

# Agricultural change in Copper Age Croatia (ca. 4500–2500 cal B.C)?

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**Abstract** The Copper Age in the Carpathian Basin is marked by a distinct change in settlement patterns, material culture, social traditions and subsistence practices; however, few studies address the nature of crop cultivation in the region. This paper examines new archaeobotanical data from 13 Copper Age (ca. 4500–2500 cal BC) sites located in continental Croatia, in order to assess the extent to which crop agriculture may have changed and contributed to overall subsistence economies in the Copper Age. From the archaeobotanical results, a dominance in einkorn and emmer is seen followed by barley. Less frequently millet, naked wheat and spelt/new glume wheat are also recovered, but due to their limited numbers, it is less clear whether they were grown as crops or represent weeds. Pulses (e.g. lentil, pea and grass pea), fruit remains (e.g. cornelian cherry and chinese lantern) and wild plant and weed species are also recovered, although more commonly from the late Copper Age sites. The archaeobotanical results show a clear reduction in the quantity and range of plant species recovered during the early/middle Copper Age; however, this is likely the result of taphonomic bias rather than a reduction in crop cultivation. The results therefore highlight problems of recovery bias in the region, which makes comparisons between sites as well as the reconstruction of crop husbandry regimes difficult. Overall, the results from continental Croatia suggest that the type of crops

cultivated continued relatively unchanged from the late Neolithic, although it is clear that more research is desperately needed to explore the relationship between crop agriculture and the changing socio-economic environment of the Copper Age in the region.

**Keywords** Archaeobotany · Eneolithic · Agro-pastoralism · Crop cultivation · Carpathian Basin

## Introduction

The Copper Age in the Carpathian Basin is marked by a distinct change in settlement patterns, material culture, social traditions and subsistence practices (Bánffy 1994; Bognar-Kutzián 1972:160–164; Gyucha et al. 2014; Kalicz 1970; Parkinson 2006). However, limited systematic investigations have led to an inadequate understanding of crop agriculture and its role in society from ca. 4500 to 2500 cal BC. This is particularly evident in Croatia where almost no information exists on the development of agriculture during the Copper Age. This paper therefore presents new archaeobotanical evidence from 13 Copper Age sites in continental Croatia, exploring the range of domestic crops that may have been cultivated at this time. In addition, the data will be examined in light of prevailing theories on the development of Copper Age subsistence strategies and assess the extent to which agriculture may have changed and contributed to overall subsistence economies in the region.

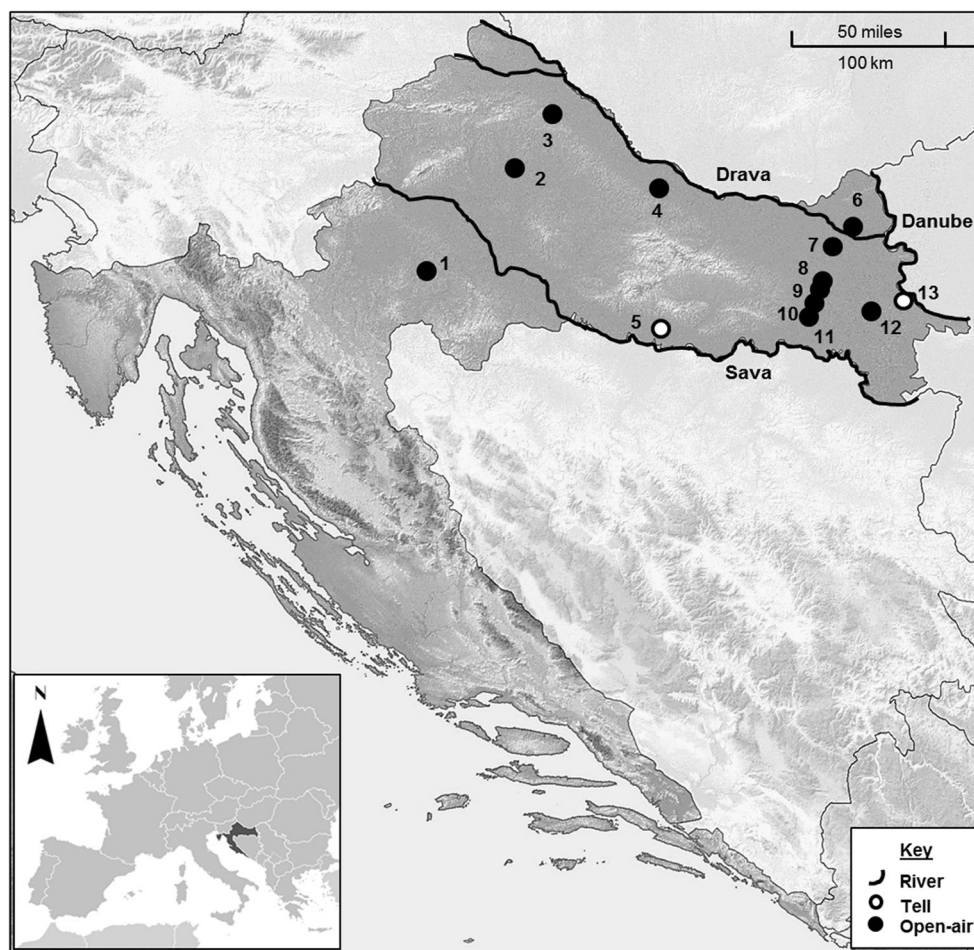
The 13 Copper Age study sites include Barbarsko, Čeminac-Vakanjac, Čepinski Martinci-Dubrava, Đakovo-Franjevac, Jurjevac-Stara Vodenica, Lasinja, Potočani, Pajtenica-Velike Livade, Slavča, Tomašanci-Palača, Virovitica-Bateliše, Vinkovci, 14 Matije Gupca and Vučedol (Fig. 1). Located within continental Croatia, the

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**Fig. 1** Location of Croatian study sites. 1 Lasinja, 2 Barbarsko, 3 Potočani, 4 Virovitica-Bateliše, 5 Slavča, 6 Čeminac-Vakanjac, 7 Čepinski Martinci-Dubrava, 8 Pajtenica-Velike Livade, 9 Jurjevac-Stara Vodenica, 10 Tomašanci-Palača, 11 Đakovo-Franjevac, 12 Vinkovci, 14 Matije Gupca, 13 Vučedol



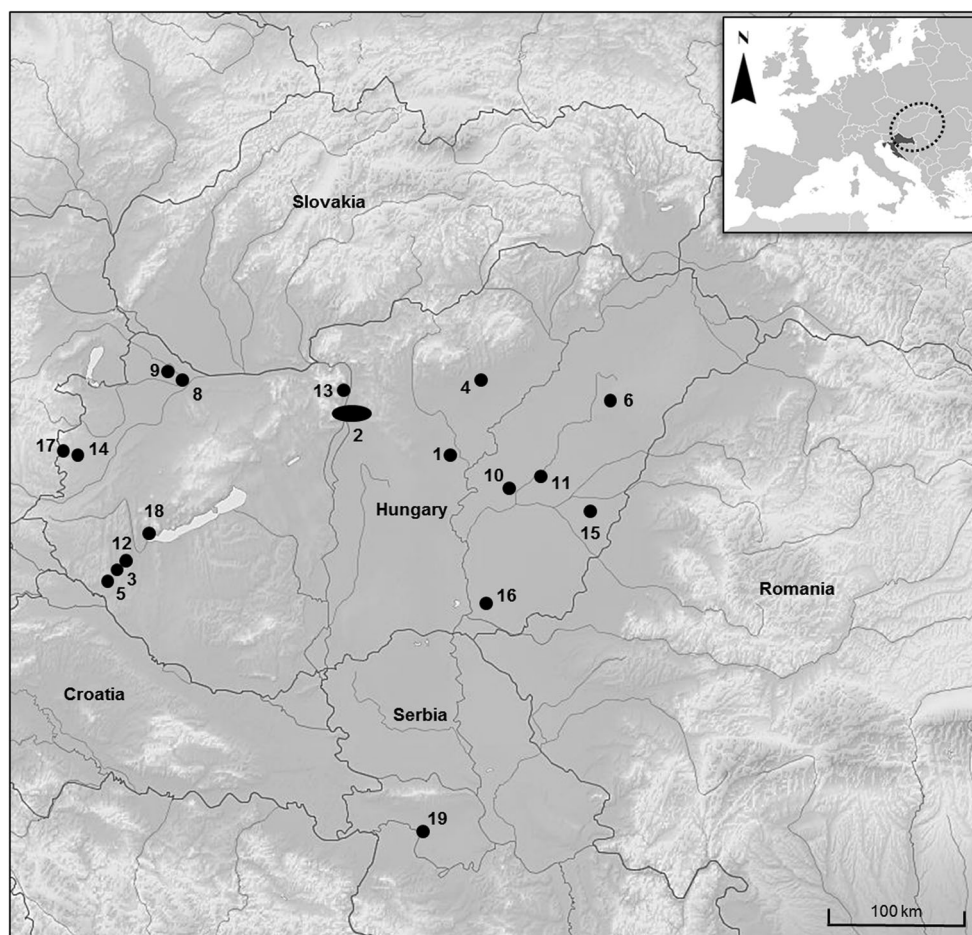
region is roughly bordered by the river Drava to the north, the Sava to the south and the Danube to the east and is characterised by relatively flat and extremely fertile loess plains. Continental Croatia is also situated within the south-western area of the Carpathian Basin, which is bordered by the Carpathian Mountains, the Alps, the Dinaric Alps and the Balkan Mountains, and also includes present day Hungary, eastern Slovenia, northern Serbia, western Slovakia, northern Bosnia and Herzegovina and north-western Romania (Fig. 2). The area covers ca. 300,000 km<sup>2</sup> and consists of two main geographical units, the peripheral mountains and the central fertile alluvial plains, i.e. Pannonian Plain, which is roughly dissected by the Danube and Tisza rivers.

### Defining the Copper Age in the Carpathian Basin

The transition from the Neolithic to the Copper Age, or Eneolithic, was not immediate and so many different interpretations exist as to the exact start date of the Copper Age (Sraka 2014). Historically, the Copper Age was marked by the start of copper metallurgy; however, the

emergence of copper mining and metallurgy is nowadays unquestionably connected to the Vinča culture, with the production of copper tools and weapons of basic appearance emerging in the central Balkans ca. 5000 to 4500 BC during the late Neolithic (Antonović 2009; Šljivar 2006; Radičević et al. 2010). The Copper Age is therefore defined by the changes seen in settlement patterns, ceramics, burial customs and trade networks, which occurred across the Carpathian Basin from ca. 4500 to 2500 cal BC (Bánffy 1994; Bogner-Kutzian 1972:160–164; Gyucha et al. 2014; Kalicz 1970; Parkinson 2006). However, defining cultural boundaries and chronologies can be problematic (Raczky and Siklósi 2013; Sraka 2014). In Croatia, the relationships between the various Copper Age cultures are uncertain, so this paper will not focus on or try to disentangle the complexities of the cultural traditions present in this region. That being said, Fig. 3 outlines the suggested development of cultures within continental Croatia with an arbitrary timespan of early/middle Copper Age (ca. 4500 to 3500 cal BC) and late Copper Age (ca. 3500 to 2500 cal BC) that will be used to examine the archaeobotanical data.

**Fig. 2** Map of the Carpathian Basin showing the location of Copper Age settlements with archaeobotanical remains discussed in the text. See Table S1 for a detailed list of the sites



## The Archaeological evidence

The archaeological evidence for the Copper Age in the Carpathian Basin is sporadic, with much of the period being characterised by generalised patterns. The majority of the evidence comes from the region of modern day Hungary, although zooarchaeological and archaeobotanical evidence is still fairly limited and almost non-existent in Croatia and Serbia. Typically, the transition to the Copper Age has been seen as a period where the large multilayer tell sites of the late Neolithic were gradually replaced by smaller dispersed and more transient settlements and a shift in subsistence practices that focused more on animal husbandry than crop agriculture (Bognar-Kutzian 1972; Bökönyi 1974; Gyulai 2010; Parkinson 2006:186). In Hungary, Parkinson (2006:144–145) showed a 700 % increase in sites during the Neolithic/Copper Age transition, suggesting that the pattern of residential mobility expanded considerably. His research showed two distinct settlement patterns: (a) the foundation of new site clusters in previously uninhabited micro-regions located in a particular river drainage and (b) the expansion of sites over a larger area within a previously inhabited late Neolithic cluster (Parkinson 2006:144). Evidence suggests that the small early

Copper Age settlements began to function as economically integrated units, with different households specialising in different craft activities (Parkinson et al. 2004). In addition, settlement specialisation is seen in eastern Serbia where a number of early Copper Age sites show a greater focus on copper ore extraction, while others show a continued focus on animal husbandry (Kapuran and Milošević 2013). Large long-lived formal cemeteries also appear at this time, along

4500	Sopot	Lengyel/ Vinča	Neolithic/Copper Age Transition
4000		Lasinja	Early/ Middle Copper Age
		Retz-gajary/ Boleraz	
3500			
3000		Baden	Late Copper Age
		Kostolac	
2500		Vučedol	

**Fig. 3** Chronological depiction of archaeological cultures in continental Croatia during the Copper Age



with an increase in grave goods, but they are usually isolated and unassociated with settlement sites (Bognar-Kutzian 1963, 1972; Chapman 2000).

By the late Copper Age, settlement patterns once again begin to change with the development of large tell sites, similar to the late Neolithic (Tasić 2003–2004). In Croatia, it is suggested that larger tell settlements may have represented a socio-economic centre with potential strategic, hierarchical and communication roles, with smaller satellite sites clustered typically near rivers or streams (Balén 2002, 2011; Durman 1995; Forenbaher 1994). In Hungary, Baden culture sites show a dense network of large and small sites, including caves, occupied for long and short periods, ranging over upland and lowland locations (Horváth and Virág 2003:127). The development of local metallurgical centres and the unequal growth of wealth may also explain the increase of fortified tell sites in the Carpathian, along with the expansion of long distance regional exchanges (Jovanović 2009; Sherratt 1998:10; Šljivar 2006). The nature of Copper Age societies is therefore likely to have varied regionally, depending on local geography, accessibility to resources and socio-economic inclinations. For example, the strong metallurgical base of the late Copper Age Vučedol culture, seen in the arc of mines along the mountains of the Carpathian Basin, would have resulted in faster technological innovations and social change closer to these centres, while those further afield would have developed at a slower rate, potentially holding on longer to late Neolithic values and traditions (Jovanović 1971).

### Evidence of animal husbandry practices

Traditional theories marked the Copper Age as a period which saw the impact of the ‘*Secondary Products Revolution*’, where technological innovations and subsistence changes included the introduction of the light plough, the wheel, animal traction, wool and milk production, manifesting in the increase in cattle in zooarchaeological assemblages (Bognar-Kutzian 1972; Bökönyi 1974; Sherratt 1981, 1983). Linked with these changes was the widespread practice of grazing animals in open areas (incorporating the practice of transhumance), the establishment of specialised pastoral subsistence strategies, as well as greater population mobility and long-distance transportation of goods. It was suggested that the larger cattle herds would require more grazing land, which was why settlements became smaller and more dispersed at the beginning of the Copper Age (Bognar-Kutzian 1972; Bánffy 1994; Molnár and Sümegei 2007).

Today, the increase in cattle and the exploitation of secondary products is clearly seen during the Neolithic, where mixed husbandry regimes were practiced (Copley et al. 2003; Craig et al. 2003, 2005; Evershed et al. 2008; Greenfield and Arnold 2015; Orton 2012; Spangenberg et al. 2006). Instead, the early Copper Age faunal remains, although particularly limited,

have begun to reveal variations in the proportion of domestic species at sites. For example, a reduction in cattle and increase in pig is seen in certain areas of Hungary (Parkinson et al. 2004; Giblin 2009), while cattle still seem to dominate the few Croatian and Serbian sites excavated (Balén 2005; Miculinić and Mihaljević 2003; Radmanović et al. 2014; Trbojević-Vukičević et al. 2011; Tasić 1979). In addition, an increased focus on domesticates is seen from assemblages where there is a marked reduction in wild animals identified from the late Neolithic to the early Copper Age (Bartosiewicz 2005; Gyucha et al. 2013).

Continuation in herd management from the Late Neolithic is supported by stable isotope and lipid studies, which suggest that herding remained small-scale and that dairy use was minimal (Giblin 2009; Giblin et al. 2013; Hoekman-Sites and Giblin 2012). They proposed that the cultural changes that occurred at the beginning of the Copper Age were associated with the emergence of smaller independent farmsteads, as well as the possible use of secondary products like manure, rather than a dramatic increase in herds and the use of secondary products (ibid.). Similar herd mobility is also seen from a study on sheep/goat and cattle molars which indicated that the tested animals were not herded in upland areas in the Carpathian Mountains (Giblin 2014). This is supported by stable isotope research in Romania, which shows that late Copper Age domestic stocks were reared within close proximity of the settlements, rather than through large-scale seasonal mobility (Balesse et al. 2015). However, herd movement may be identified from cave sites along the Dinaric Alps, which show evidence of seasonal/periodic use from the Neolithic to the Bronze Age as herd pens and camps (Mlekuž 2007; Reed 2015). Animal husbandry strategies are therefore likely to have varied regionally depending on the local environment and settlement preferences.

Pastoral specialisation has also been linked to the development of broad exchange networks and markets, and an increase in social complexity and political centralisation (Sherratt 1981, 1983), while general herd based strategies provide for local consumption and subsistence security (Stein 1987). Evidence of plant and animal specialisation and market economies can be identified from the late Bronze Age, where ‘palace-economies’ geared towards surplus production, redistribution and trade develop in the eastern Mediterranean (e.g. Halstead 1992, 1995a; Sherratt and Sherratt 1993; Foxhall 1995; Rougemont 2014). However, for the Copper Age large-scale surplus production, beyond what may be classed as a ‘normal’ surplus and trade (Halstead 1987, 1989), is not evident in the archaeological record.

Strong symbolic and ceremonial values also seem to exist for certain domestic animals; for example, pig burials were discovered at the late Copper Age site of akovo-Franjevac, Croatia (Balén 2011:165). In addition, late Copper Age Baden culture cemeteries in the Carpathian Basin commonly contain

animal burials, predominantly cattle, as well as fired clay cart models (Anthony 2007:159; Chapman 2000:312; Horváth 2010).

### Evidence of crop husbandry practices

Evidence of Copper Age crop agriculture in the Carpathian Basin is relatively infrequent and less investigated than the Neolithic or Bronze Age. In eastern Slovenia, no archaeobotanical remains seem to be dated to the Copper Age, while in western Slovenia, only six sites have identified plant remains dating to this period (Culiberg et al. 1992; Jeraj et al. 2009; Šercelj and Culiberg 1980, 1984; Šercelj 1981–1982; Tolar et al. 2011; Velušček et al. 2004). Bosnia and Herzegovina too has no identified archaeobotanical material dating to the Copper Age. In northern Serbia, only one site, Gomolava (Van Zeist 2003), has so far yielded plant remains from late Copper Age levels, and in north-west Romania, only one late Copper Age/early Bronze Age site, Cheile Turzil, has archaeobotanical evidence (Ciută 2009). In Slovakia, archaeobotanical remains have been identified from 18 sites (Hajnalová 2007), while in Hungary, 28 sites have evidence of Copper Age plant remains (Gyulai 2010; Kasper 2003; Kenéz et al. 2014). In Croatia, two coastal sites have archaeobotanical evidence (Huntley 1996; Borojević et al. 2008), while in continental Croatia, only the preliminary results of three of the study sites published here, Pajtenica-Velike Livade, Đakovo-Franjevac and Jurjevac-Stara Vodenica, provide any archaeobotanical evidence in the region (Đukić 2014; Reed 2011).

Generally, cereal remains are dominated by barley (*Hordeum vulgare* ssp. *vulgare*), both naked and hulled, Einkorn (*Triticum monococcum*) and emmer (*Triticum turgidum* ssp. *dicoccum*—formerly *Triticum dicoccum*). Less common are the occasional finds of broomcorn millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), naked wheat (*Triticum turgidum* ssp. *durum*/*Triticum aestivum*), ‘new type’ glume wheat and spelt (*Triticum aestivum* ssp. *spelta*). Whether these latter species were cultivated as crops during the Copper Age is still debated. For example, spelt and broomcorn millet are not believed to have been cultivated as crops until sometime during the 3rd millennium BC (Akeret 2005; Jacomet 2008; Motuzaite-Matuzeviciute et al. 2013; Valamoti 2013).

Pulses are particularly rare during this period with only a few finds of pea (*Pisum sativum*), lentil (*Lens culinaris*), grass pea (*Lathyrus sativus*) and bitter vetch (*Vicia ervilia*). Evidence of flax (*Linum usitatissimum*) is also uncommon, except for the discovery of a Copper Age pot that contained over 3000 flax seeds at Lovice-Pod, Slovakia (Hajnalová 2007). Other oil plants recovered include a large deposit of poppy (*Papaver somniferum*), found at Hočevarica, Slovenia (Tolar et al. 2011), and the presence of charlock (*Sinapis arvensis*) at Öcsöd-Kendereshalom, Hungary, may also

indicate oil extraction (Gyulai 2010:88). Common wild fruit and nut remains include cornelian cherry (*Cornus mas*), hazelnut (*Corylus avellana*), grape (*Vitis vinifera* ssp. *sylvestris*), chinese lantern (*Physalis alkekengi*), raspberry/blackberry (*Rubus* sp.) and acorns (*Quercus* sp.). A range of wild plant and weed species are also commonly identified including grasses (e.g. *Bromus* sp.) and fat hen (*Chenopodium album*).

Due to the largely restricted datasets available for this region, there is limited information about the types of crop husbandry regimes that may have been practiced (e.g. weeding, ploughing, manuring, irrigation). The use of animal traction, a key aspect of the ‘*Secondary Products Revolution*’, would have increased a household’s productivity in areas such as field tillage, which can be up to 15 times faster than manual cultivation, and the transportation of goods (Sherratt 1981, 1983; Halstead 1995b; Bogucki 1993). Unlike northwest Europe, where plough marks have been seen since ca. 3500 cal BC (Prösch-Danielsen 1993; Greenfield 2010), no plough marks or remains of the plough’s themselves have been found in the Carpathian Basin. Zooarchaeological evidence of traction-related pathologies have tentatively shown an increase during the late 4th millennium BC suggesting a link with the spread of the plough and wheeled vehicles (Greenfield 2010). However, in the Carpathian Basin, evidence of plough cultivation from the archaeobotanical record has not been identified until the Bronze Age, inferred from the increase in open-ground herbaceous species, such as cornflower (*Centaurea* sp.), knotweeds (*Polygonum* sp.) and docks (*Rumex* sp.), as well as an increase in cereal pollen in Hungary (Gardner 2002; Gyulai 1993). On a theoretical level, Chapman (1981:92–4) proposed that arid cultivation may have developed at some of the large late Neolithic Vinča sites in order to utilise the fertile chernozem soils in the region, while Halstead (1995b) suggested that the penetration of Copper Age communities into ‘marginal’ environments indicated the adoption of the plough. However, given the evidence, so far, it is difficult to determine the extent to which communities may have employed plough cultivation during the Copper Age in the Carpathian Basin and further evidence is clearly needed.

### Methodology

During 1999 to 2014, archaeobotanical samples were collected from 13 sites; Barbarsko, Čeminac-Vakanjac, Čepinski Martinci-Dubrava, Đakovo-Franjevac, Jurjevac-Stara Vodenica, Lasinja, Potočani, Pajtenica-Velike Livade, Slavča, Tomašanci-Palača, Virovitica-Batelije, Vinkovci, 14 Matije Gupca, and Vučedol (Fig. 1). Two types of site were excavated: flat, or horizontal, settlements, which have only a few layers of occupation, and tell sites, which have multiple episodes of rebuilding within a relatively concentrated area. The tell sites Slavča and Vučedol were sampled over a number

of field seasons while the remaining flat settlements were sampled as part of rescue excavations commissioned by the Ministarstvo Kulture Republike Hrvatske (Croatian Ministry of Culture). In addition to the settlements, samples were also taken from Potočani, a large burial pit filled with 50 individuals.

Each sampling method was determined and implemented by the directors of the excavation in relation to their own aims and objectives. Samples from Barbarsko, Đakovo-Franjevac, Jurjevac-Stara Vodenica, Lasinja, Pajtenica-Velike Livade, Potočani, Tomašanci-Palača and Virovitica-Bateliše were recovered only from pit features due to heavy erosion of the sites. The remaining sites were sampled from a range of contexts relating to human activities, such as settlement areas, house floors, hearths, pits and ditches. Sample sizes were not recorded for any of the samples, but an estimate has been calculated based on the directors sampling strategy. In general, a minimum of one bucket (ca. 11 l) of sediment was collected for each sample, although at Čepinski Martinci-Dubrava and Čeminac-Vakanjac, a minimum of two buckets were collected per sample.

Flotation was conducted either by bucket flotation or using a flotation machine with sieves ranging from 250 µm to 1 mm. Many of the sieve sizes are estimated, but it is believed that a 1 mm sieve was used for many of the rescue sites, Barbarsko, Đakovo-Franjevac, Jurjevac-Stara Vodenica, Lasinja, Pajtenica-Velike Livade, Potočani, Tomašanci-Palača, Vučedol and Virovitica-Bateliše, 300 µm at Čeminac-Vakanjac and Čepinski Martinci-Dubrava, and a 250 µm sieve at Vinkovci, 14 Matije Gupca and Slavča.

The floated remains were completely sorted for plant remains at all sites and the charcoal volume for each flot was recorded. All plant remains were carbonised and were identified using a low power  $\times 7$ –40 binocular microscope and comparisons made from the modern reference collections at the Institute of Archaeology, University College London and the School of Archaeology and Ancient History, University of Leicester. The nomenclature of scientific plant names follows Zohary et al. (2012) for cultivars and Tutin et al. (1964–1980) for wild plants.

A standardised counting method was used, where each grain counts as one and the whole grain equivalent (WGE) was estimated for fragments of grains. This was achieved by weighting 10 whole grains of a particular species then dividing by 10 to determine the average weight of a single grain, then the weight of the fragments are converted into the equivalent number of whole 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 parts of the same seed, such as *Cornus mas*.

## Results

For the purpose of this paper, the 13 study sites were examined as either an early/middle Copper Age (4500–3500 cal BC) or late Copper Age assemblage (3500–2500 cal BC) (Table 1). For the early/middle Copper Age, the sites included Barbarsko, Čepinski Martinci-Dubrava, Čeminac-Vakanjac, Jurjevac-Stara Vodenica, Lasinja, Potočani, Pajtenica-Velike Livade, Slavča, Tomašanci-Palača and Virovitica-Bateliše. For the late Copper Age, the sites included Čepinski Martinci-Dubrava, Tomašanci-Palača, Đakovo-Franjevac, Slavča, Vinkovci, 14 Matije Gupca and Vučedol. Forty-five samples from Slavča were categorised as Copper Age only as the samples have not been identified yet to a particular cultural group and so could represent occupation levels from the end of the Neolithic to the late Copper Age.

### Early/middle Copper Age (ca. 4500–3500 cal BC)

A total of 73 samples were examined from 11 sites containing 1486 seed items (Table 1). Seed density is particularly low at all the sites ( $< 1$  seed per litre), suggesting slow accumulation of plant remains within the contexts, except at Lasinja, which has a seed density of 5.7, and Slavča, which has a seed density of 10.5. Standard deviation was also low at most of the sites indicating little variation between the samples, although the following sites have a number of samples that increased their standard deviations. At Slavča, two samples have between them 349 glume wheat glume bases, at Lasinja, one sample contains 94 millet grains and at Čeminac-Vakanjac, one sample has 180 glume wheat glume bases. The average charcoal density is also extremely low ( $< 0.43$  cm<sup>3</sup>/l), except at Čepinski Martinci-Dubrava, which has a charcoal density of 1.35 (cm<sup>3</sup>/l) and Barbarsko, which has a charcoal density of 2.27 (cm<sup>3</sup>/l).

Cereal grain and chaff dominate the 11 site assemblages, from 56 % at Tomašanci-Palača to 99 % of the remains at Slavča, followed generally by fruits, wild plants and weed species (Tables 2, 3, and 4). Of the cereals, einkorn (*Triticum monococcum* L. ssp. *monococcum*) and emmer (*Triticum turgidum* L. ssp. *dicoccum*) grain and chaff dominate many of the sites, with a large number of *Triticum* sp. glume bases also being recovered from Slavča and Čeminac-Vakanjac (Table 2). Thirteen barley grains (*Hordeum vulgare* ssp. *vulgare*) are identified from the assemblages and only one barley rachis was identified from Slavča. Of interest was the large number of foxtail millet (*Setaria italica*) grains from Lasinja, which were slightly larger, more rounded and less slender than *Setaria viridis/verticillata*.

Pulses and oil plants were rare with only one large unidentified pulse from Potočani and two possible flax seeds (*Linum usitatissimum*) from Čeminac-Vakanjac (Table 3). The fruit spectrum is dominated by cornelian cherry (*Cornus mas*),

**Table 1** Summary of the 13 Copper Age sites and their archaeobotanical assemblages

Site name	<sup>14</sup> C-dates (cal BC) (estimated date)	Cultural group	No. of samples with plant remains	Total volume (l)	Total no. of seed items (WGE) <sup>a</sup>	Average charcoal density (cm <sup>3</sup> /l)	Average seed density (n/l)	Features sampled	References
Early/Middle Copper Age									
Slavča	—	Sopot, Lasinja	4	44	462	0.43	10.5	Various	1
Čepinski Martinci-Dubrava	(4200–3800)	Lasinja	1	20	8	1.35	0.40	Pit	2
Jurjevac-Stara Vodenica	4320–3960	Lasinja	8	88	45	0.09	0.50	Pit	3
Potočani	4230–4040	Lasinja	1	55	69	0.00	0.00	Grave pit	4
Pajtenica-Velike Livade	4300–3900	Lasinja	16	176	24	0.09	0.10	Pit/ditch	5
Tomašanci-Palača	4340–3950	Lasinja	12	132	134	0.10	1.00	Pit	6
Lasinja	4040–3950	Lasinja	2	22	125	0.10	5.70	Pit	7
Barbarsko	4320–3360	Lasinja, Retz-gajary	1	11	3	2.27	0.00	Pit	8
Čeminac-Vakanjac	(3750–3600)	Retz-gajary	23	460	565	0.00	1.20	Various	2
Tomašanci-Palača	3700–3630	Retz-gajary	2	22	28	0.00	1.30	Pit	6
Virovitica-Batelije	3510–3330	Retz-gajary, Boleraz	3	33	14	0.00	0.40	Pit	9
Middle/Late Copper Age									
Čepinski Martinci-Dubrava	(3370–2900)	Baden	1	20	32	0.63	1.6	Pit	2
Tomašanci-Palača	3270–3240	Baden	3	33	26	0.20	0.80	Pit	6
Đakovo-Franjevac	3340–2830	Kostolac	26	253	289	10.07	1.20	Pit	10
Vučedol	3490–2790	Baden, Kostolac	34	374	1571	1.07	4.20	House	11
Slavča	—	Kostolac	18	198	363	1.37	1.83	Various	1
Vinkovci/Matije Gupca 14	2880–2480	Vučedol	4	216	1733	1.87	7.60	Pit	12
Copper Age									
Slavča	—	Sopot, Lasinja, Kostolac	42	462	2391	0.70	5.17	Various	1

<sup>a</sup> Not including unidentified items

1 Skelec 1997, Mihaljević 2004, 2005, 2006, 2007, 2008, 2009; 2 H. Kalafatić pers. comm.; 3 Balen 2008a; 4 Balen 2007a, 2010; 5 Balen 2006a; 6 Balen 2008b, 2010; 7 J. Balen pers. comm.; 8 Balen and Dmić 2014; 9 Balen 2006b, 2010; 10 Balen 2010, 2011; 11 Balen 2005, 2007b, 2008c, 2010; 12 Krznarić Škrivanko 2007; Miloglav 2007, 2012

**Table 2** Total number of cereal grains and chaff remains per study site

	Samples (n)	Cereal grain (%)	<i>Hordeum vulgare</i> ssp. <i>vulgare</i>	<i>Hordeum vulgare</i> ssp. <i>vulgare</i> (twisted)	<i>Triticum turgidum</i> L. ssp. <i>dicoccum</i>	<i>Triticum monococcum</i> L. ssp. <i>monococcum</i> (1-grain)	<i>Triticum monococcum</i> ssp. <i>monococcum</i> (2-grain)	<i>Triticum mono/</i> <i>dicoc</i>	<i>Triticum</i> cf. <i>aestivum</i> L. ssp. <i>spelta</i> /'new type' glume wheat	Naked wheat <sup>a</sup>	<i>Triticum</i> sp.	<i>Panicum miliaceum</i>
Early/Middle Copper Age												
Slavča	4	1	1		1				1	1	2	
Čepinski Martinci- Dubrava	1	75	2	1								
Jurjevac-Stara Vodenica	8	35			6							
Potočani	1	67		1	7	1					2	
Pajtenica-Velike Livade	16	67	3					1			2	
Tomašanci-Palača	12	8			1		1	1			5	
Lasinja	2	86	(1)									6
Barbarsko	1	100	2	1								
Čeminac-Vakanjac	23	10	1		1	14		5			17	
Tomašanci-Palača	2	56			1	1					3	
Virovitica-Batelije	3	8									1	
Middle/Late Copper Age												
Čepinski Martinci- Dubrava	1	100					(4)				3	
Tomašanci-Palača	3	33	1							2		
Đakovo-Franjevac	26	37	4		4	35		6		1	22	1
Vučedol	34	82	7	1	22	336	1	105	2	1	178	
Slavča	18	7			5	5				2	9	
Vinkovci/Matije Gupca 14	4	19	16	1	125	53		32	16	16	51	2
Copper Age												
Slavča	42	3	25		11	3			1		18	
Total (n)	199	61	4	184	448	6	150	20	23	313	9	58
	<i>Setaria italica</i>	<i>Panicum/</i> <i>Setaria</i> sp.	Cereal chaff (%)	<i>Hordeum vulgare</i> ssp. <i>vulgare</i> rachis	<i>Triticum turgidum</i> L. ssp. <i>dicoccum</i> glume base	<i>Triticum monococcum</i> L. ssp. <i>monococcum</i> glume base	'New type' glume wheat glume base	<i>Triticum</i> cf. <i>aestivum</i> L. <i>spelta</i> glume base	<i>Triticum</i> sp. glume base	Naked wheat <sup>a</sup> rachis	Cerealia rachis	Straw
Early/Middle Copper Age												
Slavča			98	1	8	11	5		453		1	
Čepinski Martinci- Dubrava			0									
Jurjevac-Stara Vodenica			29		1				4			
Potočani	1		22		3				1			
Pajtenica-Velike Livade			0									
Tomašanci-Palača			66		2				60		1	
Lasinja	48	47	0									
Barbarsko			0									
Čeminac-Vakanjac	1		77		21	2			282			1



Table 2 (continued)

<i>Setaria italica</i> sp.	<i>Panicum/ Setaria</i> sp.	Cereal chaff (%)	<i>Hordeum vulgare</i> ssp. vulgare rachis	<i>Triticum turgidum</i> L. ssp. <i>dicoccum</i> glume base	<i>Triticum monococcum</i> L. ssp. <i>monococcum</i> glume base	'New type' glume wheat glume base	<i>Triticum cf. aestivum</i> L. <i>spelta</i> glume base	<i>Triticum</i> sp. glume base	Naked wheat rachis	Cerealia rachis	Straw
		0		2	1			8			
Tomašanci-Palača		92									
Virovitica-Batelije		0									
Middle/Late Copper Age											
Čepinski Martinci-Dubrava		67		2	1			3			
Tomašanci-Palača		15			11			4			
Đakovo-Franjevac	4	2			9			7	1		15
Vučedol		87		10	21		1	216			2
Slavča		0						3			
Vinkovci/Matije Gupca 14											
Copper Age	4	93	5	93	41		3	218	1	1	
Slavča	47	6	142	97	5	4	3159	2	3	18	
Total (n)											

<sup>a</sup> *Triticum turgidum* L. ssp. *durum*/*Triticum aestivum* L. ssp. *aestivum*. (number) = cf.

which was recovered from four of the sites, followed by chinese lantern (*Physalis alkekengi*), which was found at two sites (Table 3). Wild plant and weed species are not commonly identified from the sites with Čeminac-Vakanjac having the highest number at 32 seeds and 13 different species, of which grasses and dwarf elder (*Sambucus ebulus*) predominated (Table 4).

### Late Copper Age (ca. 3500–2500 cal BC)

A total of 86 samples were examined from 6 sites containing 4002 seed items (Table 1). Seed density was generally higher than the early/middle Copper Age ranging from 0.8 at Tomašanci-Palača to 7.6 at Vinkovci/Matije Gupca 14. Standard deviation was relatively high (8.7) for Vučedol indicating variation between the samples. In particular, three samples from house floors and one sample from a burnt wall at Vučedol had high concentrations of einkorn and indeterminate cereal fragments. Charcoal density was also higher ranging from 0.2 (cm<sup>3</sup>/l) at Tomašanci-Palača to 10.07 (cm<sup>3</sup>/l) at Đakovo-Franjevac.

Cereal grain and chaff dominate the assemblages of all but Vinkovci/Matije Gupca 14, where 77 % of the site assemblage is wild plant and weed species (Tables 2, 3, and 4). Einkorn dominates the cereal remains at Đakovo-Franjevac and Vučedol, while emmer dominates Vinkovci/Matije Gupca 14. Overall, barley is not found in high quantities with the highest number of grains, 16, being found at Vinkovci/Matije Gupca 14 (Table 2). No barley rachis was identified for this period. At Vinkovci/Matije Gupca 14 and Vučedol, a number of possible spelt or 'new type' glume wheat grains, characterised by the blunt apex and no dorsal ridge (Jones et al. 2000; Kohler-Schneider 2003), were recovered. However, due to similarities in morphology, their poor state of preservation and the fact that no identified glume bases were recovered restricted their identification to species (Table 2). A small number of naked wheat grains (identified as *Triticum turgidum* L. ssp. *durum*/*Triticum aestivum* L. ssp. *aestivum*) were also recovered at all the sites during this period.

Pulses and oil plants are far more common, especially at Đakovo-Franjevac, which had seeds of grass pea (*Lathyrus sativus*), lentil (*Lens culinaris*) and pea (*Pisum sativum*), and at Vinkovci/Matije Gupca 14, where 47 flax seeds were identified (Table 3). The fruit remains were dominated by chinese lantern, which were recovered in small numbers from all four sites, as well as cornelian cherry which was identified at three of the sites (Table 3). A couple of blackberry (*Rubus fruticosus*) seeds were also recovered from Đakovo-Franjevac and Slavča. Wild plant and weed species are present in higher quantities at all the sites except Slavča, where only 4 % of the assemblage contained wild plant and weed species (Table 4). As already noted, Vinkovci/Matije Gupca 14 has a

**Table 3** Pulses, oil plants and fruit remains per study site

	Samples (n)	Pulses (%)	<i>Lathyrus sativus</i>	<i>Lens culinaris</i>	<i>Pisum sativum</i>	<i>Vicia ervilia</i>	Large pulse indet.	Oil plants (%)	<i>Linum usitatissimum</i>	<i>Linum</i> cf. <i>usitatissimum</i>	Fruits and nuts (%)
Early/Middle Copper Age											
Slavča	4	0					1	0			0
Čepinski Martinci- Dubrava	1	0						0			0
Jurjevac-Stara Vodenica	8	0						0			35
Potočani	1	6					1	0			0
Pajtenica-Velike Livade	16	0						0			0
Tomašanci-Palača	12	0						0			14
Lasinja	2	0						0			5
Barbarsko	1	0						0			0
Čeminac-Vakanjac	23	0						1		2	7
Tomašanci-Palača	2	0						0			33
Virovitica-Batelijske	3	0						0			0
Middle/Late Copper Age											
Čepinski Martinci- Dubrava	1	0						0			0
Tomašanci-Palača	3	0						0			0
Đakovo-Franjevac	26	9	1	2	11		4	2	3		10
Vučedol	34	1			4		1	1	6		0
Slavča	18	0						0		1	2
Vinkovci/Matije Gupca 14	4	0					1	3	47		1
Copper Age											
Slavča	42	0		1		1	6	1	13		0
Total (n)	199		1	3	15	1	14		69	3	
		cf. <i>Cornus mas frag</i>	<i>Corylus</i> sp.	<i>Physalis alkekengi</i>	<i>Prunus</i> cf. <i>spinosa</i>	<i>Rubus fruticosus</i>	<i>Rubus</i> sp.	<i>Sambucus</i> sp.			Indet. seed/shell
Early/Middle Copper Age											
Slavča											
Čepinski Martinci-Dubrava											
Jurjevac-Stara Vodenica						1					
Potočani											
Pajtenica-Velike Livade											
Tomašanci-Palača				2							9
Lasinja				3					1		1
Barbarsko											
Čeminac-Vakanjac	8									2	4
Tomašanci-Palača			2								

**Table 3** (continued)

	cf. <i>Cornus mas frag</i>	<i>Corylus</i> sp.	<i>Physalis alkekengi</i>	<i>Prunus cf. spinosa</i>	<i>Rubus fruticosus</i>	<i>Rubus</i> sp.	<i>Sambucus</i> sp.	Indet. seed/shell
Virovitica-Bateliše								
Middle/Late Copper Age								
Čepinski Martinci-Dubrava								
Tomašanci-Palača			8		2	1		1
Đakovo-Franjevac			1					
Vučedol			2		2			
Slavča	1		8					
Vinkovci/Matije Gupca 14								
Copper Age								
Slavča		2	1	1	4	2	2	2
Total (n)	9	2	25	1	4	2	2	17

particularly high percentage, which is from the recovery of large numbers of grass species (*Bromus* sp., *Phleum* sp. etc.) and goosefoot/fat hen (*Chenopodium* sp./*Chenopodium album*), which equalled 1212 seeds (Table 4).

### Copper Age (4500–2500 cal BC)

For the 42 undated Slavča samples, a total of 2391 seed items were recovered. Seed density was relatively high at 5.17, but the charcoal density was low at 0.7 (cm<sup>3</sup>/l). The chaff remains dominated, representing 93 % of the assemblage. Unfortunately, due to poor preservation at the site, 2118 glume bases could not be identified to species. Where possible, einkorn, emmer and new glume wheat glume bases were identified (Jones et al. 2000; Kohler-Schneider 2003), along with five barley rachis. Of the small number of cereal grains identified, barley dominates, followed by einkorn and then emmer and one possible spelt or 'new type' glume wheat (Table 2). One lentil and one bitter vetch (*Vicia ervilia*) were recovered along with 13 flax seeds. Of the fruits, only one cornelian cherry and one chinese lantern seed was identified. The wild plant and weed seed spectrum is dominated by grasses and fat hen, but due to poor preservation, few seeds were able to be identified to species (Table 4).

## Discussion

### Assessing the archaeobotanical data from continental Croatia

The limited occurrence of archaeobotanical sampling at sites has resulted in a large gap in our understanding of agricultural development in Croatia. Where samples are taken, there is no consistency and little record of the methods used, which presents problems when analysing possible patterns between sites. The different sites examined here have a number of biases within their assemblages. Most notably is the difference in sieve sizes used between the sites, which means that smaller seeds and plant items may have been lost at Barbarsko, Đakovo-Franjevac, Jurjevac-Stara Vodenica, Lasinja, Pajtenica-Velike Livade, Potočani, Tomašanci-Palača, Vučedol and Virovitica-Bateliše, which used slightly larger mesh sizes (cf. Keeley 1978; Pearsall 2000). In addition, the limited range of contexts sampled will also impact the representativeness of the archaeobotanical data (Hillman 1981; Jacomet and Brombacher 2005). The bias towards pits in the Croatian assemblage, as well as the low seed density, may suggest that many of the remains represent the slow accumulation of secondary or tertiary deposits, which have little association with activities in the location of the context. This is most evident from the high

**Table 4** Seeds and fruits of wild plants and weed species per study site

	Early/Middle Copper Age	Slavča	Čepinski Dubrava	Martinci-	Jurjevac-Stara Vodenica	Potočani	Pajtenica-Velike Livade	Tomašanci- Palača	Lasinja	Barbarsko	Čeminac- Vakanjac	Tomašanci- Palača	Virovitica- Batelije
Samples (n)		4	1		8	1	16	12	2	1	23	2	3
Wild plant/weed species (%)		0	25		0	6	33	13	8	0	0	11	0
<i>Ajuga reptans</i>													
<i>Agrostemma githago</i>													
cf. <i>Agrostemma githago</i>											1		
Asteraceae													
<i>Astragalus</i> sp.									1				
<i>Bromus</i> sp.								1			4		
<i>Carex</i> sp.								1					
cf. <i>Carpinus betulus</i>													
Chenopodiaceae		2											
<i>Chenopodium</i> sp.													
<i>Chenopodium album</i>													
<i>Cirsium</i> sp.											2		
cf. <i>Convolvulus arvensis</i>													
Compositae													
Cyperaceae													
<i>Dasypyrum/Secale</i> sp.													
<i>Festuca</i> sp.													
<i>Galium aparine</i>								6					
<i>Galium</i> sp.						1		1			1		
Gramineae large						1	2	3	7		7	1	
Gramineae small											1		
<i>Hypericum</i> sp.													
cf. <i>Juncaceae</i>											1		
<i>Lolium</i> sp.													
<i>Mentha</i> sp.													
cf. <i>Medicago</i> sp.									1				
<i>Phalaris</i> sp.											1		
<i>Phalaris/Phleum</i> sp.													
<i>Phleum</i> sp.													
<i>Plantago lanceolata</i>													
<i>Plantago</i> sp.											1		
<i>Poa</i> sp.													
<i>Polygonum</i> sp.											1		
<i>Polygonum aviculare</i>									1		2		
<i>Potentilla</i> sp.													
<i>Rumex</i> sp.													
<i>Rumex/Polygonum</i> sp.													
<i>Sambucus ebulus</i>								2	1		8		
<i>Setaria viridis/verticillata</i>													
<i>Silene</i> sp.													
<i>Salvia</i> sp.													
cf. <i>Sherardia arvensis</i>													



**Table 4** (continued)

	Early/Middle Copper Age	Slavča	Čepinski Martinci- Dubrava	Jurjevac-Stara Vodenica	Potočani	Pajtenica-Velike Livade	Tomašanci- Palača	Lasinja	Barbarsko	Čeminac- Vakanjac	Tomašanci- Palača	Virovitica- Batelije
Small seeded legumes			1							1		
<i>Solanaceae</i>												
<i>Teucrium</i> sp.												
<i>Teucrium chamaedrys</i>												
<i>Trifolium</i> sp.												
<i>Urtica</i> sp.												
<i>Verbena officinalis</i>												
<i>Viola</i> sp.										1		
	Middle/Late Copper Age		Čepinski Martinci- Dubrava	Tomašanci- Palača	Đakovo- Franjevac	Vučedol	Slavča	Vinkovci/ Matije Gupca 14		Copper Age	Slavča	Total (n)
Samples (n)			1	3	26	34	18	4			42	201
Wild plant/weed species (%)	0		0	28	14	4	77		4			
<i>Ajuga reptans</i>						1						1
<i>Agrostemma githago</i>					3	7		2				12
cf. <i>Agrostemma githago</i>												1
Asteraceae								1			3	4
<i>Astragalus</i> sp.												1
<i>Bromus</i> sp.					17	30	2	381			48	483
<i>Carex</i> sp.						1	2	1				5
cf. <i>Carpinus betulus</i>					1							1
Chenopodiaceae						1	1				1	5
<i>Chenopodium</i> sp.								108			1	109
<i>Chenopodium album</i>					2	1		513			7	523
<i>Cirsium</i> sp.												2
cf. <i>Convolvulus arvensis</i>						1						1
Compositae											3	3
Cyperaceae								1				1
<i>Dasyphyrum/Secale</i> sp.								1				1
<i>Festuca</i> sp.						1						1
<i>Galium aparine</i>						1		2			1	10
<i>Galium</i> sp.					4	1					1	9
Gramineae large					5	14	1	200			10	251
Gramineae small					1	3		3			3	11
<i>Hypericum</i> sp.						2		1				3

**Table 4** (continued)

	Middle/Late Copper Age	Čepinski Martinci- Dubrava	Tomašanci- Palača	Đakovo- Franjevac	Vučedol	Slavča	Vinkovci/ Matije Gupca 14	Copper Age	Slavča	Total (n)
cf. <i>Juncaceae</i>										1
<i>Lolium</i> sp.				1	1		1			3
<i>Mentha</i> sp.					1					1
cf. <i>Medicago</i> sp.										1
<i>Phalaris</i> sp.					4					5
<i>Phalaris/Phleum</i> sp.					1				3	4
<i>Phleum</i> sp.				1	3		10			14
<i>Plantago lanceolata</i>					1					1
<i>Plantago</i> sp.					1					2
<i>Poa</i> sp.					2					2
<i>Polygonum</i> sp.				4	4	1	2		2	14
<i>Polygonum aviculare</i>					2					5
<i>Potentilla</i> sp.					1	1	1			3
<i>Rumex</i> sp.					1					1
<i>Rumex/Polygonum</i> sp.				6					4	10
<i>Sambucus ebulus</i>				2	3		3			19
<i>Setaria viridis/verticillata</i>				5	6	2			1	14
<i>Silene</i> sp.				1	3					4
<i>Salvia</i> sp.					1					1
cf. <i>Sherardia arvensis</i>									2	2
Small seeded legumes				3	2		12			19
<i>Solanaceae</i>				1						1
<i>Teucrium</i> sp.				1	5		2			8
<i>Teucrium chamaedrys</i>					5					5
<i>Trifolium</i> sp.					3					3
<i>Urtica</i> sp.					1				1	2
<i>Verbena officinalis</i>							1			1
<i>Viola</i> sp.						1	2			4

percentage of glume wheat glume bases recovered from pits at Slavča, Tomašanci-Palača, Virovitica-Bateliše, which may represent crop processing by-products that were either deliberately or accidentally thrown in a fire and then swept outside (Hillman 1984; Van der Veen 2007). Further bias may be seen by the lack of barley rachis within the Croatian assemblages, where its absence may not necessarily suggest its absence as a crop but rather that barley was processed away from the settlement or did not survive the carbonisation process (cf. Dennell 1976; Hillman 1981). The movement of remains through contexts has also been recently demonstrated from the dating of broomcorn millet that turned out to be younger than their contexts suggested (Motuzaite-Matuzeviciute et al. 2013). The anomalous foxtail millet remains from one sample at Lasinja may therefore represent younger remains, especially as foxtail millet is only identified as a minor crop from the Iron Age onwards (Bakels 2013; Schmidl et al. 2007).

Another consideration is the differences in site formation, as the greatest numbers of identified plant items as well as the greatest range of species identified were from Vučedol, Slavča and Vinkovci/Matije Gupca 14, which are all sites where either higher concentrations of occupation are present or where the successive layers of occupation permitted greater preservation. In contrast, many of the other sites were excavated as part of rescue excavations, which in some cases limited the number of samples collected, and many were located in agricultural fields that were heavily ploughed, making sampling only possible from pit features (e.g. Jurjevac-Stara Vodenica, Pajtenica-Velike Livade, Tomašanci-Palača and Đakovo-Franjevac).

Comparison between the study sites in terms of crop importance is also difficult as the particularly low numbers of plant remains identified at the majority of the sites restricts interpretation beyond the presence of species. According to van der Veen and Fieller (1982), every sample requires at least 384 items, with one taxon making up 50 % of the assemblage, to ensure a 95 % chance of estimating the contribution of each taxon. Samples with fewer than 50 or 100 items are also excluded from crop processing and husbandry analysis (Bogaard 2004; Valamoti 2004; Van der Veen 1992). The exact importance of each taxon in these assemblages is therefore questionable, especially as only two samples from Vinkovci/Matije Gupca 14 have over 384 plant remains, and these are dominated by brome grass (*Bromus* sp.) and fat hen (*Chenopodium album*), and one sample at Vučedol which has a large number of unidentified cereal remains. As a result, the data will be examined below at the macro-level in order to examine general patterns between continental Croatia and the neighbouring regions of Hungary and Serbia.

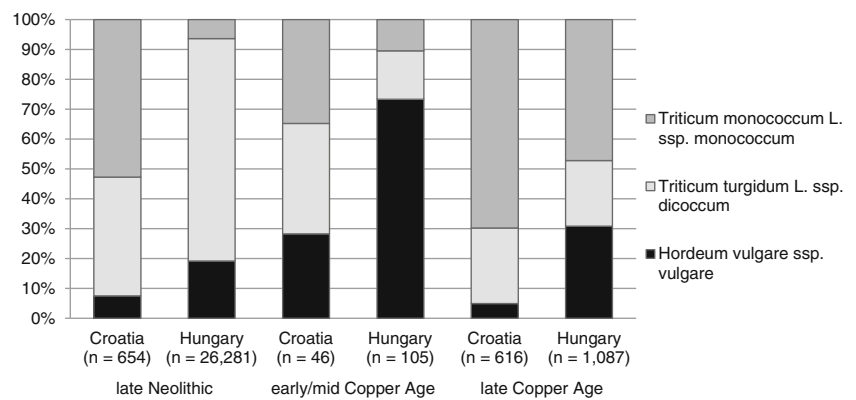
### The Neolithic/Copper Age transition: continuation or change in crop agriculture?

In continental Croatia, archaeobotanical data from the late Neolithic is also relatively sparse, with only eight sites providing evidence (Burić 2007:45–46; Đukić 2014; Obelić et al. 2002; Reed 2015). From the data collected, the most frequent and abundant crops, in terms of no. of identified items, were einkorn and emmer (Fig. 4; Table 5). To a lesser extent barley, lentil, pea and flax, as well as the fruits cornelian cherry (*Cornus mas*) and chinese lantern (*Physalis alkekengi*) were also recorded for the period (Reed 2015). Whether this pattern continues into the early/middle Copper Age in Croatia is difficult to say with such a limited number of identified remains. From the 46 grains of emmer, barley and einkorn, the proportions are relatively similar, although the frequency of barley seems to increase (Fig. 4; Table 5).

In neighbouring Hungary, the archaeobotanical data for the late Neolithic is slightly larger with 18 sites producing archaeobotanical remains (Gyulai 2010). Barley is the most frequently found, followed by emmer, then einkorn and naked wheat (Table 5). Proportionally, the number of grains recovered is greatest for emmer (Fig. 4); however, this is due to over 16,000 emmer grains being recovered from late Neolithic Tiszapolgár-Csőszhalom. With that site removed, the proportion of barley grains recovered is slightly higher than emmer. Few chaff remains seem to have been identified to species and probably indicates poor preservation at the sites, whether through pre or post depositional processes. In addition to the cereals, pulses and oil plants are also identified, with lentil and pea being the most frequently recovered. A slight increase in the frequency of barley as well as the proportion of barley grains may be seen for the early/middle Copper Age (Table 5, Fig. 4). However, this is based on only 105 grains of barley, emmer and einkorn (Fig. 4) and 7 sites where the highest concentration of only 30 grains of barley were recovered from Rákospalota-Újmajor, near Budapest (Gyulai 2010). Other crop items are rare, although a small number of lentil and flax were also identified for this period.

In Serbia, only 10 sites have provided archaeobotanical data for the late Neolithic Vinča culture (Filipović and Obradović 2013). Einkorn and emmer appear most frequently at the majority of sites followed less often by naked wheat and hulled barley (ibid.). Similar to continental Croatia and Hungary, lentil, pea and flax are also frequently identified at the sites. Unfortunately, only the one late Copper Age site, Gomolava (Van Zeist 2003), has evidence of archaeobotanical remains from Serbia, so no patterns can be seen between the late Neolithic and early/middle Copper Age. This pattern is also seen in Bosnia and Herzegovina, where emmer and einkorn are more frequently recovered during the late Neolithic, followed by barley, naked wheat, lentil, pea and flax, but no

**Fig. 4** Proportion of einkorn, emmer and barley grains per period for continental Croatia and Hungary



early/middle Copper Age data currently exists (Reed 2013: Chapter 8).

Comparing continental Croatia and Hungary, where there is evidence of both late Neolithic and early/middle Copper

Age plant remains, there is a clear reduction in the quantity and range of plant items recovered from both regions. This has been suggested as evidence of a reduction in the production of arable crops during the early/middle Copper Age (Gyulai

**Table 5** Crop frequency per site in continental Croatia and Hungary for the late Neolithic to late Copper Age (undated sites are excluded)

	Late Neolithic		Early/Mid Copper Age		Late Copper Age	
	Croatia	Hungary	Croatia	Hungary	Croatia	Hungary
No. of sites	8	18	11	13	6	13
Cereal grain						
<i>Hordeum vulgare</i> ssp. <i>vulgare</i>	25 %	44 %	64 %	54 %	67 %	92 %
<i>Triticum turgidum</i> L. ssp. <i>dicoccum</i>	63 %	38 %	55 %	31 %	67 %	69 %
<i>Triticum monococcum</i> ssp. <i>monococcum</i> (2-grain)	63 %	27 %	36 %	23 %	67 %	38 %
<i>Triticum aestivum</i> L. ssp. <i>spelta</i>	25 %	11 %				8 %
<i>Triticum aestivum</i> L. ssp. <i>spelta</i> /'new type' glume wheat			9 %		33 %	
Naked wheat <sup>a</sup>	50 %	27 %	9 %		83 %	31 %
<i>Panicum miliaceum</i>	13 %	22 %	9 %	15 %	33 %	8 %
<i>Setaria italica</i>	13 %		27 %		17 %	
Cereal chaff						
<i>Hordeum vulgare</i> ssp. <i>vulgare</i> rachis	13 %	11 %	9 %			15 %
<i>Triticum turgidum</i> L. ssp. <i>dicoccum</i> glume base	38 %		55 %	23 %	33 %	54 %
<i>Triticum monococcum</i> L. ssp. <i>monococcum</i> glume base	38 %		27 %	15 %	67 %	31 %
<i>Triticum</i> cf. <i>aestivum</i> L. <i>spelta</i> glume base	25 %		9 %		17 %	8 %
'New type' glume wheat glume base					17 %	8 %
Naked wheat <sup>a</sup> rachis	25 %					
Pulses						
<i>Lathyrus sativus</i>	13 %	11 %			17 %	
<i>Lens culinaris</i>	50 %	16 %		8 %	17 %	
<i>Pisum sativum</i>	38 %	33 %			33 %	8 %
<i>Vicia ervilia</i>	13 %	5 %				
Oil Plants						
<i>Camelina sativa</i>		5 %				
<i>Linum usitatissimum</i>	25 %	5 %	9 %	8 %	67 %	



2010: 87). However, the low recovery of archaeobotanical remains does not necessarily correlate with a reduction in crop agriculture for a number of reasons. First, as seen with the Croatian samples, inconsistent recovery techniques in the region will impact on the quality and quantity of remains recovered. Second, the process of carbonisation itself only allows a small fraction of the local plant spectra to be preserved; therefore, the carbonised remains will only ever provide a limited view on the crop agriculture of a settlement. Third, the preservation of remains at flat open-air settlements can be particularly low compared with the larger multi-generational tell sites of the late Neolithic, and so a reduction in plant items could be a result of site formation processes.

The slightly higher presence of barley seen in the first half of the Copper Age in Hungary has also been linked to hulled barley's greater tolerance of environmental extremes (Ceccarelli et al. 2001; Lister and Jones 2013), thus responding better to possible deteriorating environmental conditions especially seen during the onset of sub-boreal. These fluctuating climatic conditions have been noted in Slovakia where a dry period persists at the end of the late Neolithic, shifting back to a more humid climate ca. 4000 to 3500 BC, followed by drought conditions ca. 3500 to 3000 BC, finally shifting back to humid condition for the end of the Copper Age (Tóth et al. 2011). In Hungary, interpreting climatic fluctuations can be difficult with two major climatic boundaries roughly corresponding with the Great Hungarian Plain (to the east), which is arid and continental, and Transdanubia (to the west), which is more humid and moderate (Nagy-Bodor et al. 2000). Thus, during the sub-boreal, which occurred ca. 3000 cal BC, the Great Hungarian Plain became more arid, while precipitation increased in Transdanubia (ibid.). However, fluctuations existed as paleontological evidence dating to the start of the Copper Age in eastern Hungary suggests that the local alluvium was moister than the preceding Neolithic, although with less pronounced fluctuations in the summer water table (Magyari et al. 2012). Rákoskeresztúr-Újmajor, which had the highest number of barley grains, is located roughly in the middle of these two climatic zones, making it unclear how these changing environments may have impacted on crop growing, especially as huge variations likely existed across the complex networks of swamps, seasonally flooded alluvial soils and micro-climates that make up Hungary.

Settlement locations do not seem to change radically between the late Neolithic and early/middle Copper Age in continental Croatia. Within the vicinity of most of the Copper Age sites is a Neolithic settlement (e.g. Vinkovci/Matije Gupca 14 is a couple of miles north of the Neolithic tell site of Sopot), and all are located on alluvial plains, near watercourses, where agriculture is still practiced today. In Hungary too, studies show a continuation in settlement locations from the late Neolithic, predominantly along active watercourses (Gyucha

et al. 2009; 2011). It is suggested that fields, whether for crops or pasture, were located more on the Pleistocene levees, while the seasonally flooded alluvium was only opportunistically exploited for crop farming (Magyari et al. 2012). Exploitation of these floodplains may therefore explain the recovery of non-cereal based food sources (e.g. nutlets of *Scheonoplectus lacustris*) and other water/marsh plants seen at early/middle Copper Age sites (Gyulai 2010: 87–90). Unfortunately, methods to examine what crop husbandry regimes may have been practiced (i.e. weeding, manuring, tillage) in the region are restricted by poor quality datasets (see Bogaard 2004; Kreuz and Schäfer 2011 for reconstructions at Neolithic sites in central Europe). However, the continuation of crop agriculture would tie in with the recent isotope and lipid residue analysis, which suggested the emergence of smaller independent farmsteads with a similar herding strategy to that of the late Neolithic (Giblin 2009, 2014; Giblin et al. 2013, Hoekman-Sites and Giblin 2012).

### Late Copper Age agricultural development (ca. 3500 to 2500 cal BC)

By the late Copper Age, einkorn is recovered in greater quantities in continental Croatia, although the majority are from Vučedol, while the frequency of barley, emmer and einkorn is the same (Table 5, Fig. 4). The chaff remains are dominated by emmer and einkorn glume wheat glume bases, but as already discussed above this may be preservation bias rather than an indication that barley was not cultivated as a crop. A greater variety and quantity of plants are recovered for this period; however, this is likely due to formation processes at the sites, particularly at Slavča, Vučedol and Vinkovci/Matije Gupca 14, rather than a difference in crop husbandry methods.

In Hungary, a particularly high barley frequency is seen for the late Copper Age (Table 5), though a higher number of einkorn grains were identified overall (Fig. 4). Similar to the earlier phase, many of the sites have only a handful of grains, with only Győr-Szabadrétdomb and Budapest, Albertfalva-Kitérő út having over 100 grains of barley and Budapest, Albertfalva-Kitérő út having 449 of the einkorn grains recovered from the period (Gyulai 2010). Pulses are still relatively rare and no oil plants have been positively identified.

In Serbia, only Gomolava has provided any archaeobotanical data. Here, there seems to be a similar percentage of barley and einkorn grains recovered, followed less often by emmer, broomcorn millet and naked wheat (van Zeist 2003). Of the other possible crops, only a few pulses of lentil and bitter vetch, as well as only one flax seed, were identified.

Once again, the relatively low number of plant remains recovered and low numbers of samples from each site prevent any further analysis of the possible agricultural regimes. Overall, the range and quantity of cereals and pulses are similar to that of the late Neolithic. With these similarities, it is

therefore unclear how the sub-boreal (ca. 3000 BC) may have impacted on crop agriculture in the region. The zooarchaeological data is also limited during the late Copper Age making reconstructions of possible pastoral regimes difficult (Arnold and Greenfield 2006: 122).

## Conclusion

This study presents archaeobotanical evidence for crop agriculture during the Copper Age in continental Croatia. From the results, the low quantity and diversity of plant remains, particularly for the early/middle Copper Age, is likely due to factors such as poor preservation, site formation and sampling strategies rather than a reduction in crop agriculture. The dataset highlights the difficulties in comparing sites with different sampling strategies and problems that can arise when interpreting crop husbandry regimes based on low quantities of plant remains. Thus, no clear differences in crop cultivation were seen between the different sites and further work is needed in collecting more archaeobotanical data.

That being said when examining the data at the macro-scale general patterns may be seen. For instance, similarities with late Neolithic assemblages are seen in terms of the range and numbers of plant remains, where the main crops cultivated were likely emmer and einkorn and to a lesser extent barley. Less frequently, millet, naked wheat and spelt/new glume wheat are also found, especially at the late Copper Age sites; however, due to their low numbers, it is unclear whether these represent crops in their own right or were weeds within the main crops. Pulses (e.g. lentil, pea and grass pea), fruit remains (e.g. cornelian cherry and chinese lantern) and wild plant and weed seeds are also recovered, although again more commonly from the late Copper Age sites.

In conclusion, the continuation in crop agriculture inferred from the data presented here and the fact that recent archaeological evidence advocates small-scale animal husbandry regimes Giblin 2009; Giblin et al. 2013, Hoekman-Sites and Giblin 2012) would suggest that agro-pastoral regimes did not change dramatically in light of socio-economic or climatic changes seen during the Copper Age. It is therefore proposed that an agro-pastoral regime dominated in continental Croatia with an equal focus on crops and animal husbandry during the Copper Age, although variations are likely to have existed between the sites.

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