheat and broad bean being grown in Croatia. Unfortunately, the quantity of plant remains is very low preventing any further analyses of the remains; for example, weed ecology or stable isotope analyses on the grains to determine differences between the sites in terms of manuring regimes (e.g. Bogaard et al., 2007; Aguilera et al., 2018). Consequently, nothing is known about agricultural intensity or whether crops were grown differently in different regions of Croatia and how this may have impacted the local landscape. What we can say is that a wider range of crops were present by the late Bronze Age, especially seen at sites such as Kalnik-Igrišče, providing a coherent picture of subsistence change that occurred by the end of the Bronze Age.

Other plant resources available in the wild would have been collected and used for different purposes, such as food, fuel, handicraft, construction, dying, fodder, medicine, etc. Unfortunately, the presence and potential of wild foods used in the past is usually underestimated by archaeobotanists since there is a reduced chance of many wild foods being preserved through carbonisation (e.g. flowers, leaves, fresh fruits, etc.) (Colledge and Conolly, 2014; Antolín et al., 2016). From the Croatian sites, fruit and nut remains were rare, but Cornelian cherry (*Cornus mas*) and Chinese lantern (*Physalis alkekengi*) were both identified (Tab. 1). Both could have grown in the local landscape and have been identified as gathered foods in the region since the Neolithic (Reed, 2015, 2017). Some have suggested that the fruits of the Cornelian cherry could have been eaten fresh or dried or used to create a kind of fermented beverage (Castelletti et al., 2001; Fiorentino et al., 2004). However, there is currently no evidence that such a drink existed, as this was inferred from the fact that evidence of cornelian cherry decreases in the archaeological record from the Iron Age when grape started to be cultivated more regularly.

Due to the low density of remains found generally at the sites it is unclear whether any other wild foods could have been collected at this time. Some species such as fat hen (*Chenopodium album*) and Polygonum species such as *P. lapathifolium, P. persicaria* and *P. aviculare* could be collected for food purposes. However, as most of these species are also commonly identified as weeds occurring in the crop fields or in nitrogen-rich places/soils linked to anthropogenic activities, it is not easy to determine that they were intentionally collected or accidentally brought inside the settlements, especially as we do not see large concentrations at the Croatian sites. The only other taxon to highlight here is the discovery of poppy (*Papaver sominferum*) at Beli Manastir-Sudaraž, as it is a useful plant for food, oil and medicine. Whether it was utilised at the site is unclear, but it is found at middle to late Bronze Age sites across Europe, even if in relatively low numbers (e.g. Bouby et al., 1999; Gyulai, 2010; Tereso et al., 2016).

AGRICULTURE IN THE CARPATHIAN BASIN BY THE LATE BRONZE AGE

How does continental Croatia compare to neighbouring regions in the Carpathian Basin? In Hungary, where the vast majority of archaeobotanical evidence comes from in the region, the mid/late Bronze Age is dominated by barley (*Hordeum vulgare*), emmer (*Triticum dicoccum*) and einkorn (*Triticum monococcum*; Gyulai, 2010; Reed, 2013; Filatova et al., 2019). In particular, the middle Bronze Age site of Bölcske-Vörösgyír had over 9000 barley and 20 000 einkorn grains and Kakucs-Turján mögött over 20 000 einkorn grains, while at the late Bronze Age settlement Ludas, Varjú dűlő contained over 35 000 emmer grains (Gyulai, 2010; Filatova et al., 2019). In Serbia the Bronze Age tell site of Feudvar was dominated by einkorn, emmer and barley (Kroll and Reed 2016). In contrast, continental Croatia is mainly dominated by broomcorn millet (*Panicum miliaceum*), barley and free-threshing wheat (*Triticum aestivum/durum*). This is particularly evident at Kalnik-Igrišče and Mačkovac-Crišnjevi. The most frequently identified pulses are lentils (*Lens culinaris*) and peas (*Pisum sativum*) within Hungary and Serbia. The largest numbers of lentils recovered are from the middle Bronze Age sites of Tiszaalpár-Várdomb and Bölcske-Vörösgyír, which had over 4500 and 3000 seeds respectively. In Serbia, over 3600 peas were recovered from the middle Bronze Age tell site of Feudvar and over 2700 peas at the late Bronze Age settlement of Hissar (Kroll and Reed, 2016; Medović and Mikić, 2021). In Croatia, again the pattern is slightly different with broad bean dominating late Bronze Age sites, followed by lentil and only a few finds of pea, again mainly from Kalnik-Igrišče. Clearly, the datasets vary in quality and quantity and sites with large deposits can skew the results, so these observations need examining further as more sampling is undertaken.

From the early Bronze Age, gold-of-pleasure (*Camelina sativa*), mustard (*Brassica rapa/nigra*), safflower (*Carthamus tinctorius*), poppy (*Papaver somniferum*) and linseed (*Linum usitatissimum*) are also documented in the Carpathian Basin and South-east Europe more generally. Linseed and poppy are old domesticates that spread throughout Europe from the Neolithic onwards and are present at sites within Croatia, including Bronze Age Beli Manastir-Sudaraž (Reed, 2015, 2017). The lump of gold-of-pleasure recovered from Kalnik-Igrišče, Croatia, as well as finds from Feudvar, Serbia, and Kastanas, Macedonia, indicate its use as a crop during this period (Kroll, 1983: 58–59; Kroll, 1998: 313; Reed at al., 2021). *Lallemantia* sp., and safflower are regionally limited to the south-eastern part of Europe, mostly northern Greece, in their use and distribution (Marinova and Riehl, 2009; Stika and Heiss, 2013; Valamoti, 2013). Safflower is found in large quantities at the fortified tell settlement of Turkeve-Terehalom, Hungary, but is rarely found in the Carpathian Basin in the Bronze Age (Gyulai, 2010: 105; Kroll, 1990).

Regardless of what crops dominate the assemblages what we generally see is an increase in crop diversity from the Copper Age to the late Bronze Age (Gyulai, 2010; Reed, 2013, 2017). Diversification is a technique that can be used to help reduce risk of crop failure, especially during periods of climate change (Halstead, 1990, 1995). Diversification is usually associated with more intensive regimes (e.g. more labour input per area), although, some suggest that an increase in crop diversity may also indicate an increase in agricultural production (Kreuz and Schäfer, 2008). This phenomenon of increased crop varieties is also seen across Western and Central Europe (Bakels, 1991, 2009; Effenberger, 2018), and the Mediterranean (Valamoti and Jones, 2003). Effenberger (2018) linked the rising diversity of crop plants in the late Bronze Age in northern Germany and Scandinavia to an increase in trade that resulted in an accelerated assimilation of innovations. Others have linked increased diversification to environmental or climatic changes. For example, Cremaschi et al. (2016), analysing a sediment sequence from the Villaggio Piccolo in the Po Valley, Italy, suggested that plant diversification increased during periods of dryness or phases of water crises. Zavodny et al. (2017) also proposed that to help minimise risk in the Lika region of Croatia during the Iron Age farmers, as a response to the marginal environment that were soil poor with long winters, adopted millet and a greater range of crops in order to stagger growing seasons.

As with the other periods, little research exists on reconstructing crop husbandry regimes for the Bronze Age in the Carpathian Basin. From archaeobotanical remains recovered from middle Bronze Age settlements in Hungary, Gyulai (2010: 106) suggests that areas were cleared and both autumn and spring crops were cultivated until the soil was exhausted, then left fallow. In addition, the continual recovery of pea and barley in Bronze Age levels in Hungary has been suggested to represent evidence of crop rotation at some sites (Gyulai, 2010: 102). At the Bronze Age site of Ganglegg, in north-east Italy, analyses of the arable weeds showed that a crop rotation system was practiced within a 500 m radius of the settlement (Schmidl and Oeggl, 2005). This involved the summer growing of broad bean, pea and broomcorn millet, while barley was sown in the autumn. Similarly palynological studies at Terramare culture villages, in the Po Valley, Italy, suggest complex and diversified land-use strategies, involving crop field (cereal/legume) rotation, alternation of fields and pastures, manuring and wood management since their establishment (Mercuri et al., 2006a, b). The increase in free-threshing wheat, which is a more demanding crop in relation to soil moisture and fertility, by the Bronze Age has also been attributed to new agricultural techniques, such as crop rotation (Hansen, 1988). Unfortunately, the dataset so far from Croatia does not provide evidence for crop rotation, but it is likely that some form of rotation system was practiced.

CONCLUSION

This study presents the archaeobotanical remains from ten Bronze Age settlement and cemetery sites in continental Croatia, which considerably expands the evidence in the region to 17 sites. Overall, the density of plant remains from the ten sites was low and consisted of either cereal grains or wild taxa, with the majority coming from Mačkovac-Crišnjevi. Oats and broomcorn millet (*Panicum miliaceum*) are the most dominant cereals, followed by small numbers of barley (*Hordeum vulgare*), emmer (*Triticum dicoccum*) and free-threshing wheat (*Triticum aestivum/durum*). If we look at all the sites from continental Croatia, we see a dominance in the late Bronze Age of the crops broomcorn millet, barley and free-threshing wheat, broad bean, and lentil (*Lens culinaris*), although emmer, einkorn (*Triticum monococcum*) and spelt (*Triticum spelta*) are also evident. The collection of fruits and nuts from the local environment is also evident, including acorns, cornelian cherry and Chinese lantern. Unfortunately, the limited sampling at sites, poor preservation and lack of carbon dating present problems when exploring questions of agricultural development through time and space, but what we can say is that by the late Bronze Age there is a greater diversity of crops cultivated.

Compared to neighbouring regions we see variations in the dominant crops, with millet being more common at early Iron Age sites in Hungary, while oats are not seen in any quantity until the late Iron Age. Carbon dating the oats would help determine whether they are contemporary with the other late Bronze Age finds in Croatia. But as the identification of the oat florets to species is inconclusive the remains could represent wild oat remains. Overall, it is unclear whether these changes in agricultural practice are linked to climatic or environmental influences, socio-economic changes, a response to the influx of new crops, technologies and ideas, or a mix of factors. Increased sampling at Bronze Age sites in Croatia is clearly needed to help build a more robust picture of the development of crop husbandry and landscape use in the region.

ACKNOWLEDGEMENTS

Many thanks to Hrvoje Kalafatić for his contribution to several of the archaeological excavations presented here and to the anonymous reviewers for their helpful suggestions.

REFERENCES

Aguilera, M., Zech-Matterne, V., Lepetz, S., Balasse M., 2018. Crop Fertility Conditions in North-Eastern Gaul During the La Tène and Roman Periods: A Combined Stable Isotope Analysis of Archaeobotanical and Archaeozoological Remains. Environmental Archaeology 23(4), 323–337. https://doi.org/10.1080/14614103.2017.1291563

Akeret, Ö., 2005. Plant remains from a Bell Beaker site in Switzerland, and the beginnings of *Triticum spelta* (spelt) cultivation in Europe. Vegetation History and Archaeobotany 14(4), 279–286. https://doi.org/10.1007/s00334-005-0071-1

Andrić, M., 2007. Holocene vegetation development in Bela krajina (Slovenia) and the impact of first farmers on the landscape. The Holocene 17(6), 763–776. http://dx.doi.org/10.1177/0959683607080516

Andrič, M., Willis, K.J., 2003. The phytogeographical regions of Slovenia: a consequence of natural environmental variation or prehistoric human activity? Journal of Ecology 91(5), 807–821. https://doi.org/10.1046/j.1365-2745.2003.00808.x

Antolín, F., Berihuete, M., López, O., 2016. Archaeobotany of Wild Plant use: Approaches to the Exploitation of Wild Plant Resources in the Past and its Social Implications. Quaternary International 404-A, 1–3. https://doi.org/10.1016/j.quaint.2016.01.029

Arnoldussen, S., Steegstra, H., 2016. A bronze harvest: Dutch Bronze Age sickles in their European context. Palaeohistoria 57/58, 63–109.

Außerlechner, M.V., 2021. Plant use and rites at burnt offering sites in the Eastern Alps during the Bronze and Iron Ages. Vegetation History and Archaeobotany 30, 155–170. https://doi.org/10.1007/s00334-020-00816-9

Bakels, C., 1991. Tracing crop processing in the Bandkeramik culture. In: Renfrew, J.M. (ed.), New light on early farming. Recent developments in palaeoethnobotany. Edinburgh University Press, Edinburgh, pp. 281–288.

Bakels, C., 2009. The Western European loess belt: agrarian history, 5300–A.D. 1000. Dordrecht, Springer.

Balen, J., 2013. Viškovci-Gradina. Hrvatski Arheološki Godišnjak 9/2012, 37–38.

Balen, J., 2014. Viškovci-Gradina. Hrvatski Arheološki Godišnjak 10/2013, 51–53.

Balen, J., 2015. Viškovci-Gradina. Hrvatski Arheološki Godišnjak 11/2014, 55–57.

Balen, J., 2016. Viškovci-Gradina. Hrvatski Arheološki Godišnjak 12/2015, 79–81.

Balen, J., 2020. Tomašanci-Palača – Settlements of the Late Stone, Copper and Bronze Age. Catalogi et Monographiae 17. Musei Archaeologici Zagrabiensis, Zagreb.

Bogaard, A., 2004. Neolithic Farming in Central Europe: An Archaeobotanical Study of Crop Husbandry Practices. Routledge, London.

Bogaard, A., Heaton, T.H.E., Poulton, P., Merbach, I., 2007. The impact of manuring on nitrogen isotope ratios in cereals: archaeological implications for reconstruction. Journal of Archaeological Science 34, 335–343. https://doi.org/10.1016/j.jas.2006.04.009

Bojčić, Z., Hršak, T., 2008. Kuševac – Topolina (AN 24A). Hrvatski Arheološki Godišnjak 5/2007, 40–42.

Borojević, K., Forenbaher, S., Kaiser, T., Berna, F., 2008. Plant use at Grapčeva cave and in the eastern Adriatic Neolithic. Journal of Field Archaeology 33(3), 279–303. https://doi.org/10.1179/009346908791071231

Bouby, L., Leroy, F., Carozza, L., 1999. Food plants from late bronze age lagoon sites in Languedoc, southern France: Reconstruction of farming economy and environment. Vegetation History and Archaeobotany 8, 53–69. https://doi.org/10.1007/BF02042843

Cappers, R.T.J., Neef, R., 2012. Handbook of Plant Palaeoecology. Barkhuis, Groningen.

Caracuta, V., Fiorentino, G., 2018. Plant rituals and fuel in Roman cemeteries of Apulia (SE Italy). In: Livarda, A., Madgwick, R., Riera Mora, S. (eds), The bioarchaeology of ritual and religion. Oxbow books, Oxford, pp. 58–68.

Castelletti, L., Castiglioni, E., Rottoli. M., 2001. L'agricoltura dell'Italia settentrionale dal Neolitico al Medievo. In: Failla, O., Forni, G. (eds), Le piante coltivate e la loro storia. FrancoAngeli, Milano, pp. 33–84.

Chapman, J., 2018. Climatic and human impact on the environment?: a question of scale. Quaternary International 496, 3–13. https://doi.org/10.1016/j.quaint.2017.08.010

Colledge, S., Conolly, J., 2014. Wild plant use in European Neolithic subsistence economies: a formal assessment of preservation bias in archaeobotanical assemblages and the implications for understanding changes in plant diet breadth. Quaternary Science Reviews 101, 193–206. https://doi.org/10.1016/j.quascirev.2014.07.013

Cremaschi, M., Mercuri, A.M., Torri, P., Florenzano, A., Pizzi, C., Marchesini, M., Zerboni, A., 2016. Climate change versus land management in the Po Plain (Northern Italy) during the Bronze Age: New insights from the VP/VG sequence of the Terramara Santa Rosa di Poviglio. Quaternary Science Reviews 136, 153–172. https://doi.org/10.1016/j.quascirev.2015.08.011

Demény A., Kern, Z., Czuppon, Gy., Németh, A., Schöll-Barna, G., Siklósy, Z., Leél-Őssy, Sz., Cook, G., Serlegi, G., Bajnóczi, B., Sümegi, P., Király, Á., Kiss, V., Kulcsár, G., Bondár, M., 2019. Middle Bronze Age humidity and temperature variations, and societal changes in East-Central Europe.

Quaternary International 504, 80–95. https://doi.org/10.1016/j.quaint.2017.11.023

Duffy, P., Parditka, G., Giblin, J., Paja, L., 2019. The problem with tells: Lessons learned from absolute dating of Bronze Age mortuary ceramics in Hungary. Antiquity 93(367), 63–79. https://doi.org/10.15184/aqy.2018.179

Earle, T., Ling, J., Uhnér, C., Stos-Gale, Z., Melheim, L., 2015. The Political Economy and Metal Trade in Bronze Age Europe: Understanding Regional Variability in Terms of Comparative Advantages and Articulations. European Journal of Archaeology 18(4), 633–657. https://doi.org/10.1179/1461957115Y.0000000008

Effenberger, H., 2018. The plant economy of the Northern European Bronze Age – more diversity through increased trade with southern regions. Vegetation History and Archaeobotany 27, 65–74. https://doi.org/10.1007/s00334-017-0621-3

Feurdean, A., Marinova, E., Nielsen, A.B., Liakka, J., Veres, D., Hutchinson, S.M., Braun, M., Timar-Gabor, A., Astalos, C., Mosburgger, V., Hickler, T., 2015. Origin of the forest steppe and exceptional grassland diversity in Transylvania (central-eastern Europe). Journal of Biogeography 42, 951–963. https://doi.org/10.1111/jbi.12468

Filatova, S., Gyulai, G., Kirleis, W., 2019. Environmental imposition or an ancient farmers' choice? A study of the presence of "inferior" legumes in the Bronze Age Carpathian Basin (Hungary). In: Dal Corso, M., Kirleis, W., Kneisel, J., Taylor, N., Wieckowska-Lüth, M., Zanon, M. (eds), How's Life? Living Conditions in the 2nd and 1st Millennia BCE. Sidestone press, Leiden, pp. 57–84.

Filipović, D., Meadows, J., Dal Corso, M., Kirleis, W., Alsleben, A., Akeret, Ö., Bittmann, F., Bosi, G., Ciută, B., Dreslerová, D., Effenberger, H., Gyulai, F., Heiss, A.G., Hellmund, M., Jahns, S., Jakobitsch, T., Kapcia, M., Klooß, S., Kohler-Schneider, M., Kroll, H., Makarowicz, P., Marinova, E., Märkle, T., Medović, A., Mercuri, A.M., Mueller-Bieniek, A., Nisbet, R., Pashkevich, G., Perego, R., Pokorný, P., Pospieszny, Ł., Przybyła, M., Reed, K., Rennwanz, J., Stika, H.-P., Stobbe, A., Tolar, T., Wasylikowa, K., Wiethold, J., Zerl, T., 2020. New AMS 14C dates track the arrival and spread of broomcorn millet cultivation and agricultural change in prehistoric Europe. Scientific Reports 10, 13698. https://doi.org/10.1038/s41598-020-70495-z

Fiorentino, G., Castiglioni, E., Rottoli, M., Nisbet, R., 2004. La colture agricole nel corso dell'età del Bronzo: sintesi dei dati e linee di tendensi. In: Cocchi Genick, D. (ed.), L'età del Bronzo Recente in Italia, Atti del Congresso Nazionale Lido di Camaiore, 26–29 ottobre 2000. Baroni, Viareggio, pp. 219–226.

Fischl, K.P., Reményi, L., 2013. Interpretation Possibilities of the Bronze Age Tell Sites in the Carpathian Basin. In: Anders, A., Kulcsár, G. (eds), Moments in Time: Papers presented to Pál Raczky on his 60th birthday. L'Harmattan, Budapest, pp. 725–738.

Fischl, K.P., Kiss, V., Kulcsár, G., Szeverényi, V., 2013. Transformations in the Carpathian Basin around 1600 B.C. In: Risch, R., Meller, M. (eds), 1600 – Cultural change in the shadow of the Thera-Eruption? Tagungen des Landesmuseums für Vorgeschichte Halle (9). Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt. Landesmuseum für Vorgeschichte, Halle, pp. 355–372.

Fuller, D., Stevens, C.J., McClatchie, M., 2014. Routine activities, tertiary refuse, and labor organization. Social inferences from everyday archaeobotany. In: Madella, M., Lancellotti, C., Savard, M. (eds), Ancient Plants and People. Contemporary Trends in Archaeobotany. Tucson, University of Arizona Press, pp. 174–217.

Gaastra, J.S., de Vareilles, A., Vander Linden, M., 2022. Bones and Seeds: An Integrated Approach to Understanding the Spread of Farming across the Western Balkans. Environmental Archaeology 27(1), 44–60. https://doi.org/10.1080/14614103.2019.1578016

Gogâltan, F., 2008. Fortified Bronze Age Tell Settlements in the Carpathian Basin. A General Overview. In: Czebreszuk, J., Kadrow, S., Müller J. (eds), Defensive Structures from Central Europe to the Aegean in the 3rd and 2nd millennia BC. Studien zur Archäologie in Ostmitteleuropa 5. Poznań, Bonn, pp. 39–56.

Gogâltan, F., 2019. The Chronology of the Bronze Age Tell and Tell-like Settlements in the Carpathian Basin. Revisited after 15 Years. Studia Hercynia 24, 198–214.

Grindean, R., Tanţău, I., Fărcaş, S., Panait, A., 2014. Middle to late Holocene vegetation shifts in the NW Transylvanian lowlands (Romania). Studia UBB Geologia 59, 29–3.

Gumnior, M., Herbig, C., Krause, R., Urdea, P., Ardelean, A.C., Stobbe, A., 2020. Palaeoecological evidence from buried topsoils and colluvial layers at the Bronze Age fortification Corneşti-Iarcuri, SW Romania: results from palynological, sedimentological, chronostratigraphical and plant macrofossil analyses. Vegetation History and Archaeobotany 29, 173–188. https://doi.org/10.1007/s00334-019-00762-1

Gyulai, F., 2010. Archaeobotany in Hungary: Seed, Fruit, Food and Beverage Remains in the Carpathian Basin from the Neolithic to the Late Middle Ages. Archaeolingua, Budapest.

Halstead, P., 1990. Waste not, want not: Traditional responses to crop failure in Greece. Rural History 1(2), 147–164.

Halstead, P., 1995. Late Bronze Age Grain Crops and Linear B Ideograms *65, *120, and *121. The Annual of the British School at Athens 90, 229–234.

Hansen, J.M., 1988. Agriculture in the Prehistoric Aegean: Data versus Speculation. American Journal of Archaeology 92(1), 39–52.

Harding, A., 2013. Salt in Prehistoric Europe. Sidestone Press, Leiden.

Hillman, G.C., 1981. Reconstructing crop husbandry practices from charred remains of crops. In: Mercer, R. (ed.), Farming Practice in British Prehistory.

Edinburgh University Press, Edinburgh, pp. 123–162.

Hillman, G.C., 1984. Interpretation of archaeological plant remains: The application of ethnographic models from Turkey. In: van Zeist, W., Casparie, W.A. (eds), Plants and Ancient Man; studies in palaeoethnobotany, Proceedings of the sixth symposium of the International Workgroup for Paleoethnobotany. A.A. Balkema, Rotterdam, pp. 1–41.

Hršak, T., 2009. Grabrovac-Ciglana. Hrvatski Arheološki Godišnjak 6/2008, 21–23.

Hršak, T., 2010. Grabrovac-Ciglana. Hrvatski Arheološki Godišnjak 7/2009, 28–29.

Hršak, T., 2015. Beli Manastir-Sudaraž (AN 3A). Hrvatski Arheološki Godišnjak 11/2014, 13–16.

Hršak, T., Bojčić, Z., 2007. Štrosmajerovac-Pustara. Hrvatski Arheološki Godišnjak 4/2006, 41–43.

Hubbard, R.N.L.B., Clapham, A., 1992. Quantifying macroscopic plant remains. Review of Palaeobotany and Palynology 73, 132–73. https://doi.org/10.1016/0034-6667(92)90050-Q

Huntley, J., 1996. The plant remains. In: Chapman, J., Shiel, R., Batović, Š. (eds), The Changing Face of Dalmatia. Leicester University Press, Leicester, pp. 225.

Jacomet, S., 2006. Identification of Cereal Remains from Archaeological Sites. Archaeobotany Laboratory, IPAS, Basel University, Basel. 2nd ed.

Jacomet, S., Brombacher, C., 2005. Reconstructing intra-site patterns in Neolithic lakeshore settlements: The state of archaeobotanical research and future prospects. In: Casa, P., Trachsel, M. (eds), WES'04 – Wetland Economies and Societies. Proceedings of the International Conference in Zurich, 10–13 March 2004. Chronos, Zürich, pp. 69–94.

Jones, G., 1984. Interpretation of archaeological plant remains: ethnographic models from Greece. In: van Zeist, W., Casparie, W.A. (eds), Plants and ancient man: Studies in palaeoethnobotany. A.A.Balkema, Rotterdam, pp. 43–61.

Jones, G., 1991. Numerical analysis in archaeobotany. In: van Zeist, W., Wasylikowa, K., Behre, K.-E. (eds), Progress in old world palaeoethnobotany. A.A. Balkema, Rotterdam, pp. 63–80.

Karavanić, S., Mihaljević, M., Kalafatić, H., 2002. Naselje Mačkovac-Crišnjevi kao prilog poznavanju početaka kulture polja sa žarama u slavonskoj Posavini. Prilozi Instituta za arheologiju u Zagrebu 19, 47–62.

Kristiansen, K., 2016. Bronze Age trade and migration. In: Kiriatzi, E., Knappett, C. (eds), Human Mobility and Technological Transfer in the Prehistoric Mediterranean. British School at Athens Studies in Greek Antiquity, Cambridge, pp. 154–181.

Kristiansen, K., Sørensen, M., 2019. Wool in the Bronze Age: Concluding Reflections. In: Sabatini, S., Bergerbrant, S. (eds), The Textile Revolution in Bronze Age Europe: Production, Specialisation, Consumption. Cambridge University Press, Cambridge, pp. 317–332.

Kroll, H., 1983. Kastanas. Ausgrabungen in einem Siedlunghügel der Bronze- und Eisenzeit Makedoniens 1975–1979. Die Pflanzenfunde. Prähistorische Archäologie in Südosteuropa 2, Berlin.

Kroll, H., 1990. Salfor von Feudvar, Vojvodina. Archäologisches Korrespondenzblatt 20, 41–46.

Kroll, H., 1998. Die Kultur- und Naturlandschaften des Titeler Plateaus im Spiegel der metallzeitlichen Pflanzen-reste von Feudvar. In: Hänsel, B., Medović, P. (eds), Feudvar. Ausgrabungen und Forschungen in einer Mikroregionam Zusammenfluss von Donau und Teiss. 1 Das Plateau von Titel und Šajkaška. Archäologische und naturwissen-schaftliche Beiträge zu einer Kulturlandschaft. Prähistorische Archäologie in Südosteuropa 13, 305–317.

Kroll, H., 2015. Tragovi prapovijesnih korištenih biljaka iz Monkodonje-Biljni nalazi. In: Hänsel, B., Mihovilić, K., Teržan, B. (eds), Monkodonja. Istraživanje protourbanog naselja brončanog doba Istre. Knjiga 1. Iskopavanje i nalazi građevina. Monografije i katalozi Arheološki muzej Istre 25. Pula, 104–108.

Kroll, H., Reed, K., 2016. Die Archäobotanik. Würzburg University Press, Würzburg.

Kreuz, A., Schäfer, E., 2008. Archaeobotanical consideration of the development of Pre-Roman Iron Age crop growing in the region of Hesse, Germany, and the question of agricultural production and consumption at hillfort sites and open settlements. Vegetation History and Archaeobotany 17, 159–179. https://doi.org/10.1007/s00334-008-0182-6

Kučan, D., 1984. Kulturpflanzenfunde aus Pod bei Bugojno, Zentralbosnien (Hallstatt- u. La Tène-Zeit). In: Zeist, W., Casparie, W.A. (eds), Plants and ancient man. Studies in palaeoethnobotany, Proceeding of the sixth symposium of the International Work Group for Palaeoethnobotany, Groningen, 30 May – 3 June 1983. A.A. Balkema, Rotterdam, pp. 247–256.

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 northern Great Hungarian Plain. Journal of Biogeography 37, 915–935. https://doi.org/10.1111/j.1365-2699.2009.02261.x

Magyari, E.K., Chapman, J.C., Fairbairn, A.S., Francis, M., de Guzman M., 2012. Neolithic human impact on the landscapes of North-East Hungary inferred from pollen and settlement records. Vegetation History and Archaeobotany 21, 279–302. https://doi.org/10.1007/s00334-012-0350-6

Mareković, S., Karavanić, S., Kudelić, A., Šoštarić, R., 2015. The botanical macroremains from the prehistoric settlement Kalnik-Igrišče (NW Croatia) in the context of current knowledge about cultivation and plant consumption in Croatia and neighbouring countries during the Bronze Age. Acta Societatis Botanicorum Poloniae 84(2), 227–235. http://dx.doi.org/10.5586/asbp.2015.015

Marinova, E., Riehl, S., 2009. *Carthamus* species in the ancient Near East and south-eastern Europe: archaeobotanical evidence for their distribution and use as a source of oil. Vegetation History and Archaeobotany 18, 341–349. https://doi.org/10.1007/s00334-009-0212-z

Medović, A., 2002. Archäobotanische Untersuchungen in der metallzeitlichen Siedlung Židovar, Vojvodina/Jugoslawien. Ein Vorbericht, (Starinar) 52, 181–190.

Medović, A., Mikić, A., 2021. Archaeoentomological assessment of weevil (Coleoptera, Bruchidae) infestation level of pea (*Pisum sativum*) at the Late Bronze Age settlement Hissar. Field & Vegetable Crops Research / Ratarstvo i povrtarstvo 58(1), 14–22.

Megaloudi, F., 2005. Burnt sacrificial plant offerings in Hellenistictimes: an archaeobotanical case study from Messene, Peloponnese, Greece. Vegetation History and Archaeobotany 14, 329–340. https://doi.org/10.1007/s00334-006-0072-8

Mercuri, A.M., Accorsi, C.A., Bandini Mazzanti, M., Bosi, G., Cardarelli, A., Labate, D., Marchesini, M., Trevisan Grandi G., 2006a. Economy and environment of Bronze Age settlements – Terramaras – in the Po Plain (Northern Italy): first results of the archaeobotanical research at the Terramara di Montale. Vegetation History and Archaeobotany 16, 43–60. https://doi.org/10.1007/s00334-006-0034-1

Mercuri, A.M., Accorsi, C.A., Bandini Mazzanti, M., Bosi, G., Trevisan Grandi, G., Cardarelli, A., et al., 2006b. Cereal fields from the middle-recent Bronze Age, as found in the Terramara di Montale, in the Po Plain (Emilia Romagna, Northern Italy), based on pollen, seeds/fruits and microcharchoals. In: Morel, J.-P., Tresserras, J., Matalama, J.C. (eds), The archaeology of crop fields and gardens. Centro Universitario per i Beni Culturali, Ravello. Edipuglia, Bari, pp. 251–270.

Mihaljević, M., Kalafatić, H., 2007a. Crišnjevi (naselje i nekropola). Hrvatski Arheološki Godišnjak 4/2006, 90–91.

Mihaljević, M., Kalafatić, H., 2007b. Veliki Šeš. Hrvatski Arheološki Godišnjak 4/2006, 106–107.

Mihaljević, M., Kalafatić, H., 2008. Crišnjevi (naselje i nekropola). Hrvatski Arheološki Godišnjak 5/2008, 117–118.

Mihaljević, M., Kalafatić, H., 2014. Mačkovac-Crišnjevi i Oštrovi (naselje I nekropola). Hrvatski Arheološki Godišnjak 11/2013, 100–101.

Mihaljević, M., Radović, S., 2018. Arheološka baština naselja Zapolje. Gradski muzej, Nova Gradiška.

Miller, D., 2018. Stable Carbon and Nitrogen Isotope Analysis in Italy and Croatia: Bronze Age Food Practices Across the Adriatic. Unpublished thesis, Sapienza University of Rome, Rome.

Motuzaite-Matuzeviciute, G., Staff, R., Hunt, H., Liu, X., Jones, M., 2013. The early chronology of broomcorn millet (*Panicum miliaceum*) in Europe. Antiquity 87(338), 1073–1085.

Nikolić, T., 2018. Flora Croatica Database. Available from: http://hirc.botanic.hr/fcd. Accessed December 2021.

Ramspott, F., 2017. Croatia country 3D render topographic map border. https://pixels.com/featured/croatia-country-3d-render-topographic-map-border-frank-ramspott.html

Reed, K., 2013. Farmers in Transition: The Archaeobotanical Analysis of the Carpathian Basin from the Late Neolithic to the Late Bronze Age (5000–900 BC). Unpublished thesis, School of Archaeology and Ancient History, University of Leicester.

Reed, K., 2015. From the field to the hearth: Plant remains from Neolithic Croatia. Vegetation History and Archaeobotany 24(5), 601–619. https://doi.org/10.1007/s00334-015-0513-3

Reed, K., 2017. Agricultural Change in Copper Age Croatia (ca. 4500–2500 cal B.C)? Archaeological and Anthropological Science 9(8), 1745–1765.

Reed, K., Kudelić, A., Essert, S., Polonijo, L., Karavanić, S., 2021. House of plenty: Reassessing food and farming in Late Bronze Age Croatia. Environmental Archaeology (online first). https://doi.org/10.1080/14614103.2021.1979385

Reed, K., Balen, J., Drnić., Essert, S., Kalafatić, H., Mihaljević, M., Zavodny, E., 2022. Unearthing millet in Bronze and Iron Age Croatia. In: Kirleis, W., Dal Corso, M., Filipović, D. (eds), Millet and what else? The wider context of the adoption of millet cultivation in Europe. Sidestone Press, Leiden, pp. 95–106.

Rottoli, M., Castiglioni, E., 2011. Plant offerings from Roman cremations in northern Italy: A review. Vegetation History and Archaeobotany 20(5), 495–506. https://doi.org/10.1007/s00334-011-0293-3

Schmidl, A., Oeggl, K., 2005. Subsistence strategies of two Bronze Age hill-top settlements in the Eastern Alps – Friaga/Bartholomäberg (Vorarlberg, Austria) and Ganglegg/Schluderns (South Tyrol, Italy). Vegetation History and Archaeobotany 14, 303–312. https://doi.org/10.1007/s00334-005-0088-5

Smith, H., Jones, G., 1990. Experiments on the effects of charring on cultivated grape seeds. Journal of Archaeological Science 17(3), 317–27.

Smith, D., Gaffney, V., Howard, A., Smith, K., Tetlow, E., Grossman, D., Tinsley, H., 2006. Assessing the later prehistoric environmental archaeology and landscape development of the Cetina Valley, Croatia. Environmental Archaeology 11(2), 171–186. https://doi.org/10.1179/174963106x123197

Staniuk, R., 2021. Early and middle Bronze Age chronology of the Carpathian Basin revisited: questions answered or persistent challenges? Radiocarbon 63(5), 1525–1546. https://doi.org/10.1017/RDC.2021.83

Stika, H.-P., Heiss, A.G., 2013. Plant cultivation in the Bronze Age. In: Fokkens, H., Harding, A. (eds), The Oxford Handbook of the European Bronze Age. Oxford University Press, Oxford, pp. 348–369.

Sümegi, P., Gulyás, S., Persaits, G., Szelepcsényi, Z., 2012. Long environment change in forest steppe habitat of the Great Hungarian Plain based on paleoecological data. In: Rakonczai, J., Ladányi, Z. (eds), Review of climate change research program at the University of Szeged (2010–2012). SZTE TTIK Földrajzi és Földtani Tanszékcsoport, Szeged, pp. 7–24.

Šoštarić, R., 2001. Karbonizirani biljni ostaci iz prapovijesnog lokaliteta u Novoj Bukovici na položaju Sjenjak. Prilozi Instituta za Arheologiju u Zagrebu 18, 79–82.

Šoštarić, R., 2004. Arheobotanička analiza uzoraka s lokaliteta Torčec-Gradić. Podravina, Koprivnica III/6, 107–115.

Tereso, J.P., Bettencourt, A.M.S., Ramil Rego, P., Teira Brión, A., López-Dóriga, I., Lima, A., Silva, R.A., 2016. Agriculture in NW Iberia during the Bronze Age: a review of archaeobotanical data. Journal of Archaeological Science Report 10, 44–58. https://doi.org/10.1016/j.jasrep.2016.07.011

Valamoti, S.M., 2013. Healing with Plants in Prehistoric Northern Greece: A Contribution from Archaeobotany. Offa 69/70 (2012/2013), 479–494.

Valamoti, S.M., Jones, G., 2003. Plant diversity and storage at Mandalo, Macedonia, Greece: archaeobotanical evidence from the Final Neolithic and Early Bronze Age. Annual of the British School at Athens 98, 1–35.

Van der Veen, M., 1992. Crop Husbandry Regimes: An Archaeobotanical Study of Farming in northern England 1000 BC–AD 500. J.R. Collis Publications, Sheffield.

Van der Veen, M., 2007. Formation processes of desiccated and carbonized plant remains – the identification of routine practice. Journal of Archaeological Science 34(6), 968–990. https://doi.org/10.1016/j.jas.2006.09.007

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

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, 740–750. https://doi.org/10.1890/0012-9658(1997)078[0740:DSCCVC]2.0.CO;2

Zavodny, E., Culleton, B.J., McClure, S., Kennett, D.J., Balen, J., 2017. Minimizing risk on the margins: Insights on Iron Age agriculture from stable isotope analyses in central Croatia. Journal of Anthropological Archaeology 48, 250–261. https://doi.org/10.1016/j.jaa.2017.08.004

Zavodny, E., McClure, S.B., Welker, M.H., Culleton, B.J., Balen, J., Kennett D.J., 2019. Scaling up: stable isotope evidence for the intensification of animal husbandry in Bronze-Iron Age Lika, Croatia. Journal of Archaeological Science Report 23, 1055–1065. https://doi.org/10.1016/j.jasrep.2018.10.008

Zohary, D., Hopf, M., 2000. Domestication of Plants in the Old World. Oxford University Press, Oxford. 3rd ed.

Zólyomi, B., Kéri, M., Horváth, F., 1997. Spatial and temporal changes in the frequency of climatic year types in the Carpathian Basin. Coenoses 12(1), 33–41.