Vegetation History and Archaeobotany (2019) 28:623–634
https://doi.org/10.1007/s00334-019-00719-4

ORIGINAL ARTICLE

Grains from ear to ear: the morphology of spelt and free-threshing wheat from Roman Mursa (Osijek), Croatia

Kelly Reed[1] · **Sanela Sabljić**[2] · **Renata Šoštarić**[2] · **Sara Essert**[2]

Received: 26 August 2018 / Accepted: 8 February 2019 / Published online: 26 February 2019

Abstract

Cereals were a significant part of the Roman diet, yet knowledge about their cultivation, distribution and consumption in certain regions is particularly lacking. In Europe, studies generally suggest that from the Iron Age to the Roman period there was a reduction in barley cultivation, an increase in spelt over emmer, a preference for free-threshing wheat over glume wheats, as well as the increased cultivation of rye and oats. Up till now, there was little evidence on crop cultivation in Croatia, but the discovery of around 24,000 cereal grains from the oven of a 2nd-4th c. AD Roman villa in the modern town of Osijek provides important insights into diet and subsistence in the Roman province of Pannonia. Here, the dominance of free-threshing wheat, spelt and rye with only a relatively small amount of other cereals, chaff and weeds corresponds well with this pattern seen elsewhere in Europe. The relatively clean grain deposit suggests that this sample represents processed grain ready for final food preparation and consumption at the villa. The morphological variation and overlap seen between the carbonised spelt and free-threshing wheat grains, as well as the identification of 'stunted' cereal grains, is also discussed.

Keywords Pannonia · Crop agriculture · Rye · Diet · Grain size · Archaeobotany

Introduction

Cereal grain was a significant part of the Roman diet, but which cereals were grown and consumed depended on a number of variables, including geographical location (climate), culture, class, economy and technology. Furthermore, the suitability of each crop to produce a certain food such as bread, porridge etc., its price, and whether its secondary products were useful in the local economy, such as chaff as temper for mud bricks, would have determined its cultivation within a particular region. This is supported by the archaeobotanical evidence, which shows that the range and preference of crops cultivated across the Roman Empire varied from region to region (for example, van der Veen 1992; Rösch 1998; Matterne 2001; Wiethold 2003). Over 80% of the population was probably engaged in agriculture and was capable of producing on average a sufficient surplus (10–20%) to sustain other parts of the population (Erdkamp 2005, p 12; Goodchild 2006). Landowning and agriculture were also deeply rooted in Roman traditions, symbolising their ancestral past, while land and agricultural labour was considered an excellent and prestigious source of income for Roman senators (Kehoe 1997; Rosenstein 2008).

In Rome the most common grain consumed was wheat, with records in Imperial Rome of the grain dole providing 5 modii (roughly 33 kg) of unmilled wheat per month to each male citizen (Garnsey 1991; Erdkamp 2016, p 46). Apart from *Triticum aestivum* (bread wheat), remains of other cereals such as *Panicum miliaceum* and *Setaria italica* (broomcorn and foxtail millet), *Hordeum* (barley), *Triticum dicoccum* (emmer), *Avena* spp. (oats) and *Secale cereale* (rye) are all found at Roman sites such as Pompeii and Herculaneum (for example, Meyer 1980; Murphy et al. 2013). Pulses, such as *Vicia faba* (broad bean), *Cicer arietinum* (chickpea), *Lens culinaris* (lentil) and *Pisum sativum* (pea),

Communicated by S.M. Valamoti.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00334-019-00719-4) contains supplementary material, which is available to authorized users.

✉ Kelly Reed
kellyreed@hotmail.co.uk

[1] Oxford Martin School, University of Oxford, 34 Broad St, Oxford OX1 3BD, UK

[2] Division of Botany, Department of Biology, Faculty of Science, University of Zagreb, Marulićev trg 20/II, 10 000 Zagreb, Croatia

were also probably important crops (Garnsey 1999, p 15), although these are usually found less frequently than cereals in the archaeobotanical record. However, the biggest change seen in the Roman diet was the consumption of diverse and often imported 'exotic' foods. Probably spread by the military, non-native and imported food plants have been found in towns and settlements across Europe (Livarda and van der Veen 2008; van der Veen et al. 2008; Livarda 2011).

In terms of cereal crops, much of the evidence comes from north-western and central Europe. Here many authors have observed relative changes from *Hordeum* sp. to *Triticum* spp., from *T. dicoccum* (emmer) to *T. spelta* (spelt), from the glume wheats to free-threshing wheats and the start of *Secale* (rye) and *Avena* (oat) cultivation. Although some of these changes began in certain regions as early as the late Bronze Age, this general pattern is seen to culminate in the Roman period, although there are exceptions (van der Veen 1992; Roymans 1996, p 79; Rösch 1998, p 115; Kreuz 1999). In addition, not all cereals found would necessarily represent locally grown crops, but rather imports (for instance, Kreuz 2004; Zech-Matterne et al. 2009). Evidence from the lower Rhine suggests that cereals such as *T. spelta* were imported to certain Roman military camps and towns (Knörzer 1981; Bakels 1991; Roymans 1996, p 79). When cultivated, research suggests that *T. aestivum* was grown on the 'best' soils, while *T. spelta* and *T. dicoccum* were grown on thinner soil (van der Veen 1992; Matterne 2001, pp 106–107). Bakels (2009, p 167) also notes that large *villae rusticae*, or countryside villas, in the northern parts of the loess soil region of Germany and the Netherlands were specialising in one or two crops and growing them on a large scale.

The identification of cereal remains from archaeological sites is achieved through external morphological features (e.g. Jacomet 2006). However, distinguishing charred grains of *T. spelta* from *T. dicoccum* and *T. spelta* from *T. aestivum/durum* (free-threshing wheat) has proven difficult on occasion (Helbæk 1964; van Zeist 1968; Jacomet 2006). Other criteria used to discriminate the caryopses rely on univariate measurements such as their length, width, thickness/height and calculations of ratios of these dimensions (e.g. Maier 1996). Some studies have started to develop more advanced geometric morphometrics, which allow a more precise quantification of shape than traditional morphometric approaches (Burger et al. 2011; García-Granero et al. 2016; Bonhomme et al. 2017). However, distortion due to charring of the cereal grains (barley, wheat and millet) has been shown to 'smooth' the shape differences between similar taxa (Braadbaart et al. 2005; Braadbaart 2008; García-Granero et al. 2016). What these and other studies over the years have shown is that grain shape varies from grain to grain and from crop to crop, due to genetic and ecological factors as well as from the charring process. Yet few studies have considered the morphological composition of an ear of *Triticum* sp. and how the course of grain growth varies, for instance depending on the order of flowering, and what this means for the differentiation of certain *Triticum* taxa in the archaeological record.

This study focuses on the recovery of 24,000 grains, mostly of *T. aestivum/durum, T. spelta* and *Secale*, from the oven of a Roman villa in the town of Osijek, Croatia. Dating to the 2nd-4th c. AD, this deposit represents the single largest deposit of cereals from the region and provides important insights into possible consumption preferences and local agriculture. The aim of this paper is twofold. First, to present the archaeobotanical remains from Osijek and discuss them in terms of local diet and subsistence within Roman Pannonia and the wider empire. Second, in order to explore issues of identification between the wheat species, measurements of grain length, breadth and height within an ear of modern spelt and free-threshing wheat will be compared to the archaeobotanical material from Osijek.

The archaeological site

The Roman town of *Aelia Mursa* is situated today in the lower town of present-day Osijek, Croatia. Supported by ancient Latin inscriptions, Mursa was founded by Emperor Hadrian as a putative *colonia* or veteran colony sometime around AD 120/130 (*Corpus Inscriptionum Latinarum* III 3280, Reimer and de Gruyter 1863; Suic 1985, p 60). Located close to the Danube frontier, *limes*, Mursa was probably an important commercial, administrative and religious centre in the region, linked to local military installations as well as the wider Roman empire by a series of important road and river networks (Fig. 1; Domić Kunić 2012, pp 37, 44; Pinterović 1978; Fulford 1992). The town was fortified, had a regular street grid and probably contained buildings typical of any Roman city of that period (Filipović 2006).

Little is known about the diet and subsistence of the towns people, although recent archaeobotanical remains recovered from a cesspit located within Roman Mursa provide a rare glimpse at the consumption patterns and trade networks in this region, with evidence of imported food, such as *Oryza* cf. *sativa* (rice) and *Piper nigrum* (black pepper) (Reed and Leleković 2019). A handful of pottery studies in eastern Croatia have also highlighted trade, with evidence of amphorae coming from Italy, Spain and possibly North Africa (Ožanić 2004; Nagy 2014). Local production is shown by pottery strainers, flat-based vessels with perforations on the base and walls, which may have been used to prepare and process foods like cheese. These are found in both rural and urban contexts in southern Pannonia, at sites such as Vinkovci (Roman *Cibalae*), Srijemska Mitrovica (*Sirmium*), the villages of Gomolava, Progar, Ivandvor

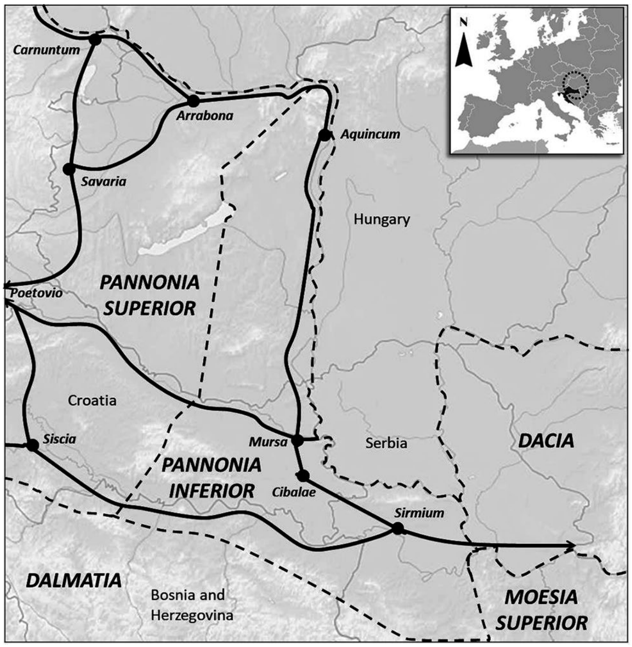

Fig. 1 Pannonia during the Roman period, showing the main road network and important towns

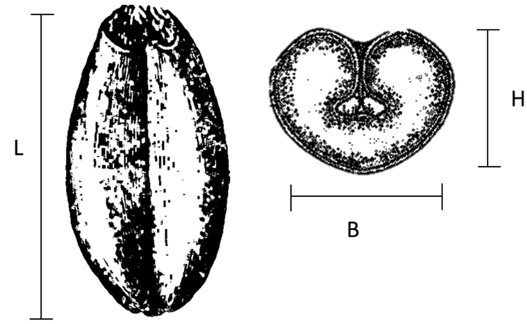

Fig. 2 The measurement points on the grains. L, length; B, breadth; H, height

and in *villae rusticae* at Prosina and Kudoš, dating from the 2nd–3rd c. AD (Ožanić 2009).

New evidence on diet and subsistence practices at Mursa comes from the site of Osijek-Silos, which was discovered at the crossing of two streets, ulica Huttlera and Frankopanska, at the site of a demolished 50 m high silo. Excavations at this site during 2005 uncovered a section of an urban villa located on the southern outskirts of the Roman town of Mursa. Three trenches, totalling 500 m^2, were excavated and according to preliminary analysis of the archaeological material, the site dates from the 2nd–4th c. AD. It is suggested that within trenches 1 and 2 the *impluvium*, the sunken part of an atrium or inner courtyard of a building, and its kitchen were uncovered (Filipović and Katavić 2005, 2006). Finds included, an amphora fragment, an oven and a piece of an altar. Within the oven area a dense deposit of carbonised plant remains was uncovered, providing the first evidence of plant remains from the Roman town.

Materials and methods

Archaeobotanical material

One archaeobotanical sample was collected from the oven within the kitchen in Trench 1. The whole sample, about 1 l in volume, was analysed in the Department of Botany, Faculty of Science in Zagreb, Croatia, with further identifications made by K. Reed, University of Oxford, UK. The sample mostly consisted of charred plant remains and quantities of coal dust, which contributed to the sample mass. The sample was pure, without any soil or similar admixture, so it was not necessary to undertake flotation.

Sorting and identifications were made using a binocular microscope with 10–20 × magnification. Charred plant remains were identified with the help of reference literature (Cappers et al. 2006; Jacomet 2006) and by comparison with a reference collection of recent and sub-recent seeds and fruits, as well as with plants in the Herbarium Croaticum collection at the Botany Department, Faculty of Science at Zagreb University (ZA). Plant nomenclature follows the Flora Croatica Database (https://hirc.botanic.hr/fcd/). During identification, 50 grains of *T. spelta* and *T. aestivum*/*durum* were photographed in dorsal and lateral view using a stereomicroscope with a digital camera, and measured using ImageJ v.1.8.0, an open source image analysis program (https://imagej.nih.gov/ij/download.html). Three measurements were selected: total length (L), breadth (B) and height (H) (Fig. 2).

The whole sample was initially sorted and the seeds identified in 2010 (Starčević 2010); however a re-examination of the sample in 2018 indicated that it was not possible to distinguish *T. spelta, T. dicoccum* and *T. aestivum*/*durum* in every grain due to overlapping grain morphology. Instead they were re-categorised into 'typical' examples of each taxon and further mixed groups. Due to the large quantity of these grains and time restrictions, 5% of the material was initially examined (850 grains) and the proportion of grains calculated per taxon. A further 5% was then examined to see if the proportion of each varied significantly. Through this process, very little variation was seen, with around 45% of the grains representing *T. aestivum*/*durum*, 27% *T. spelta* and 2% *T. dicoccum*. It was therefore decided that the 10% subsample provided a relatively accurate proportional representation of the overall taxon content of the sample.

Identification criteria

The free-threshing tetraploid *Triticum turgidum/durum* and hexaploid *Triticum aestivum/compactum* wheat grains were not distinguished within the samples due to the morphological similarities of the grains and the absence of diagnostic rachis fragments. Thus, free-threshing wheat (FT) is used in this paper to describe these taxa. 'Typical' FT grains were wider and more rounded than the *T. spelta* and *T. dicoccum* grains, with blunted apex and embryo ends, a deep embryo area and convex on both sides of the embryo in dorsal view with a low to medium dorsal ridge (Fig. 3a). *Triticum spelta* was identified by grains with almost parallel sides in both dorsal and side view with a flat dorsal ridge (Fig. 3b). A small number of grains were classed as possible 'stunted' *T. spelta*, as they were a third of the size in most cases, but still retained characteristics of spelt. Grains with flatter dorsal ridges, that were slightly wider and more rounded, but were parallel in side view, were categorised as *T. aestivum/spelta. Triticum dicoccum* was identified by a high dorsal ridge that was often not symmetrically rounded but twisted, a higher embryo than the *T. aestivum* and *spelta* grains, and the widest point in side view was just above the embryo. Where grains had asymmetrical dorsal ridges and were slightly wider above the embryo, but flatter and more spelt-like, they were categorised as *T. dicoccum/spelta*. A further group of *T. aestivum/dicoccum* was also created where grains had a high dorsal ridge and high embryo typical of *T. dicoccum*, but were slightly more puffy and rounded like *T. aestivum*.

Secale cereale grains varied in shape from more compact to longer, more elongated grains, but were easily distinguished from the *Triticum* grains as they were generally narrower with a truncated apex and long scutellum. Grains with a shorter scutellum or that seemed particularly narrow (similar to *Secale vavilovii*, wild rye) were grouped as possible rye grains (cf. *Secale cereale*).

Modern *T. spelta* and *T. aestivum*

Ears of modern *T. spelta* were collected from Sharpham Park, an organic spelt farm in Somerset, in July 2018. Ears of modern *T. aestivum* were collected from a local field in Leicestershire in August 2017. For both *T. spelta* (Fig. 4a) and *T. aestivum* (Fig. 4b), the grains from one ear were removed, their positions noted and the length, breadth and height of each uncharred grain was measured using ImageJ (ESM Tables 1, 2). Only one ear from *T. spelta* and FT is presented here to show how a single ear varies, rather than repeating studies that show grain variation in a crop.

Results

The archaeological sample was of an exceptionally large grain deposit and contained approximately 24,000 carbonised seeds, with 98% of the sample coming from cereals (Table 1). Preservation was good with many of the grains retaining their seed coat patterning. Overall, the sample was dominated by FT, *T. spelta* and *Secale* (Fig. 5). Other cereal species identified included *T. dicoccum, Hordeum vulgare, T. monococcum* (einkorn) and four grains of *Panicum miliaceum*. The *Hordeum* grains typically looked like the hulled variety and two grains were slightly twisted indicating the presence of the four-row variety. Only five fragments of

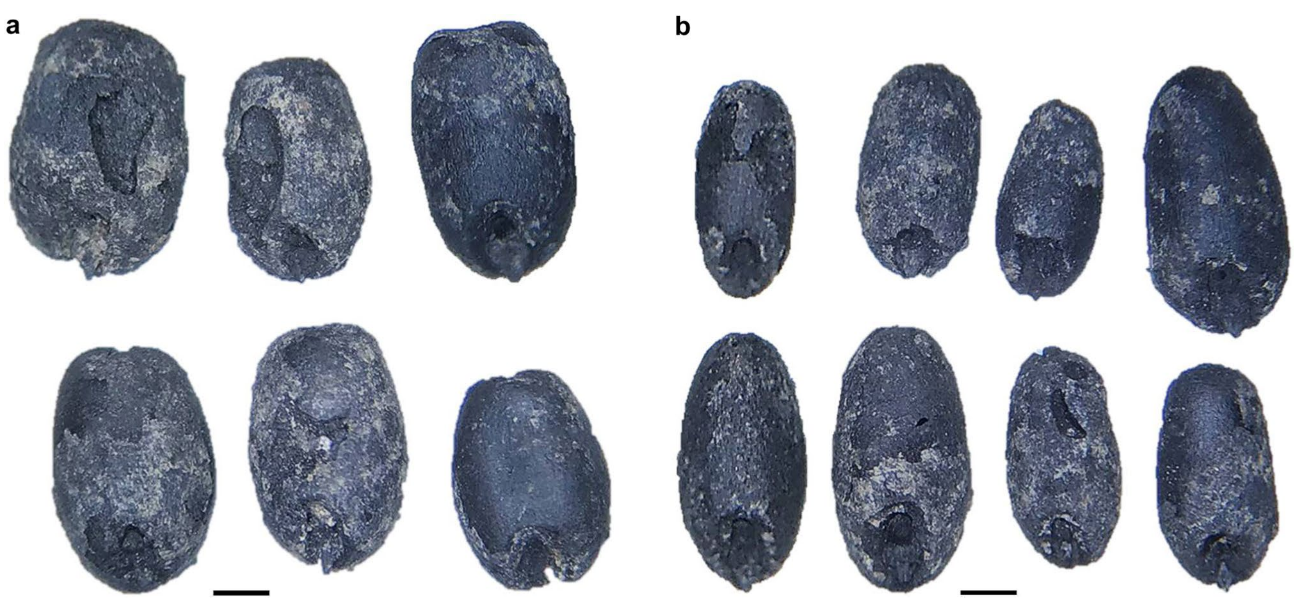

Fig. 3 Carbonised grains from Osijek-Silos; **a**, free-threshing wheat (FT); **b**, *T. spelta*; scale bar = 1 mm (images taken by K. Reed)

Fig. 4 Modern wheat ear and grains; **a**, *T. aestivum* from Leicestershire; **b**, *T. spelta* from Sharpham Park; scale bar = 5 cm (images taken by K. Reed)

cereal chaff were recovered, one FT rachis, one *T. dicoccum* glume base, two *T. monococcum* glume bases and one unidentified glume base. Evidence of other crops was limited to the recovery of one *Lens culinaris* (lentil), three peas (*Pisum sativum*), two possible peas and one bitter vetch (*Vicia ervilia*).

Over 400 wild plant or weed seeds were identified from the sample with 63% being *Agrostemma githago* (corncockle). Grasses, such as *Bromus* sp. (brome grass) and *Lolium* sp. (ryegrass), were also commonly recovered along with *Galium*/*Asperula* sp. (bedstraw/woodruff) and *Vicia sativa* (common vetch). Only two grains of *Avena* sp. (oat) were identified, but with the absence of diagnostic florets it was not possible to determine whether this was wild or cultivated. Thus, it is likely that it represents a weed within the main crops and so has been grouped with the wild/weed taxa.

Statistical analyses

In order to visualise the large variability in grain shape of the *T. spelta* and FT recovered from Osijek-Silos, one ear of modern uncharred *T. spelta* and one of modern uncharred FT was examined. Interestingly the measurements from the modern grains show a clear separation in the length to breadth ratio of the *T. spelta* and FT, but the length to height ratio overlaps (Fig. 6). This was also seen visually when examining both modern species with around 25% of the *T. spelta* grains having relatively high dorsal ridges and around 30% of the FT grains having a relatively flatter dorsal ridge. There were also a couple of 'stunted' *T. spelta* grains that

Table 1 Charred plant remains from Osijek-Silos

Taxon	Numbers and estimates[a]
Cereal grain	
Hordeum vulgare	40
Panicum miliaceum	4
Secale cereale	3,095
cf. *S. cereale*	278
Free-threshing wheat (FT)	7,492[a]
FT/*Triticum spelta*	3,765[a]
T. dicoccum	486[a]
T. dicoccum/*T. spelta*	442[a]
T. dicoccum/FT	93[a]
T. monococcum	131
T. spelta	4,691[a]
T. spelta 'stunted' grains	46[a]
Triticum sp.	1,024
Cerealia, fragments	1,997
Cereal chaff	
T. aestivum/*durum*, rachis	1
T. dicoccum, glume	1
T. monococcum, glume	2
Triticum sp., glume	1
Pulses	
Lens culinaris	1
Pisum sativum	3
cf. *Pisum sativum*	2
Vicia ervilia	1
Wild/weed taxa	
Agrostemma githago	252
Asteraceae	1
Avena sp	2
Bromus sp	8
cf. *Cirsium* sp	3
Convolvulus arvensis	3
Lolium cf. *remotum*	30
Galium/*Asperula* sp	47
Poaceae, large seeded	8
Lithospermum arvense	3
Polygonum sp	2
Vicia sativa	13
cf. *Vicia* sp	3
Total	23,971

[a]Figure based on subsample, totals from which were adjusted accordingly to estimate figures for the whole sample

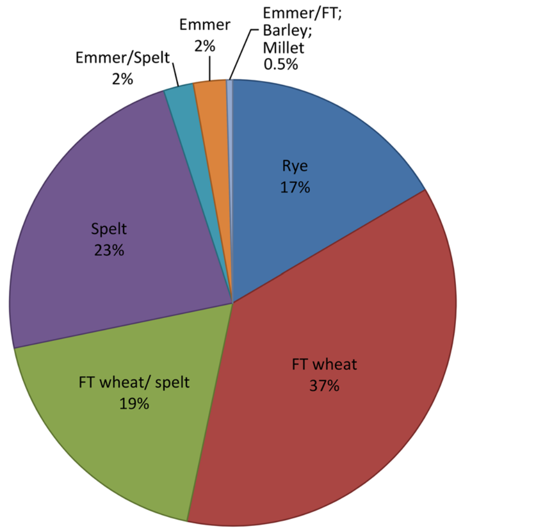

Fig. 5 The proportion of grains per identified cereal taxon (not including *Triticum* sp. or Cerealia fragments)

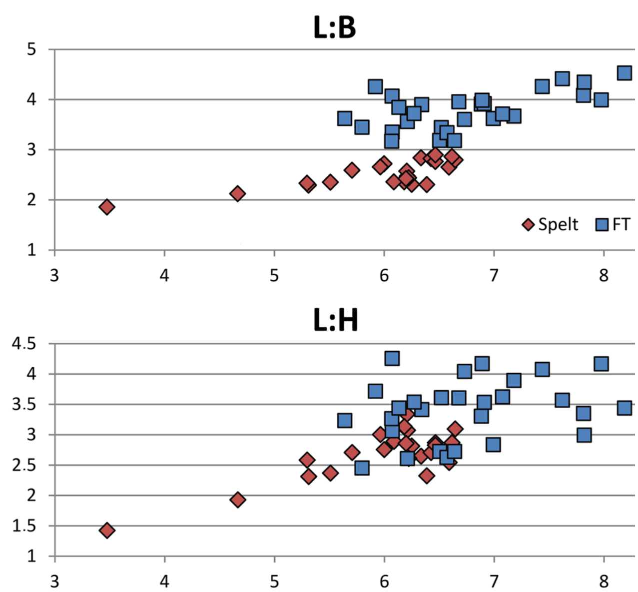

Fig. 6 Measurement ratios of modern *T. spelta* and FT. L, length; B, breadth; H, height (mm)

were half the size of the other grains (Fig. 6, lower left), but were almost fully formed with the typical morphological shape of *T. spelta*; these were also noticed in the archaeobotanical samples (Fig. 7). These two 'stunted' grains were located in the middle and at the end of the ear in the modern material and there was no clear size difference between the basal grains and those found elsewhere in the ear.

From Osijek-Silos, 50 randomly selected charred grains identified as *T. spelta* and FT were also plotted and they showed a large overlap in both length to breadth and length to height ratios (Fig. 8). In terms of the length to breadth, if we take the median breadth at around 2.5 mm, approximately 10% of the FT and *T. spelta* grains show similar ratios. This overlap in L:B ratio is probably due to the effects of charring on the grains, as charring experiments have shown that generally the higher the temperature, the more the length decreases and the breadth increases (Boardman and Jones 1990; Braadbaart et al. 2005; Braadbaart 2008; Charles et al. 2015). The L:H ratios show a similar overlap of 6 mm with the modern uncharred grains, which had an overlap of 8 mm.

Grains identified as *T. spelta* /FT were generally fragmented in the sample, but to explore whether the above

Fig. 7 Comparison of the 'stunted' *T. spelta* from Osijek-Silos and modern examples from Sharpham Park; scale bar = 1 mm (images taken by K. Reed)

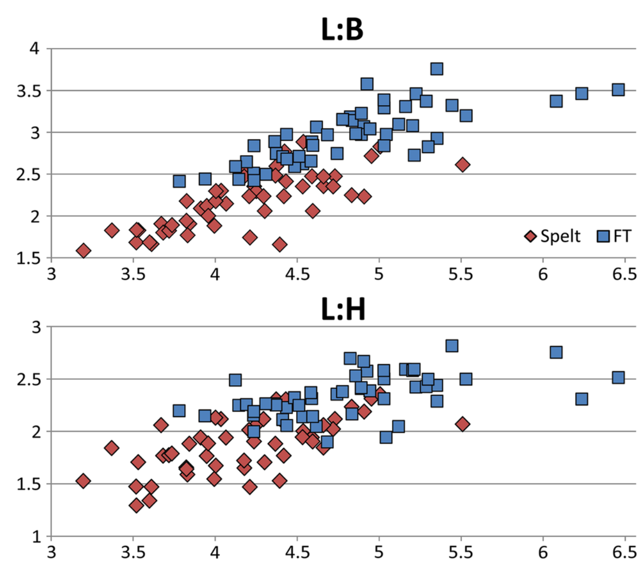

Fig. 8 Measurement ratios of charred *T. spelta* and FT from Osijek-Silos; L, length; B, breadth; H, height (mm)

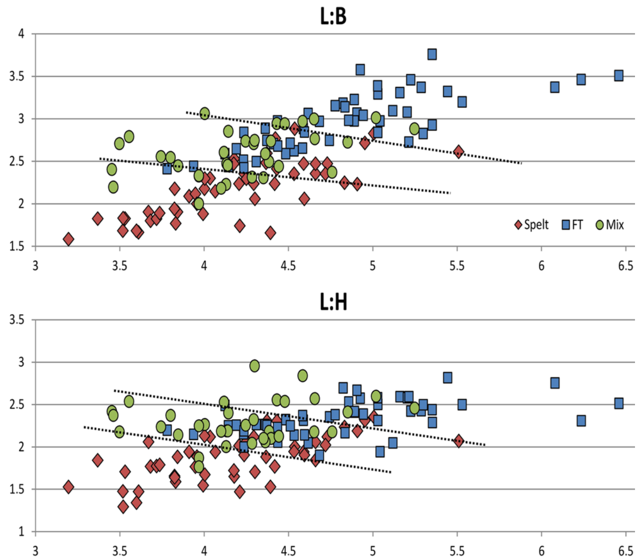

Fig. 9 Measurement ratios of charred *T. spelta*, FT and mixed *T. spelta*/FT from Osijek-Silos, L, length; B, breadth; H = height (mm)

measurements can be used to distinguish the grains in this category further, 35 whole grains of *T. spelta* /FT were measured and compared with the 'typical' grains (Fig. 9). From the graphs, eight of the grains (22%) could possibly be re-classified as FT, while possibly five as *T. spelta* (14%). If we extrapolate this to the whole sample, the following quantities may be suggested: FT = 8,320, *T. spelta* = 5,218 and FT/ *T. spelta* = 2,410. However, this has little impact on the overall proportion of grains recovered from the site.

Discussion

The growth of wheat grains consists of three phases (Beltrono et al. 2006):

1. Immediately after flowering, when grain number per spike is established, there is a 'lag phase', of around 4–7 days (Hunt et al. 1991) when the number of endosperm cells formed determines the potential grain size (Brocklehust 1977).
2. Grain size and dry weight then increase steadily at a constant rate; however these changes depend on growth conditions and the cultivar (Sofield et al. 1977).
3. Finally, grain development coincides with the maximum grain dry weight and is referred to as the physiological maturity of the grain.

The number and size of the grains is therefore dependant on a number of factors. For example, Saini and Aspinall (1981) found that drought conditions led to the death of the floret and this occurs most commonly at the terminal and basal floret of the spike, probably due to male sterility caused by water stress. Furthermore, Zhang and Oweis (1998) highlight that adequate water at or after the flowering period is needed to increase the rate of photosynthesis and provide extra time to move the carbohydrate to the grains, which increases their size. As well as weather, low soil fertility and disease can also encourage erratic and uneven germination. This is clearly not a new problem, as even in the Roman period Pliny noted that *siligo* (*T. aestivum*) ripened unevenly, which made harvesting difficult (*Naturalis Historia* 18.91, Rackham and Jones 1975). This variability in grain size and shape is clearly seen in the samples presented here, with similarities in variation seen between the grains of charred FT and *T. spelta* from Osijek-Silos and the modern uncharred *T. spelta* and FT, including the presence of 'stunted' *T. spelta* grains. This variability is therefore an inherent trait that exacerbates the difficulties of separating *T. spelta* and FT in archaeobotanical samples, because measurements alone are not enough to separate these taxa.

The processing of *T. spelta, T. dicoccum* and *T. monococcum* differs from FT as they are hulled, with the glumes remaining tightly closed over the grain and not removed by threshing, so the absence of chaff could suggest that the cereals were already processed and ready for food preparation. Roman recipes indicate that *T. spelta* and *T. aestivum* were sometimes mixed in baking, for example in breads and cakes (Leon 1943), while *T. aestivum* was noted by both Columella and Pliny to produce the highest quality bread (*De Re Rustica* 2.6.2, Ash 1941; N.H. 18.86-90; Rackham and Jones 1975). *Secale* can also make bread, but it makes a denser loaf than *T. spelta* or *T. aestivum*.

It is unclear how the grains became carbonised in the oven, although the large quantities may suggest either one or three separate charring events for each of the three main cereals. Could the cereals be from drying the grain before milling? Could the cereals have been spoilt? Or could they have simply been charred by accident? (van der Veen 2007). Unfortunately, comparative sites are absent in the region as archaeobotanical recovery at Roman sites is not commonly practised in the Balkans. Thus, the archaeobotanical record from Croatian Pannonia is very limited for the Roman period (Table 2) and the preceding Iron Age. Only the early Iron Age site of Sisak provides any archaeobotanical evidence from the Pannonian region. In particular, a bowl filled with millions of *Setaria italica* grains was discovered in a house context (Reed and Drnić 2016). Other contexts at Sisak have yielded a few grains of FT, *T. dicoccum, T. spelta, Panicum miliaceum* and *Vicia faba* (Reed et al., in prep). More archaeobotanical evidence is present from the late Bronze Age (see Reed 2016 for summary; Šoštarić et al. 2017), with the largest number of carbonised plant remains being recovered from Kalnik-Igrišče in central Croatia.

Table 2 Numbers of charred crop remains from Roman sites in Croatian Pannonia

Site (reference)	Vitrovitica Kiškorija (Šoštarić et al. 2015)	Park Kraljice Jelene Kosače (Reed and Leleković 2019)	Aquae Iassae Varaždinske toplice (Vikić-Belančić 1974)	Ulica I. Gundulića 39 (Reed et al. 2019)	Ulica I. Gundulića 48 (Reed et al. 2019)	120 Divaltova St. (Reed et al. 2019)	Lapovačka ulica –Kaufland (Reed et al. 2019)	Sćitarjevo (Šoštarić et al. 2006)	Ilok (Šoštarić et al. 2006)
Site type	1	2	2	3	4	4	4	4	4
Cereals									
Hordeum vulgare	87			7	2		1		5
Oryza cf. *sativa*		5							
Panicum miliaceum	283			2			3	[1,123]	23[3]
Secale cereale	2								
Setaria cf. *italica*	4								
Triticum aestivum/durum	4			2					15
Triticum dicoccum									18
Triticum monococcum									7
Triticum spelta	1				1				1 cf.
Oil crops									
Camelina sativa								[2]	
Linum usitatissimum					1				
Pulses									
Lens culinaris						7	2	[156]	[240]
Lathyrus sativus							2		
Vicia ervilia									[13]
Vicia faba	6								
Fruits									
Cucumis melo/sativus								[1]	[1]
Ficus carica								[16]	[25]
Malus sp.								[6]	
Malus/Pyrus sp.								[5]	[6]
Olea europaea									[4]
Prunus avium group								[4]	[6]
Prunus domestica	1								[13]
Prunus persica			+						
Rubus fruticosus	2								
Sambucus nigra									[16]
Vitis vinifera								[23]	[1,391]
Spice									
Piper nigrum		2							

In square brackets, uncarbonised and mineralised remains; + = presence. All numbers exclude uncertain identifications (cf.), Cerealia, weeds and unidentified plant remains (For the full list of plant remains, please see the site publication). Site type: 1, Rural settlement; 2, Urban settlement; 3, Altar in urban settlement; 4, Cemetery

Excavations of a late Bronze Age house at the site yielded ca. 69,000 carbonised plant remains, 82% of which were cereals (Mareković 2013; Mareković et al. 2015). *Panicum miliaceum* was the most dominant, representing nearly 75% of the cereal remains, followed by *Hordeum*, FT, *T. dicoccum, T. spelta* and *T. monococcum*.

From the Roman period, archaeobotanical remains have been recovered from graves at Ilok (ca. 73 km southeast of Osijek), Šćitarjevo (ca. 260 km west) (Šoštarić et al. 2006), Vinkovci and Osijek (Reed et al. 2019) and from the rural settlement of Virovitica - Kiškorija jug (ca. 120 km west) (Šoštarić et al. 2015). Collectively these sites had evidence of *Hordeum, T. aestivum, T. spelta, Secale, T. dicoccum, T. monococcum, P. miliaceum* and *S. italica*, as well as *Lens culinaris, Vicia ervilia* (grass pea) and *V. sativa*. At Ščitarjevo and Virovitica - Kiškorija jug the relatively large quantities of *P. miliaceum* have been suggested as evidence that millet was grown and consumed as a crop in its own right, rather than being a weed among other cereals. Evidence from Italy is starting to support this view of millet cultivation, with recent stable isotope analyses suggesting that urban and suburban diets differed during the Imperial period in the 1st–3rd centuries AD, with sites located near a large agricultural area in the suburbs of Rome consuming significantly more *P. miliaceum* (Killgrove and Tykot 2013). Cassius Dio, while mentioning Augustus's campaign against the Pannonians in 35 BC, states that these people 'do not cultivate [that is, make] wine, except for a little bit which is bad, since they spend most of the time in a very harsh winter [climate], but rather eat and drink both barley and millet' (*Historia Romana* 49.36, 2–4, Cary and Foster 1916). However, as only four grains were recovered from Osijek-Silos, any conclusions about its reduction in cultivation after the Roman conquest are limited. The abundance of FT, on the other hand, could indicate a relatively high status or expensive range of crops, especially as Pliny claims 'Winter wheat [bread wheat] furnishes bread of the very finest quality' (*N.H.* 18.20., Rackham and Jones 1975). Such luxuries are already seen within the Roman town of Mursa where a range of imports and exotics such as *Oryza* cf. *sativa* and *Piper nigrum* have been discovered from a cesspit a few km away from Osijek-Silos (Reed and Leleković 2019).

Further archaeobotanical evidence of Roman grain crops can be found to the north of Mursa in modern day Hungary; where Transdanubia, with its centre at *Aquincum* (now in Budapest), also belonged to the Pannonian province. Here the majority of the plant remains recovered from sites was cereal grains with a dominance of FT and *Secale*, but a relatively low presence of *T. spelta* and a clear reduction in *Hordeum* (Gyulai 2010, p 153). *Secale* is particularly interesting as it seems to have been a crop in pre-Roman northwestern Europe and was taken up by the Romans as an 'inferior' crop (Behre 1992). However, the recovery of 2 l of carbonised *Secale* grains at a late Roman watchtower at Budakalász, Hungary, suggests that rye was an important military crop (Gyulai 2010, p 154). In contrast, the large amount of *Secale* at late Roman sites in the Netherlands has been linked with native Frankish settlements, while more Roman sites, such as forts, typically produced larger amounts of *Triticum*, specifically *T. aestivum* and *T. spelta* (Lauwerier et al. 1999). Could *Secale* have been cultivated in Pannonia as a result of local influences permeating the more 'traditional' Roman agricultural crops?

Crop processing by-products of FT, *Secale* and *Hordeum* have been found in the plaster of a villa at Nemesvámos-Balácapuszta, Hungary, dating to the 1st–4th c. AD (Gyulai 2010, p 154). This would indicate that these crops were grown locally, especially as wheat is seen to have a relatively low volumetric value (Bransbourg 2012). In other words, it would have been far more cost effective for villas to have either grown or purchased their crops locally. This is also likely to have been the case at Mursa, although few rural settlements have been found in its vicinity, due in part to limited surveying. The large number of known rural settlements around the Roman town of *Andautonia* (Zagreb) (Leleković and Rendić-Miočević 2012, p 280) illustrates a possible network of sites that could have supplied the towns with cereals.

Classical authors such as Strabo and Cassius Dio emphasise three main geographical features of Pannonia, the mountains, woods with oak in the lowlands, beech on the hills, and swamps, and is depicted as a region unfavourable in both geography and climate (Strabo, *Rerum Geographicarum* 7.5,10, Jones 1917; Cassius *H.R.* 49.36, 2–3; Cary and Foster 1916). However, crop agriculture has been practised in the region from the Neolithic (Reed 2015) and today it is known for being a fertile lowland area where wheat and other cereals grow. FT and *T. spelta* are also known to grow in moderate to cold continental areas (Zohary and Hopf 2000; Cappers and Neef 2012, pp 296–297). *Secale* is primarily cultivated on marginal soils with low fertility and is recognized to be the most drought tolerant cereal crop (Starzycki 1976; Miedaner et al. 2012). Pannonia would therefore have had agricultural potential, despite the fact that most of its territory was covered by swamps and woods.

Agrostemma githago was a common weed in fields of winter cereals (especially wheat and barley) and depends on agricultural techniques, which fail to separate its seed effectively from the seed of the primary crop (Thompson 1973). Consequently corncockle, although a weed, resembles a crop plant as it depends on annual harvesting and re-sowing for its survival. Wiethold (2003) suggests that the increase in weed seeds such as *A. githago* in samples from the Roman period may indicate less care given to fields that were possibly larger than in the past, perhaps with less weeding. However, few studies have explored this idea in any detail. Fallow and rotation systems are also mentioned in the ancient literature to increase yields, ranging from a simple two-field fallow to three field rotations involving legumes or other field crops (Pliny *N.H.* 18.91, Rackham and Jones 1975). Virgil states that, "*by rotation of crops you lighten your labour*" (*Georgics* 1.79) and that one should, "*put down to yellow spelt* [a] *field where before you raised the bean with its rattling pods*" (*Georgics* 1.73-4, Fairclough 1916). The only pulse found at the site was *Vicia sativa*, which is a widely known fodder crop, although it can be consumed by humans (Bouby and Léa 2006). Columella also mentions the use of *Vicia* as a fodder crop, although it is unclear what species he is referring to (*D.R.R.* II, X, 24–30, Ash 1941). Nevertheless, their low abundance within the predominantly cereal based samples at Osijek-Silos may suggest that the vetchs represent weeds within the crop; although preservation bias may also account for their low presence. Unfortunately, the limited data from the site and region prevent any further suppositions about the cropping systems practised in Roman Pannonia.

Conclusion

The well preserved archaeobotanical sample collected from the villa oven at Osijek-Silos is the largest deposit of cereal grains recovered from the Roman period in Croatia. The dominance of free-threshing wheat, spelt and rye grain with only a relatively small amount of other cereals, chaff and weeds suggests that this sample represents processed grain ready for final food preparation and consumption at the villa. The overlapping morphologies of the FT, *T. spelta* and *T. dicoccum* grains in the sample highlight some of the difficulties in their identification. Even within one modern cereal ear there is clear variation in the size and shape of the grain. Thus measurements alone are not sufficient to help distinguish the different taxa within archaeobotanical samples.

The Roman site of Osijek-Silos is unique in the region and only a handful of late Bronze Age and Iron Age sites provide any evidence of earlier crop agriculture in Croatia. The most substantial remains come from the late Bronze Age Kalnik-Igrišče (Mareković 2013) and if we compare Osijek-Silos to this site, observations may tentatively suggest that as in northwestern and central Europe, there is a relative change from *Hordeum* to *Triticum, T. dicoccum* to *T. spelta*, from the glume wheats to FT and the start of *Secale* cultivation in the Roman period. Further data are clearly needed from the region to understand more about these changes in crop cultivation occurred.

Acknowledgements Many thanks to Slavica Filipović and colleagues for providing information about the excavation. Thanks also to Sharpham Farm (https://www.sharphampark.com/) for providing the modern spelt ears and to colleagues, especially Lisa Lodwick, Angela Kreuz, Michael Wallace and Brittany Thomas, for their helpful suggestions while writing this paper. We also thank the two anonymous reviewers whose comments/suggestions helped improve this manuscript.

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