The Roman Food System in Southern Pannonia (Croatia) From the 1st–4th Century A.D.

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Original Study

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https://doi.org/10.1515/opar-2020-0105
Received December 20, 2019; accepted April 2, 2020

Abstract: Food is an excellent medium through which to explore trade, economies, migration and landscapes, yet little is known about food production and consumption in the Roman province of Pannonia. Here we explore the current evidence for agriculture, trade and diet in southern Pannonia (modern day eastern Croatia) and what this may say about life in the region. The influx of new 'exotic' foods and technologies had a profound influence on this region. The limited archaeobotanical data suggests complex trade and local agricultural systems that allowed large towns such as *Mursa*, *Cibalae* and *Siscia* to gain access to a wide range of food items. The large quantities of pottery found not only helps us understand traded goods but also the local tastes and fashions, as well as to infer the types of dishes that could have been cooked. More evidence is clearly needed in this region but what we can see so far is that urban centres along the Danube *Limes* were firmly integrated within the wider Roman food system and that diets were probably quite varied for many who lived there.

Keywords: Archaeobotany, Pottery, Zooarchaeology, Food system, Roman frontier

1 Introduction

Food not only provides us with nourishment to grow and be healthy, but occupies a special place in our lives, connecting us to people, helping us mark milestones and linking us with our cultural heritage. Our food history is ultimately the result of the mixing of different people and the Roman period is a prime example of how expanding networks, growing economies and the movement of individuals changed production and consumption patterns in many areas of the empire. A large proportion of the population probably engaged in some form of agriculture and was capable of producing a sufficient surplus to sustain larger parts of the population (Erdkamp, 2005, p. 12). The development of numerous urban centres across the empire, one of the hallmarks of Roman rule, would not have been possible without the significant transformation of the rural economies supporting them. Thus, in order to feed its growing population the Roman Empire was dependent on the successful exploitation of agricultural resources and trade. The expansion of Roman trade networks into areas of the Middle East, North Africa and Asia, allowed people to gain access to new more 'exotic' foods for the first time. These new food items would have changed the way people ate, imagined and interacted with food at all social levels, with certain foods and meals having different embodied societal or religious meaning. The Roman economy was therefore complex, based on a market that relied on the transportation of goods, people and animals (Temin, 2012). The nuances of this economy and its interactions continue to fuel debate and new evidence is continually coming to light.

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The production and consumption of food and drink are commonly discussed in classical and archaeological studies, with large bodies of work exploring food through literary sources and archaeological remains (e.g. Vehling, 1977; Bowman & Wilson, 2013; Cool, 2006; Donahue, 2015; Erdkamp, 2005; Roller, 2017; Rosenstein, 2008; Thurmond, 2006; Wilkins & Hill, 2006). Much of this work focuses on Italy and Rome, although a growing scholarship is emerging from other parts of the empire, particularly in Britain (e.g. Allen et al., 2017; Smith at al., 2016). Attention has also shifted from 'elites' to how provincial society developed under Roman rule (Cool, 2006, p, 2). In terms of the archaeological evidence pottery, quantified by their fabric and vessel type, still seems to dominate most discussions around food and drink: especially the trade and exchange of such goods, due to the large volumes recovered in the archaeological record. Other lines of evidence are also increasing, including environmental evidence (e.g. Bakels & Jacomet, 2003; Cappers, 2006; MacKinnon, 2010; Maltby, 2016), strontium and stable isotope analyses (e.g. Killgrove & Tykot, 2013; Madgwick et al., 2019), residue analysis (e.g. Pecci et al., 2013; Pecci & D'Andria, 2014), metal and stone artefacts, as well as building architecture, such as olive oil presses or corn dryers (e.g. Allen & Lodwick 2017; Rickman, 1971; Rossiter, 1981). This increase in archaeological evidence is allowing us to examine agriculture and food more holistically, which is an important step in understanding the nature of the food systems under study and how they link with the economy, society, culture and the environment (Reed & Ryan, 2019). Using multiple lines of evidence is also important when data is limited within certain regions or sites.

This paper will explore this question within the Roman province of Pannonia, focusing on the southern region, located in modern day eastern Croatia. This region is still quite underdeveloped in its research of agricultural production, trade and patterns of consumption, with most Roman studies focusing on either the military, urban or rural settlements and architecture and pottery typologies (Iskra Janošić, 2001; Migotti, 2012; Tončinić, 2015; Ožanić Roguljić, 2016). Thus, questions around how the introduction of new food products, utensils, methods and habits may have shaped the development of production and consumption in southern Pannonia; what types of food were important trade commodities; and how these changes shaped local identities have generally not been explored. The emerging evidence from archaeobotanical and zooarchaeological studies as well as survey and excavations are beginning to provide a richer story of Roman diet and agriculture in the region. This paper will therefore outline current evidence from a range of sources and examine what this may tell us about the development of local production and consumption in southern Pannonia from the 1st to 4th century A.D.

At present very little evidence exists for diet and agriculture in the preceding Iron Age in Croatia (Reed, 2016). In southern Pannonia only one site, Sisak, has archaeobotanical evidence consisting of a pot filled with italian (*Setaria italica*) and broomcorn millet (*Panicum miliaceum*) (Reed & Drnic, 2016). Similarly, stable isotope analyses of human remains from Iron Age Vinkovci-Nama showed a clear C4 signal representing a notable millet component in the diet of most individuals (Lightfoot, Slaus, & O'Connell, 2014). The presence of millet is also attested by Strabo (64/63 BC–ca. AD 24) in his *Geograhica* (7.5.4) who describes the Pannonii as "people living for the most part on spelt and millet". The presence of wheats such as emmer, einkorn, spelt and bread wheat, as well as barley, lentil, pea and broad bean are all present in prehistoric contexts in Croatia (Reed, 2016). Yet, the lack of archaeobotanical evidence from the Iron Age restricts any conclusions about the main crops grown in the region; although it is probable that many of these crops would have been part of the diet. Subsequently, this paper will not explicitly examine changes in the region from the Iron Age to the Roman period.

1.1 Southern Pannonia

Pannonia, along with other Danubian provinces, was a military and frontier zone of the Roman Empire. Established after the Great Illyrian Revolt AD 6–9, Pannonia occupied parts of Croatia, Slovenia, Bosnia Herzegovina and Serbia (between the Drava and Sava rivers), eastern Austria (Bergenland and Viennese Basin), and western Hungary (Transdanubia). The Danube was the frontier zone for most of the province's history with only sporadic temporary expansions across it. By 106 AD, around the time of the first and second Dacian wars, Trajan divided the province into Pannonia Superior to the west, with the capital

Carnuntum (Austria), and Pannonia Inferior to the east, with the capitals in *Aquincum* (Hungary) and *Sirmium* (Serbia) (Campbell, 2013). Unsurprisingly due to its close proximity to Italy and Rome, Pannonia had one of the strongest provincial armies and played decisive roles in military and political events. In the third century Pannonia also produced, along with other Illyrian provinces, a series of 'Illyrian Emperors', including Constantine I, Valentinian I, Valens and Diocletian (Visy, 2003, p. 18).

Classical authors emphasise three main geographical features of Pannonia, the mountains, forests, and swamps, and the easiest way to travel, according to the Romans, was via the river systems. The three main rivers, the Drava, Sava and Danube, connected Pannonia to the Adriatic coast, and the Mediterranean, to the west and to the rest of the empire to the north and south. Pannonia is depicted as a region unfavourable in geography and climate by ancient authors (Strab. 7.5,10; Dio, 49.36,2–3), but by the end of the 1st, beginning of the 2nd centuries AD Pannonia was already a model province with a variety of lands: fields, pastures, forests, and meadows (Hyg. Grom. 28), and trading goods with the wider Roman Empire (Thomas, 1980, p. 281). The region was noted as having vast dense forests (e.g. Hdn. Hist. 8.1,1) and species such as saliunca (probably valerian spikenard (*Valeriana celtica*), Plin. NH 21.20,43), arum (wild ginger, Plin. NH 27.47), the European wisent (Plin. NH 8.16,40), and the "Illyria pig with solid hooves" (Plin. NH 11.106, 255). Sources also mention two game animals; bear ("Pannonian bear", Luc. 6.220–223) and wild boar ("Pannonian boars", Hadr. Carm. 4). In southern Pannonia (Figure 1), the thick deciduous forests and frequent overflowing of the rivers meant that throughout the Roman period many of the settlements, e.g. *Mursa* (Osijek, Croatia), *Cibalae* (Vinkovci, Croatia), *Sirmium* (Sremska Mitrovica, Serbia), were surrounded with swamps.

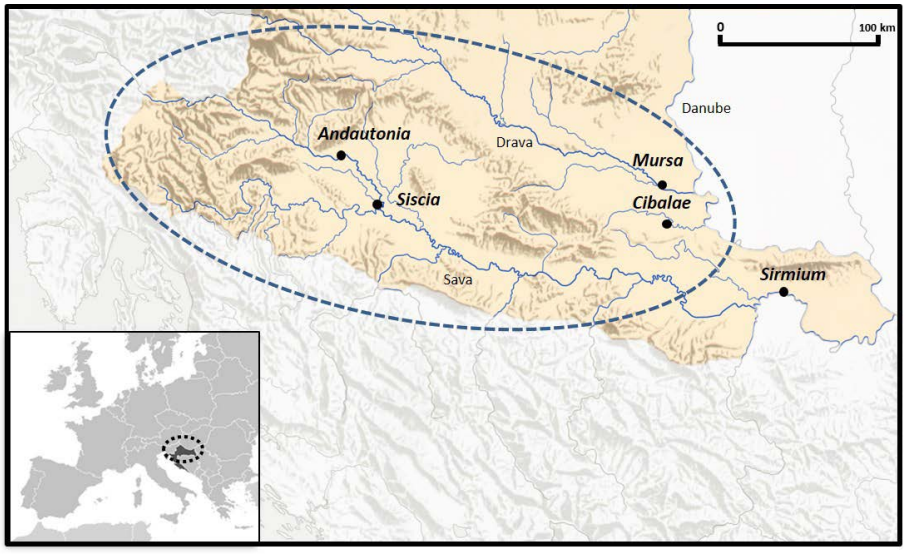

Figure 1: Map of southern Pannonia and the area under discussion.

Within southern Pannonia (Croatia) no Roman town has been excavated in its entirety as they are now under densely populated modern towns, so much of our information about the urbanization of Pannonia comes from limited archaeological evidence and the knowledge of typical Roman town planning rules. Vespasian and his heirs were fully aware of the strategic and trading importance of the River Sava valley assigning the rank of a colony to two crucial stations on the Sava; *Segestica/Siscia* (Sisak, Croatia) and *Sirmium*. The next phase of urbanization occurred during Hadrian's reign with the rank of municipium being awarded to a number of centres (e.g. *Cibalae*, which later became *Colonia Aurelia Cibalae*) and the rank of colony to *Mursa* in the AD 120/130s (Mócsy, 1974, p. 119; Boatwright, 2002, pp. 36–37). Each of the colonies (*Mursa*, *Siscia* and *Cibalae*) was founded next to rivers on known prehistoric sites (Pinterović, 1978; Iskra Janošić, 2001, Lolić & Wiewegh, 2012). *Mursa* and *Cibalae* were 42 ha and 40 ha in size and organised within a rectangular perimeter, while *Siscia* at 47 ha was less regular due to local geography,

and all were surrounded by a town wall and cemeteries situated immediately outside the walls along the main roads (Lolić & Wiewegh, 2012, p. 195). A harbour is evident at *Siscia*, but no others have so far been identified. According to Roman administrative system, the territory of the town was divided into districts (*pagi*), which were further divided into villages (*vici*), however little is known about the administrative borders of southern Pannonia. Evidence of rural settlements is sporadic ranging from several to 20 houses, accompanied by cemeteries and industrial facilities (Lolić & Wiewegh, 2012, p. 195). Along the *Limes* a series of fortified settlements and observation posts stretched along uniform intervals of 4 to 6 km from Batina Skela to Kopačevo, and along approximately 10 km intervals from Aljmaš to Ilok, due to the steep hills immediately above the Danube (Bulat, 1969).

2 The Archaeological Evidence for Food in Southern Pannonia (Croatia)

The few written accounts on Pannonia suggest that agriculture flourished during the Roman period with a reference giving permission to grow vines from the Emperor Probus (276–282 AD) and in the 4th century a reference to Pannonia being a land rich in agricultural produce and cattle (Oliva, 1962, pp. 316–318). In terms of archaeological evidence on agriculture, diet and consumption in southern Pannonia, most comes from pottery studies and to a lesser extent the identification of plant remains, animal bones and other artefacts. This section will present the current archaeological evidence for food and drink in southern Pannonia.

2.1 Pottery

The most numerous evidence of consumption and the transportation of food in southern Pannonia comes from pottery. Pottery was used for storage (e.g. dolia, water storage jars, amphorae for wine, oil etc.), in food preparation (cooking, frying, parching etc.) and in the consumption of meals (cups, bowls, platter etc.). Huge amounts of pottery have been collected from Roman sites in southern Pannonia, but only a relatively small portion of this has been published and few regional syntheses exist. Therefore, for the purposes of this paper, we will not present all the pottery evidence, but will highlight specific types that help us explore production and consumption in this region. In particular, we will focus on amphora and storage vessels, which provides evidence of trade, cooking vessels, to examine the types of dishes prepared and how they may have been served, as well as more unusual finds, such as food moulds and strainers. Many of the finds represent only one or two fragments per site. Their small statistical presence is a reflection of several factors, including insufficient analysis and publication in the region, poor preservation preventing diagnostic features being present, as well as the secondary use of such items in the Roman period, meaning that many may not have entered the archaeological record in the region.

Food depictions are also found on a few items, such as lamps with images of bread or wine. The inscription *pauperis cena pane vino radix* "Dinner of the poor is bread, wine and radish" was found on lamps from Ptuj (Slovenia), *Vindobona* (Vienna, Austria) and *Andautonia* (Šćitarjevo, Croatia) (Žižek, 2012, p. 92). However, they are unlikely to directly indicate what was on the menu in southern Pannonia, but instead probably convey other meanings for or about the person who owned it. For example, many agree that paintings or mosaics illustrating food convey a message of status, wealth and abundance about the owner (Grant, 2015, p. 19; O'Connell, 2018). Thus, these items will not be considered further in this discussion.

2.1.1 Amphora and Storage Vessels

The typological analysis of amphorae has provided a useful insight into the commercial trade links of Pannonia to the wider empire. To date pottery analyses has been conducted for *Cibalae* (Ožanić Roguljić, 2016), *Siscia* (Miletić Čakširan, 2019; Paro, Novaković, & Radman Livaja, 2018) and for *Mursa*, and some of

the *Limes* sites along the Danube (Brukner, 1981). Typically amphora typologies help us to interpret their content, although, it is widely agreed that some were reused to transport and/or store more than one type of food over its lifetime (Pecci et al., 2017, pp. 515–521).

Overall, amphorae are present in small numbers, mostly one or two specimens at each site. Most of the amphora identified from the sites originate from Italy or Spain and date to around the 1st–2nd century AD (Table 1). The fabrics of these types are also diverse, reflecting the existence of different production centres. From the 1st to 2nd century AD evidence of Lamboglia 2, Dressel 2–4 and Forlimpopoli type amphorae indicates the importation of wine from Italy (Ožanić Roguljć, 2016; Brukner, 1981). Much of the amphora found suggests that olives or dried fruits, such as dates and figs, as well as *garum* or *liquamen* were imported from Spain, Africa and Italy (Ožanić Roguljić, 2016; Paro, Novaković, & Radman Livaja, 2018 (Figure 2)). However, olive oil was also being sourced from Istria (Croatia) and transported to Pannonia in Dressel 6B amphora until the end of Hadrian's rule. The origin of Camulodunum 189 amphorae is not really known, but some suggest the structure of the clay indicates a desert environment, hence a north African origin (Brukner, 1981, T. 161., p. 55; Peacock & Williams, 1986, p. 109; Kelemen, 1990, p, 148; Bjelajac, 1996, p. 28; Vidrih Perko, 1999, p. 8; Paro, Novaković, & Radman Livaja, 2018).

Local production of amphora in southern Pannonia is not present *per se*. What is found in the pottery assemblages are big jugs with two handles that could have been used similarly to amphora. They are found in urban, military and rural sites, as well as necropolis. These jugs have also been recovered in Dalmatia (Perko, 2000, p. 434; Ožanić Roguljić, 2017, pp. 84–85), suggesting that they were used to transport food or drink, although at present it is unknown what they contained.

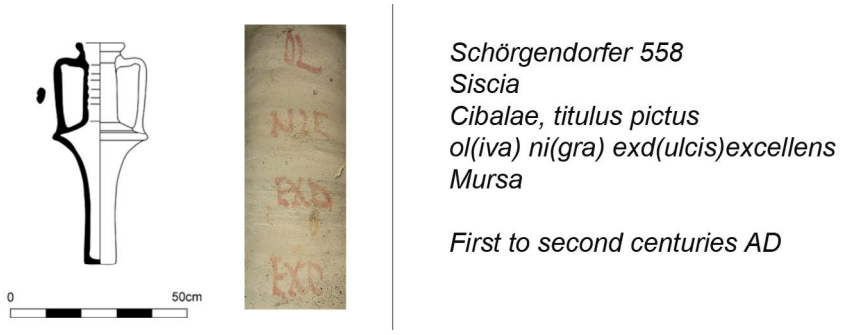

Figure 2: Schörgendorfer 558 amphora with black olive inscription, dated 1st to 2nd century AD.

Dolia or pithoi and other pots used to store food are regularly found (Jelinčić, 2003, p. 82, T. 2, p. 11; Ožanić Roguljić, 2016, p. 96; Vidošević, 2003, p. 23), but so far no organic residue analysis has been conducted to indicate what was stored in these vessels. Some do have grafitti on the vessels giving us an idea of what may have been stored inside. For example, a Dressel 8 type amphora from *Siscia* had the inscription '*Titulus a flos gari*' on the neck which indicates that the amphora contained good quality garum (*flos* meaning 'the choosiest parts') (Novaković et al., 2018, p. 238). The highest-quality garum was typically made from the blood and salted innards of fresh mackerels (Mouritsen et al., 2017).

Within the household, storage vessels were buried in the ground or housed in a wooden or masonry pedestal. The dimensions vary according to the function they performed. In southern Pannonia, a unique type, with slightly different variations, dominates assemblages from the 1st to 2nd century (Figure 3). Some have a black resin coat along the rim, while others have different variants of combed wavy or straight-line decoration on the upper part of the belly. By the 3rd to 4th century they continue to be produced, but lower quality clay is used and the decoration seems to be applied with less care (Brukner, 1981, pp. 42–43; Ožanić Roguljić, 2016, pp. 73–75). A wide variety of other pots with fewer inclusions and thinner walls are also found that could have been used for storage. For example, in Roman *Cibalae* 16 types of pots with fine fabric have been catalogued (Ožanić Roguljić, 2016, pp. 66–70).

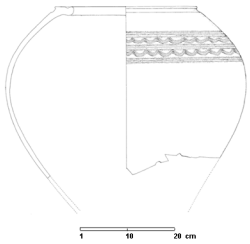

Figure 3: Pithoi storage vessel, 2nd century AD, found at Cibalae, Siscia and Mursa.

Table 1: Amphorae that would have contained foodstuff found in Roman Siscia (Sisak), Mursa (Osijek) and Cibalae (Vinkovci), Croatia.

	Origin	Date according to context	Siscia	Mursa	Cibalae
References			Novaković et al., 2018	Brukner, 1981	Ožanić Roguljić, 2016; Brukner, 1981
Wine					
Graeco italic amphora	Italy	Republican	●		
Lamboglia 2	Italy	Augustus–Claudius	●		●
Dressel 6A	Italian Adriatic	Late 1st c. BC–mid 1st c. AD	●		
Forlimpopoli	Italy	2nd–3rd CE	●		●
Rhodian	Aegean area	Mid Augustan–Antonine	●		●
Dressel 2–4	Italy	Augustus–Antonine	●		●
Dressel 1B	Etruria to Campania Italy	End of the 1st c. BC	●		
Pascual 1	Catalan coastal zone of NE Spain	Tiberian, i.e. the Claudian layer	●		
Garum					
Dressel 9 & 10 similis Lyon	Lyon, Gaul	Augustan	●		
Dressel 7	Spain	Late Augustan	●	●	●
Beltrán 2A	Spain	Augustan–the 2nd c. AD	●		
Dressel 8	Spain, Baetican coast	1st AD	●		
Oil					
Dressel 23	Spain	3rd c. AD–second half of the 5th c. AD	●		
Dressel 6B	Istria	Augustan–Flavian	●	●	●
Olive					
Schörgendorfer 558	Northern Italy	1st–2nd c. AD	●		●
Also Teutoburgium for Schörgendorfer 558				●	
Dried Fruit					
Camulodunum 189 Carrot amphora	Egyptian? Palestine?	Tiberian (*Siscia*)–end of 2nd c. AD (*Cibalae*)	●		
Defrutum					
Haltern 70	*Baetica Spain*	Tiberian	●		

2.1.2 Vessels for Cooking and Serving

As with the storage vessels it is difficult to directly deduce what may have been cooked in Pannonia as no residue analyses have so far been conducted. Instead, we must look at the functional roles of form and material to infer what types of dishes could have been cooked and served. The function and role of Roman pottery is still debated and it is hard to understand how people making and using cooking pots perceived them. Functions probably varied considerably in terms of intended and actual use, but here we will explore a few typical vessels found in southern Pannonia that might give us an indication about local eating habits.

The most common types of fine wares present during the 2nd and 3rd century are deep bowls that belong to terra sigillata and forms that imitate terra sigillata, known as Pannoniche glanztone ware or Pannonian slipped ware (Figure 4). They are frequently found in southern Pannonia and have been interpreted as bowls that serve soups or stews (Brukner, 1981, Ožanić Roguljić, 2016; Leleković, 2018). Cooking vessels include, open and closed forms, like deep bowls and pots, and in the 2nd century specific ceramic tripod vessels, where 3 legs lift the base above the direct heat (Swan, 2009, pp. 15–24; Ožanić Roguljić, 2016). Cooking vessels made in rough/coarse fabric with inclusions (Figure 5) are considered more suitable to hold liquids and withstand and retain heat. This meant they could be left on the fire for longer periods, which would be useful for stew type dishes where pulses or meats would need time to cook and soften (Arthur, 2007, pp. 18–19).

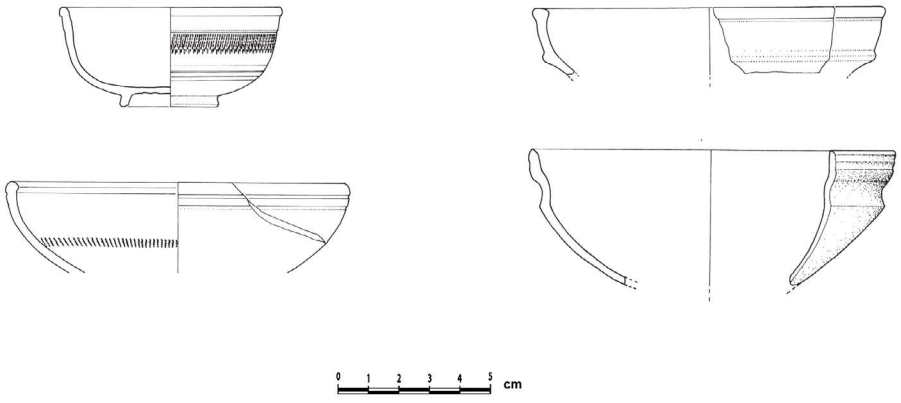

Figure 4: Examples of Pannonian slipped ware.

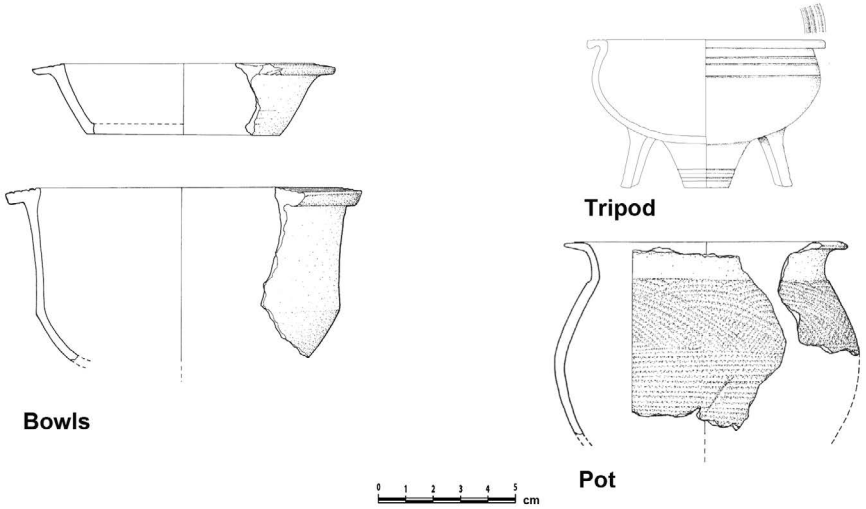

Figure 5: Examples of cooking vessels from southern Pannonia.

Other terra sigillata and thin-walled pottery groups include a range of beakers and cups that show changes in styles from the 1st to early 2nd century, and 2nd to 3rd century when imports from Gaul started to dominate. Local vessels also imitated Italian production (thin-walled pottery) in the later 2nd and 3rd century, when, influenced from Gaul, new local forms took over the market (Leleković, 2018; Šuljug & Filipović, 2018).

Double- or single-handled vessels appear in several variations and may have played a number of roles, from simple storage pots to cups or even small table kraters for mixing water and wine (Figure 6). Analyses of the contents from several archaeological contexts in other parts of the empire and data from graffiti (Gaul, Italy, Noricum) revealed that certain types were used for storing and perhaps also transporting fish or garum, fruits, legumes and olives, while some are considered as honey-storage vessels (Djaoui & Capelli, 2017; Botte, Piquès, & Djaoui, 2014; Ostia II, 95, T LVIII; Crane, 1983, p. 267.). Large dome-shaped lids used to cover food while cooking (also known as *sub testu* baking), appear in both urban (*Cibalae*) and rural (Atovac) areas of Roman Lower Pannonia. Dishes such as unleavened bread could have been prepared under a '*peka*' (or baking lid), while lids with thickened edges could have held hot coals either during baking or after to keep a dish warm (Ožanić Roguljić & Raičković Savić, in press).

Mortars and pestles (*mortarium* and *pistilum*) were also an important vessel for food preparation where foods could be crushed, ground and mixed. Production in Pannonia spanned two centuries from the time of the Flavians and Trajans in *Ptuj* (*officina Iustiniana*) and *Aquinas* (Brukner, 1981, p. 38; Gabler, 1982, p. 100; Cvjetičanin, 2003, p. 103; 2006, p. 26; Jelinčić Vučković, 2015, pp. 155–157).

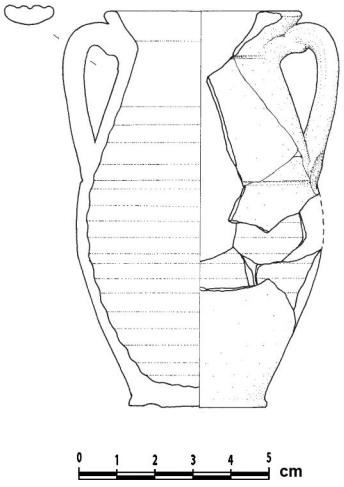

Figure 6: Example of a double handled vessel from southern Pannonia.

2.1.3 Other Vessel Types

A small number of pottery strainers (flat-based vessels with perforations on the base and walls), interpreted as items to prepare and process foods like cheese, have been discovered from the 2nd to 3rd c. AD contexts in both rural and urban contexts in southern Pannonia: *Cibalae*, *Sirmium* (Figure 7), the villages of Gomolava, Progar, Ivandvor and in *villae rusticae* of Prosina and Kudoš (Ožanić Roguljić, 2010). Vessels with a grate and high set rim (Figure 7), sometimes interpreted as a milk cooker, are also found at *Cibalae* and *Siscia* (Ožanić, 2004, p. 182). Rare examples of relief moulds (*crustulum* or *crustum*), used for baking a special seasonal cake are found at *Certissia* (Šrbinci), *Cibalae* and *Siscia* (Vikić-Belančić, 1970, T. VII, p. 5; Dimitrijević, 1979, T 24, p. 1; Migotti, 2000, p. 41; Leleković, 2004, p. 111).

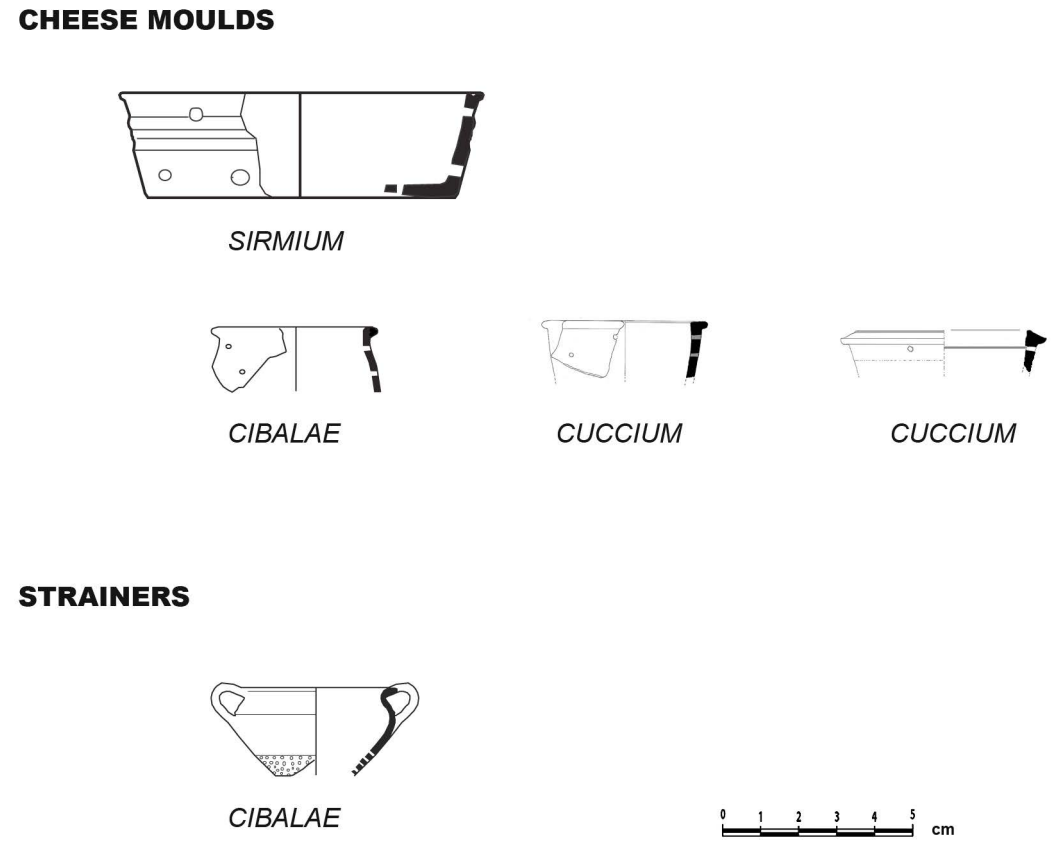

Figure 7: Examples of cheese moulds and strainers from southern Pannonia.

2.2 Plant Remains

Archaeobotanical remains recovered from within Roman southern Pannonia are still relatively rare. To date, only 10 sites have published evidence of plant remains; four from settlement occupation, one is from the area of an altar and five are from grave sites (Table 2). Unfortunately, archaeobotanical remains from grave sites can be difficult to interpret, especially within inhumations. This is because seeds can easily become accidentally incorporated within the grave either during the ceremony, or later as the ground is disturbed, and may represent general rubbish or plants from the local environment (Reed et al., 2019a; Pelling et al, 2015). Thus, in some cases the plant remains may not indicate direct evidence of human/ritual acts or offering. The density of the plant remains is usually used to determine this, for example if only one or two grains are found, these may indicate contamination, while hundreds of grains are more likely to indicate one depositional act (Jones, 1991). Understanding the context within which the archaeobotanical remains are found is therefore an important aspect of interpretation.

From the five grave sites in Pannonia only two, Roman *Cuccium* (Illok) and *Andautonia* (Šoštarić et al., 2006), contained relatively high densities of plant remains. The samples were taken from two early Roman cremation graves that were buried with a range of grave goods, including pottery, glass vessels and bronze items. A range of archaeobotanical remains were recovered in carbonised and waterlogged condition, including cereals, pulses, oil crops, fruits and vegetables and a few wild/weedy species (Table 2). Interestingly at Illok apple/pear (*Malus/Pyrus*), wild cherry (*Prunus avium*), plum (*Prunus domestica*), grape (*Vitis vinifera*), melon/cucumber (*Cucumis melo/sativus*), figs (*Ficus carica*) and olive (*Olea europaea*) were identified, which show both locally grown and imported fruits (see discussion below).

Table 2: Plant remains from Roman contexts in southern Pannonia. Numbers in [] indicate waterlogged finds, all other plant remains are carbonised.

Site name		**Vitrovitica Kiškorija**	**Park Kraljice Jelene Kosače**	**Aquae Iassae Varaždinske toplice**	**Osijek-Silos**	**Ulica I. Gundulića 39**	**Ulica I. Gundulića 48**	**Sčitarjevo**	**Illok**	**120 Divaltova Street**	**Lapovačka ulica -Kaufland**
Reference		Šoštarić et al., 2015	Reed & Leleković, 2019	Vikić-Belančić, 1974	Reed et al., 2019b	Reed et al., 2019a	Reed et al., 2019a	Šoštarić et al., 2006	Dizdar et al., 2003; Šoštarić et al., 2006	Reed et al., 2019a	Reed et al., 2019a
Type of site		Rural settlement	Town	Town	Urban villa	Altar (Urban)	Graves (Urban)	Graves (Rural)	Graves (Rural)	Graves (Urban)	Graves (Urban)
No. of samples		38	1	1	1	1	1	1	1	2	3
Cereals											
Hordeum vulgare	Barley	87			40	7	2		5		1
Oryza cf. *sativa*	Rice		5								
Panicum miliaceum	Broomcorn millet	283			4	2		[1123]	23		3
Secale cereale	Rye	2			3095						
Setaria italica	Italian millet	4									
Triticum aestivum/ durum	Bread wheat	4			7492	2			15		
T. aestivum/durum/ T. spelta	Bread/spelt wheat				3765						
Triticum dicoccum	Emmer				486				18		
Triticum dicoccum/ T. aestivum	Emmer/Bread wheat				93						
Triticum monococcum	Einkorn				131				7		
Triticum spelta	Spelt	1			4691		1		1 cf.		
Triticum spelta/ T. dicoccum	Spelt/Emmer				442						
Triticum sp.	Wheat				1024						
Cereal chaff											
Triticum aestivum rachis	Bread wheat				1						
Triticum dicoccum, glume	Emmer				1						
Triticum monococcum, glume	Einkorn				2						
Triticum sp., glume	Wheat				1						
Oil crops											
Camelina sativa	Camelina							[2]			
Linum usitatissimum	Flax						1				

Site name		Vitrovitica Kiškorija	Park Kraljice Jelene Kosače	Aquae Iassae Varaždinske toplice	Osijek-Silos	Ulica I. Gundulića 39	Ulica I. Gundulića 48	Sćitarjevo	Illok	120 Divaltova Street	Lapovačka ulica -Kaufland
Pulses											
Pisum sativum	Pea				2						
Lens culinaris	Lentil				1			[156]	[240]	7	2
Lathyrus sativus	Grass pea				2						2
Vicia ervilia	Bitter vetch								[13]		
Vicia faba	Broad bean	6									
Fruits and nuts											
Cucumis melo/sativus	Cucumber/melon							[1]	[1]		
Ficus carica	Fig							[16]	[25]		
Malus sp.	Apple							[6]			
Malus/Pyrus sp.	Apple/Pear							[5]	[6]		
Olea europaea	Olive								[4]		
Prunus avium group	Wild cherry							[4]	[6]		
Prunus domestica	Plum	1							[13]		
Prunus persica	Peach			*							
Rubus friticosus	Blackberry	2									
Vitis vinifera	Grape							[23]	[1391]		
Herbs											
Piper nigrum	Black pepper		2								

Recent archaeobotanical remains discovered from *Mursa* provide the richest archaeobotanical remains so far in southern Pannonia. Samples were collected from four cess pits dating to AD 120/130 (Reed & Leleković, 2019; Reed & Leleković, in press). Although the archaeobotanical remains have not been completely identified and fully published, a wide range of species are present, including cereals, pulses, fruits such as pomegranate, nuts such as walnut and hazelnut, vegetables such as carrot and chicory, herbs such as dill and wild/weedy species. The site is also unique as one of the cess pits contained five grains of rice (*Oryza* cf. *sativa*) and two black peppercorns (*Piper nigrum*), which would have been grown in Asia. Also, within *Mursa*, a rich deposit of 24,000 cereals was identified from the kitchen of a late 2nd–4th c. AD Roman villa (Reed et al., 2019b). The sample contained predominantly free-threshing wheat (*Triticum aestivum*), spelt (*Triticum spelta*) and rye (*Secale cereale*) with only a relatively small amount of other cereals, chaff and weeds. The relatively clean grain deposit suggests that this sample represents processed grain ready for final food preparation and consumption at the urban villa. Data on the presence of peach stones was also recorded during investigations at a settlement complex in *Aquae Iassae* (Varaždinske Toplice), however, little is known about the finds (Vikić-Belančić, 1974, p. 79).

The final settlement site to have evidence of plant remains is the Roman village of Vitrovitica Kiskorija (Šoštarić et al., 2015). Numerous features were excavated and archaeobotanical samples were collected from houses, storage and working areas. Only 38 samples contained plant remains and densities were particularly low for many of the features except complex G, dated to the 3rd and 4th c. AD, where in one of the cooking structures was found a couple hundred grains of broomcorn millet (*Panicum miliaceum*), as well as less than a hundred grains of barley (Šoštarić et al., 2015, Table 1).

2.3 Zooarchaeology

Animal remains are regularly found at Roman sites, yet few are published. Thus, for the Roman period in southern Pannonia only two sites have so far yielded published evidence of animal remains (Table 3). The cemetery site of Šepkovčica (Hincak, Mihelić, & Bugar, 2007) produced evidence of animal bones in cremation burials, however, the burnt and fragmentary evidence tells us very little about the diet and subsistence of the inhabitants, beyond their presence. The only other published zooarchaeological evidence is from the Roman village of Virovitica-Kiškorija-South (Šoštarić et al., 2015). The small number of bones recovered revealed four species, domestic cattle (*Bos taurus*), horse/donkey (*Equus/Asinus*), sheep/goat (*Ovis/Capra*) and pig (*Sus* sp.). Unpublished preliminary animal bones identified from *Cibalae* suggest the presence of domestic animals (e.g. cows, horses, sheep/goat, pigs) and wild animals (e.g. deer, bear, badger, fox) (A. Rapan Papeša pers. comm.).

Table 3: Zooarchaeological evidence from Southern Pannonia, Croatia. * = presence only.

Site name	Virovitica-Kiškorija-South	Šepkovčica
Date	3rd–5th c. AD	Second half of 1st–2nd c. & 4th c. AD
Type	Settlement	Cemetery
Reference	Šoštarić et al., 2015	Hincak et al., 2007
NISP	29	/
Cattle %	51.7%	*
Pig %	3.4%	*
Sheep/Goat %	34.5%	*
Game %		*
Equine %	10.3%	
Red deer		*
Fish		*

2.4 Osteoarchaeology

Human skeletal remains provide the most direct evidence for the health of past populations. Dental caries or excessive tooth wear (resulting from an abrasive diet) is a general indicator of diet and dental health, being associated with high levels of carbohydrate consumption and poor oral hygiene (Forshaw, 2014). In Croatia a study by Peko & Vodanovic (2016) examined the dental health of 100 individuals from late Roman *Cibalae* (3rd–5th c. AD). They found a higher prevalence of occlusal and approximal caries in males compared to females, while females had a higher prevalence of tooth cervix caries. This suggests that women consumed softer foods that didn't abrade the teeth to the same extent as the males. Work by Šlaus et al., (2004) on the health of individuals along the *Limes* in Croatia showed that the average death of males and females was around 40yrs. They also found that there was no significant difference in the quality of life of individuals who inhabited a fortified settlement on the Danubian *Limes* and individuals who inhabited the large urban settlements, including *Mursa* and *Cibalae*, in the *Limes* hinterland.

2.5 Other Evidence

Remains of agricultural buildings and facilities as well as those used for animal husbandry are rarely found in southern Pannonia. The only evidence is of two 4th century AD granary (*horrea*) located in *Siscia* (Demicheli, Radman Livaja, & Wiewegh, 2012) and possibly in the northeast part of *Cibalae* (Rapan Papeša pers. comm.; Lolić & Wiewegh, 2012, p. 214).

A large number of Roman fishing implements, mostly hooks and fishing net weights, from *Siscia* are also present in the Archaeological Museum in Zagreb (Radman-Livaja & Domiter, 2018). Unfortunately, all of them are out-of-context finds, discovered in the early 20th century during the dredging of the river Kupa and so far there are no published interpretations of these finds. The Archaeological Museum Vinkovci also has a number of fish hooks, likely used for local fishing (e.g. catfish, pike). In addition, they have identified bones of possible sea fish, a thresher shark and oyster shells associated with Roman contexts in *Cibalae*, although they have not been examined and published (A. Rapan Papeša pers. com.).

3 Discussion

> *'Farms which have nearby suitable means of transporting their products to market and convenient means of transporting thence those things needed on the farm, are for that reason profitable. For many have among their holdings some into which grain or wine or the like which they lack must be brought, and on the other hand not a few have those from which a surplus must be sent away.'* (Varro, 37 BC, De Re Rustica 1.16.2-3)

Many have attempted to understand the fundamentals of the Roman economy through the analysis of major economic activities (agriculture, trade, commerce, mining) and utilizing quantifiable bodies of artefactual and documentary evidence to place them in the broader structural context of regional variation, distribution, as well as the size and nature of supply and demand (e.g. Bowman & Wilson, 2009; Erdkamp, 2005; Hollander, 2019; Scheidel & von Reden, 2002; Temin, 2012). Temin's (2012) concludes that the Roman Empire was a market economy, where institutions or other economic forces affected prices, quantities, and related variables in one or more industries or, sometimes, in the economy as a whole. Inevitably, examining the Roman economy raises a number of general issues, including the extent to which pre-capitalist and capitalist features can be assigned, the dangers of generating statistical evidence from biased and limited data sets, as well as variability resulting from the application of different social and economic models (Bowman & Wilson, 2009).

In terms of agriculture, the relationship between the costs of commodity transportation and the location of production has also been widely discussed. In particular, von Thünen's (1826) 'isolated state' model, Weber's (1909) 'consumer city' model and Christaller's (1933) 'central place theory' have all been influential in archaeological interpretations (e.g. Bintliff, 2002; Casarotto, Pelgrom, & Stek, 2016; De Neeve, 1984; Erdkamp, 2001; Morley, 1996; Patterson, 2004; Weaverdyck, 2019). These models generally focus on the spatial distribution of agricultural practices and land use around a city or market centre, where the sole production for the city comes from its hinterland. Although hypothetical they highlight distance-based agricultural activities, taking into account production costs, transport costs to market, and profit maximization in order to determine 'rent'. Further, 'central place theory' ranks places in terms of the services they provide, i.e. higher-ranking places offer a wider range of services around a larger area. Site catchment analyses (SCA) (Vita-Finzi, Higgs, Sturdy, Harriss, Legge, & Tippett, 1970, p. 5) also suggests that human activity and mobility are limited to a certain range. For example, if a settlement is reliant on crops then it will be located near agriculturally productive soils and the further you move away, greater energy [cost] is expended to procure resources (Roper, 1979, p.120; Bailey, 2005). In particular, De Neeve (1984, p. 13) argued that, rather than zones of products, we should look instead at zones of agrarian systems, taking into account farm size, labour and population density.

These 'one size fits all' models are unlikely to account for the economic nuances that probably existed between Roman cities and their hinterlands or between different regions of the empire (e.g. Bowman & Wilson, 2009, 2011; Erdkamp, Verboven, & Zuiderhoek, 2015; Erdkamp, 2001, 2016; Horden & Purcell, 2000; Witcher, 2008; Ziche, 2006). Nevertheless, they do provide a simple framework from which to start exploring agricultural production. In particular, a number of scholars have calculated basic agricultural production zones around urban centres suggesting intensive farming occurred within a one day journey (up to 6 or 7 km away), while less intensive products or products needed less frequently would be within a weekly (7–20 km), monthly (20–40 km) or seasonal (40–80 km) distance (Bintliff, 2000; Mandich, 2015). Other

variables will also affect the length of time to transport goods, including good roads or waterways and the geology etc. (e.g. Carreras & De Soto, 2013; Hitchner, 2012). Unfortunately, the lack of archaeobotanical and zoological investigation in many parts of the Roman Empire has meant that it can be difficult to determine the actual crops produced and the precise agricultural strategies used, resulting in settlement density and population size being used as a proxy indicator for intensity of cultivation (e.g. Casarotto, Pelgrom, & Stek, 2016; Goodchild, 2007; Patterson, 2004).

Over the last two decades an increase in field survey and excavations had allowed us to build a better picture of rural and urban settlement in southern Pannonia. A few studies have begun to synthesise this work (e.g. Leleković & Rendić-Miočević, 2012; Ožanić Roguljić et al., 2019), however, few studies address the links between agricultural production and consumption in this region. If we explore southern Pannonia using the daily zone boundary of about 6–7 km, only a couple of sites identified as rural settlements or villas are located near *Siscia*, *Cibalae* and *Mursa* (e.g. Josipovac Vinogradi, Verušed, Osijek-Fergis, Čepin, Liskovac). Archaeobotanical investigations were not conducted, but at Verušed cheese moulds were recovered indicating cheese production (Lukić & Filipec, 2019). Thus, we have little knowledge about what they produced and whether they supplied the nearby towns. Around *Mursa*, *Cibalae* and *Certissia* (Đakovo) up to 20 rural settlements or villas, dating from the 1st–4th centuries AD, are located within 20 km of the urban centres (surveys during 2018 and 2019, as part of 'Life on the Roman Road' project, have revealed 15 new rural character sites around *Mursa*, in the municipality of Čepin, Anunovac and Tenja). Although the information is rather limited at present, studies in other parts of the empire suggest that there was, to varying degrees, a supply and demand relationship between the rural and urban centres, as well as between rural settlements (e.g. Witcher, 2006; Erdkamp, 2005, p. 321). In southern Pannonia, the evidence of pottery imports at many of the rural sites would suggest that they were integrated within the wider Pannonian food system. Due to the limited evidence the extent to which these settlements relied on imports or became specialist agricultural producers in their own right is unknown.

3.1 Local Food Production

In the Roman world food would have been produced at varying scales, within kitchen gardens, large crop fields, orchards and vineyards. Food production was relatively advanced with different cultivation regimes and tools, as well as techniques for grafting and cross-pollination (e.g. Lowe, 2010). Much of our evidence for horticultural plots or kitchen gardens comes from Roman literature and remains from sites such as Pompeii and Herculaneum (Jashemski, 2017). Pliny the Elder describes the value of kitchen gardens for food, although largely in terms of a bygone past when things were simpler and gardeners weren't cultivating new-fangled varieties that exceeded the limits of growth set by nature. In particular, he mentions the asparagus that had grown wild but now weighs *ternos libris*, "three to a pound" (N.H. 19.54). Kitchen gardens were useful for the cultivation of crops that required tending, watering or manuring more regularly. Their produce would have been seasonal and more perishable and so if items were sold on scale they would need to be located close to market. Physical evidence of kitchen gardens are seen in Romano-British contexts in the form of bedding trenches (parallel trenches) and inferred from agricultural tools, such as iron mattocks or spades (Lodwick, 2017, pp. 73, 80; Van der Veen, 2008). Similarly, orchards and vineyards have been identified from Britain, France, Italy and Tunisia, where parallel trenches with stake holes as well as pits laid out in regular grid patterns have been identified (Figueiral et al., 2015; Landry & Moulin, 2016; Lodwick, 2017, p. 75; Mattingly, 1996).

In southern Pannonia, quite a few tools have been discovered including a number from the Kupa river at Sisak, however, most have not been published except a probable military mattock with incised inscriptions (Radman-Livaja, 2012). These mattocks are quite common, with a flat trapezoidal spade on one side and a massive pick of rectangular cross section on the other. No other evidence has been identified in southern Pannonia, so instead we must look to the archaeobotanical evidence, as certain species would have been suited to kitchen garden or orchard cultivation. In particular, the discovery of dill (*Anethum graveolens*), carrot (*Daucus carota*), possible garlic (*Allium* cf. *sativum*), chicory (*Cichorium intybus*) and melon (*Cucumis* cf. *melo*) could indicate horticulture in or around *Mursa* (Reed & Leleković, in press). Some of the pulses,

such as lentil (*Lens culinaris*), and fruit/nut trees, such as walnut (*Juglans regia*) could have been grown in horticultural or orchard plots. Certain fruits recovered from southern Pannonia could have also grown in orchards, including peaches, plums, pears and apples. Evidence of such fruits are interesting as many would have needed a certain amount of future planning and long term investment as many would not have yielded fruits for 5–10 yrs after planting (Van der Veen, 2008). They also cannot be grown from seed but need vegetative reproduction, such as clippings or roots (*ibid*.).

Evidence of grape pips could be an indication of viticulture in Pannonia. Dio (49.36) talking of Pannonians states that "they cultivate no olives and produce no wine except to a very slight extent and a wretched quality at that". The emperor Marcus Aurelius Probus (276–282 A.D.), a native of *Sirmium*, is typically regarded as the patriarch of wine culture in the region, introducing legislation affecting viticulture that greatly eased previously existing restrictions in the northern and western provinces (Balassa, 1969). Pannonia has no evidence of wine presses, just remains of grape pips that could have arrived in Pannonia from Dalmatia or further afield in the form of dried fruits or within wine amphora. Some suggest Pannonian viticulture and the planting of orchards significantly expanded in the 3rd and 4th centuries, particularly around *villae rusticae* (Bulat, 2002, p. 46; Gyulai, 2010, p. 157; Leleković & Rendić Miočević, 2012, p. 280). Interestingly, Liber, the deity of viticulture and wine, fertility and freedom, was an important cult in southern Pannonia with many dedicated altars and inscriptions found from the 1st century AD onwards (Bulat, 2002, pp. 47–49). In particular, a 4th century altar from Popovac was dedicated to Liber by *Aurelius Constantius* and his son *Venantius*, estate owners possibly descended from Gaul, to help enrich 400 arpenes of vineyards (50 ha, 500,000 m^2) and, among other things, support his four vine varieties (*Cupenis*, *Terminis*, *Valle(n)sibus*, *Caballiori(s)*) (Baranja, CIL III 10275; Brunšmid, 1907, pp. 112–113, picture: 233; Bulat, 2002, p. 47; Dalnoki, 2009, p. 149). This altar supports the presence of viticulture in southern Pannonia by the 4th century, however, the intensity of this production and the level of specialisation at such estates is still unknown.

Cereals and pulses were diet staples during the Roman period and their cultivation would have occurred across southern Pannonia. From the archaeobotanical evidence we have a wide range of crops, including free-threshing wheat, spelt, emmer, millet, rye, lentil and pea. These crops have all been identified from prehistoric sites in the region (Reed, 2016) and ancient sources even state that the Pannonii tribe made a drink from barley and millet (Dio Cassius 49.36, 2–4) and lived for the most part on spelt and millet (Strabo VII, 5,4). By the 1st century AD and throughout the Roman period in southern Pannonia the crop evidence is consistent with many other regions in the empire, with a general reduction in einkorn, emmer and barley (e.g. Gyulai, 2010; Lepetz & Zech-Matterne, 2018; Lodwick, 2017; Murphy, Thompson, & Fuller, 2013). Increased pressure on agricultural production in Pannonia more generally would have come from the military occupation of the Danube Limes. Although we have very little evidence of how troops were supplied in Pannonia, it is likely that during the early days food was imported to sustain the troops. As Pannonia became incorporated into the empire crops, such as cereals and pulses, were probably sourced more locally. Breeze (2000, p. 60) discussing how armies were supplied, reviewed four methods: 1. the cities transported goods to the army, 2. the cities employed contractors to transport the goods, 3. the army collected the goods from the point of origin, and 4. the army employed contractors to transport the goods. Another important source was food grown on military land, which could supplement the diet (Davies, 1971). Probably a combination of these methods occurred through time in Pannonia. In addition, rare inscriptions of legion names on amphora and barrels recovered from Pannonia, Vindonissa and Britain also show that the army was supplied with a range of non-rationed foods, including olive oil (Bezeczky, 1996).

In terms of the economy some suggest that the region was unable to produce exportable surplus (i.e. to Rome) until the 3rd century when Probius and Galarius set about clearing and draining areas of Pannonia for cultivation, along with the appearance of large estates (Mócsy, 1974; De Caes. 37). Interestingly, land surveyors, commonly called *agrimensores*, record the adaption of Roman land divisioning (*centuriae*) for field systems in Pannonia (Const. Lim. 28.). But there seems to be no other evidence of land management, such as irrigation beyond utilising natural water sources (Bödőcs, Kovács, & Anderkó, 2014), and no stable isotope analyses or weed ecology has yet been conducted in the region to determine whether manuring regimes occurred (e.g. Aguilera et al., 2017; Bogaard et al., 2007). So very little is known about agricultural intensity or whether crops were grown differently and how this may have impacted the environmental landscape of southern Pannonia.

The additional labour requirements needed to support large surplus production, especially at the time of harvest, when labour demands are at their greatest, also needs to be considered. Much of the evidence of an agricultural workforce comes from ancient authors and epigraphy, yet much of this comes from the upper classes of society. Slavery is thought to predate the Roman conquest in Pannonia, but no large slave workforce is thought to have existed throughout the Roman period and only appear in cities and military camps, where soldiers often owned them (MacMullen, 1987). Erdkamp (1999) suggests that agriculture relied on the freeborn because it would have been more expensive to have kept a slave all year round to only need them at peak times of the agricultural year. Labour requirements depend on the crops grown as different cereals, pulses, fruits and vegetables will have different growing cycles. For example, in Croatia today broomcorn millet is harvested a few months later, in August/September, than other cereals such as winter wheat and rye.

Cereals and pulses, especially barley, were also noted by ancient authors as being suitable for animal feed (Columella II, 9, 14; Plin. Nat. 18.14). In southern Pannonia the fact that barley is infrequently found is interesting based on the regional heritage of supposedly eating and drinking barley; no large finds of barley have been found in Iron Age Pannonia so far, although our datasets are relatively small. It is also suggested that horses can graze quite adequately in wet areas all-year round, so the marshland areas of southern Pannonia may have been suitable for supporting military horses or even cattle (Vossen & Groot, 2008). In terms of livestock the animal bone evidence is rather limited, but shows the presence of cows, sheep/goat and pigs, which is typical for the Roman period (Table 3). The low quantity also restricts any interpretation of consumption preferences, or whether certain regions may have specialised in livestock breeding. The discovery of fish bones and fishing equipment also comes as no surprise considering the relatively close proximity of the Sava, Drava and Danube rivers and their tributaries and the fact that the major towns of *Siscia*, *Mursa* and *Cibalae* are all located on rivers.

Other forms of local production associated with food include the potters, ironmongers, butchers and merchants. In terms of pottery production, it is believed that large-scale pottery production starts in Pannonia after AD 70, with local ceramic groups emerging later during the Flavian era, or even in the time of Trajan (Leleković, 2018). A variety of forms follow the style of terra sigillata and many forms go in and out of fashion, but some types of deep bowls survive until late antiquity. During peak production, in the 2nd and 3rd century, they were made in red slip similar to Roman wares, but they also had grey or black slip that is significantly different from *the* original and was probably connected to local tastes. In southern Pannonia differences in style can be seen between its eastern (possible centres of production in *Sirmium*, *Mursa* and *Cibalae*) and western part (possible centre of production in *Siscia*). These workshops were probably closely linked with the emergence of large urban centres (Mócsy, 1974, p. 113; Kovács, 2014, pp. 129, 135). For example, in *Cibalae* over 50 pottery kilns have been identified (Iskra Janošić, 2001, p. 60). During the 3rd to 4th century, significant changes occur in Pannonian pottery production when lead glazed wares and burnished wares were (re)introduced.

3.1.1 Trade

Exportation and the movement of goods along navigable waterways and road systems allowed even the most remote outposts access to Roman produce. Goods would have been subjected to customs tax of 25% across the empire's frontiers and 2–5% *portoria* between provinces, although state cargoes, such as grain, were exempt from the *portoria* (Duncan-Jones, 2006; Wilson, 2009, p. 217). Evidence shows these taxes fluctuated through time, but the trading of goods would have been a significant source of imperial finance. Unfortunately, it is impossible to identify the proportion of traded goods into Pannonia, especially as goods could have arrived via direct and redistributive exchange. Yet the pottery evidence would suggest that a relatively wide range of food items were imported into southern Pannonia. In particular fruits such as figs, olives and pomegranates were probably imported, as the continental climate of southern Pannonia is not favourable for their cultivation. The strong evidence of olive/oil, fig and grape/wine production in Dalmatia (Glicksman, 2007) would have provided Pannonia with easy access to such products. Inscriptions from

Dalmatia also show a range of olive oil and wine traders operated in the region (Jadrić, 2007). Evidence of 2nd century Pannonian slipped ware at sites in Dalmatia and northern Italy support the presence of trade links between these regions (Ožanić Roguljić, 2017; Ožanić Roguljić & Konestra, 2017; Dobreva & Mantovani, 2017). Evidence of imports start as soon as Pannonia is established in the 1st century, with Camulodunum 189 amphorae in *Cibalae* suggesting importation of dried fruits (e.g. dates, figs, peaches or grapes), possibly from North Africa. The limited evidence of viticulture in the 1st–2nd century would suggest that grapes were imported to Pannonia, along with wine from Spain and Italy, seen from the range of amphora recovered from this period. The presence of Halern 70 amphora could indicate the possible import of defrutum, a sweet grape syrup (Pliny NH, XIV–80, Columella, De Re Rustica, XII, 19–21), or olives (Paro, Novaković, & Radman Livaja, 2018).

Of particular importance is the discovery of rice (*Oryza* cf. *sativa*) and black pepper (*Piper nigrum*) from a pit dated to AD 120/130 in *Mursa* (Reed & Leleković, 2019). The presence of rice and black pepper at *Mursa* indicates that food was being sourced from as far afield as Asia during the 2nd c. AD. The black pepper trade from India, along the Red Sea, to Europe is documented from both archaeobotanical evidence and ancient sources (Thapar, 1992; Cappers, 2006; Pliny NH 12.14; Van der Veen, 2011; Van der Veen & Morales, 2015). Archaeologically, peppercorns and rice are rare, supporting theories that they were 'luxury' or 'high status' food items. Their remains are usually found associated with military camps or towns, particularly along the European *Limes* (e.g. Livarda & Van der Veen, 2008; Livarda, 2011; Zach, 2002, pp. 104–5). The contexts range from city sewers to military hospitals and sacrificial pits, highlighting the wide range of uses that even exotic foods such as these would have had in Roman life.

Patterns of material culture in temperate Europe also shows a flow of Mediterranean goods, such as Italian and Spanish amphora, from the Iron Age and many debate the degree to which later long-distance trade from the Mediterranean was generated by civil demand as opposed to the needs of the army (e.g. Fulford, 1992; Livarda, 2011). As with rice and black pepper, other exotics are recovered from a wide range of different sites from military to urban and rustic civilian settlements through time (Livarda & Van der Veen, 2008; Livarda, 2011; Cool, 2006, p. 160; Gyulai, 2010, p. 158). In Britain, Orengo & Livarda (2016) suggest that food imports may have been state controlled in the early periods, with a strong military influence, but that the distribution of exotics beyond the areas of military activity suggest a parallel market economy of private entrepreneurs. They also showed, unsurprisingly, a strong correlation between amphora and navigable rivers, although they highlight that they would have had to make use of the road network to reach their final destination.

In southern Pannonia we are unlikely to see many 'elites', but rather a 'middle class' society made up of several military veterans that have settled in the region (Reed & Leleković, 2019). What makes a food a luxury will depend on both individual and societal views, where a given item becomes an object desired by many but only obtained by a few (Van der Veen, 2003). Marzano (2018) recently discussed the social status of fresh and salted fish in Roman Italy and suggested that the consumption of certain types of fresh fish signified status. In southern Pannonia the limited archaeobotanical evidence makes any conclusions difficult, however, the concentration of exotic plants and imported amphora within the larger towns would suggest that they had good access to imports from across the empire and that they were desired by those living in the region.

3.2 Roman Gastronomy

For as long as there has been food, there has been some form gastronomy. Gastronomy has numerous definitions, but simply put it is all about the relationship between humans, food and the world we live in. Pottery vessels cannot generally tell us what recipes were common within a society, how they were prepared and any social and cultural meanings that they carried. Yet the types of food consumed will have a direct effect on the form and type of cooking vessels used and if there were any substantial changes in the former, they should, somehow, be reflected in the latter (Arthur, 2007). Consumption also doesn't just mean eating as food can be consumed through all the senses – touch, sight, smell and sound (Sykes, 2010).

Residue analysis is beginning to uncover what some of these vessels may have contained (e.g. Cramp & Evershed, 2015; Marshall et al., 2008). For example, Dressel 1 amphora recorded from Mallorca (Ontiveros,Farreras, & Pecci, 2018) and Dressel 2–4 amphora at Villa B at Oplontis, Italy showed markers for containing wine (Pecci et al., 2017). These studies support interpretations of amphora of wine being transported into southern Pannonia. In addition, organic residue analysis is uncovering the waterproofing treatments of vessels, in order to reduce the porosity of ceramic materials and to help in long distance transportation (e.g. Fujii et al., 2019; Font et al., 2007). For example, pine pitch was identified within amphora recovered from Silchester, UK (Marshall et al., 2008), within a Beltran II A (Dressel 38) amphora found at the Roman colony Castrum Novum, Italy, (Preusz et al., 2019), and from a Dressel 1 amphora from Briatico Punta Safò, Italy (Izzo et al., 2013). From these studies we may infer that pine resin, or some other wood sap, could have been used in southern Pannonia to waterproof pottery for storage and/or transportation of food and drink items.

In southern Pannonia the absence of similar chemical analyses means we must look at ceramics as proxies of possible consumption. In table 4 we have plotted the types of vessels recovered from southern Pannonia with types of dishes that have been recorded by ancient authors. Antique sources offer us many details about how to prepare certain types of food, however, it is important to be aware that these texts were written largely about Italian or Rome's cuisine within a high status social group. Whether these dishes were cooked in their entirety or adapted in southern Pannonia is open to debate, especially as many of the ancient texts on Pannonia discuss mainly the 'barbarian' cuisine of the Pannonians in the early days of empire (Strabo VII, 317, Ammian Marcelin 26.8.2, Dion Cassius 49.36, St. Jerome, Comm. 7 and Isaiam c.19). Yet, with the introduction, or increased availability, of new foods and flavours, diverse culinary experiences would have become possible in the region (Livarda, 2017).

Cooking pots had to withstand considerable pressures of repeated heating and cooling and so its unsurprising that certain production centres during the Roman period gained reputations for producing quality items, reflecting the engagement of people with material properties and performance within wider social contexts of availability (Whitbread, 2015, p. 34). As discussed above many of the deep bowls were suited to long periods of cooking, in the case of stews or to soften meat. The more open vessels would have allowed greater fluid evaporation, resulting in dry or thick dishes. Such dishes are regularly noted in ancient sources and the form of these vessels would support this type of cooking, regardless of the exact recipes cooked.

Red slipware vessels with a flat bottom and curving walls of the recipient, either convex or concave, are thought to be connected to baking bread and a few other dish types. The form originates from the Pompeiian plates but are one of the most common form of vessels in Pannonian and Moesian from the 1st–4th c. AD (Brukner, 1981, pp. 85–86, Ožanić Roguljić, 2016, pp. 49–51). The dish *patina*, which has an entire chapter dedicated to it by Apicius, was named after these plates (Apicius, IV–II, pp. 128–143). Patina can be prepared by combining various ingredients – chopped meat, fish, entrails, fruit and vegetables. Eggs are present as an ingredient in most of these recipes, and it could be either a sweet or a savoury dish, very much like soufflé, and could be baked in a beehive oven or on an open hearth. The dominance of these plates on most sites indicates that they were multi-functional and practical, so they could be used both for serving food and for its consumption. This dish is one of the few where ancient sources and ethnology describe a certain procedure in almost identical ways (Dalby, 2003, p. 101).

Interestingly, Apicius dedicated a whole chapter to cooking legumes (Apices, V), which highlights their importance as a staple in the Roman world. In the instructions for preparing beans there is often an instruction to cook in either a clean or a new pot, which may indicate that the beans could be sensitive to cooking and could burn quickly. Bread would have also been a staple and various types of bread were baked, including white bread (*panis mundus*) and whole grain bread (*autopyrus*), with or without yeast. The bread was usually named after the preparation method, the form and the baking method (*panis depsiticus*), the origin of the flour or the food with which it was consumed (Cool, 2006, p. 75; Dalby, 2003, pp. 58–61). Other ingredients were added to the bread such as cheese (*libum*), pepper or fat (Pliny NH, XXII, 138; Cato, pp. 74–75; Cool, 2006, p. 75; Dalby, 2003, pp. 58–61). Unfortunately, no evidence of bread exists in southern Pannonia, but its presence may be inferred from the large quantities of grain recovered, along with vessels and baking lids suitable to bake bread.

Table 4: Interpretation of foods that could be cooked in different vessels, based on Cato *De agrigurlutra*, Plinius *Naturalis Historia*, Apicius *De re coquinaria* and experimental archaeology.

Type of vessel	Types of foods that could be cooked	Siscia	Mursa	Cibalae
Patina	Patina – a dish	•	•	•
Peka Sub testu/baking lid	Mainly bread, but also meat			•
Hemispherical bowls: Table ware/for serving	pulse, tisana, conchila	•	•	•
Hemispherical bowls: Coarse ware/for cooking	pulse, tisana, conchila, chicken, goat, mutton or lamb	•	•	•
Tripod pottery vessel	pulse, tisana, conchila, chicken, goat, mutton or lamb			•

4 Conclusions

The Roman food system was a complex interaction of different actors and activities. This makes examining such ancient systems difficult and highlights the importance of examining food in the past in a more holistic way using as much of the archaeological evidence as possible. This was our intention here, to examine current evidence from a range of sources and examine what this may tell us about the development of production and consumption in southern Pannonia from the 1st to 4th century A.D. From the pottery evidence we see extensive trade links across the empire from as early as the 1st century A.D. allowing food items from Spain, Italy and even possibly North Africa to be transported to southern Pannonia. The range of pottery types discovered in southern Pannonia indicate the type of foods that may have been consumed in the region, including dried fruits, garum and olive oil. These links are seen further with the trade of Pannonian Slipped Ware to northern Italy and Dalmatia in the 2nd century. Unfortunately, short-distance trade is harder to track, yet local trade and exchange between towns and villages would have been extremely important. The increasing number of rural sites identified in southern Pannonia can only help with this. Different pottery production zones suggest that vessels used for cooking, storage and serving were an important element of food. Shifts in tastes and fashions, as well as stylistic influences from around the empire can be seen in the pottery styles that emerge in southern Pannonia.

The picture so far in southern Pannonia shows similarities in crop production to others regions of the Roman Empire, although this is based on very small archaeobotanical and zooarchaeological evidence, as well as having access to a wide range of imported foodstuff. The limited data prevents any assumptions regarding regional patterns of agricultural production or changes through time. Yet, the fertility of both the land and rivers in the region would have also played an important role in enabling a wide variety of locally produced food to be available with minimal transport costs. Evidence from human dental remains has also started to reveal potential differences in consumption between genders, with women eating softer foods.

The influx of new foods, people and ideas in the 2nd century A.D. would have had a significant effect on southern Pannonian culture provoking a change in world-view, diet and cuisine. Evidence of such a wide variety of foods on the Danubian frontier, including 'exotics' such as rice and black pepper, also challenges long held beliefs that only 'elites' would have had access to such a diverse range of imports and emphasises how integrated the region was within the wider food system. Imports may also be closely connected with the military stationed along the Danube, as well as with veterans that settled in towns such as *Mursa*. The movement of goods linked to the military is unclear at present yet, from other regions of the empire it is clear that the army were supplied with a range of imported goods, both sanctioned and unsanctioned. How the local towns and military food networks link is also uncertain, but there was probably a degree of overlap that allowed citizens to access certain goods and vice versa. As health is linked with diet, we may assume that the similarities in the quality of life between inhabitants of fortified settlements on the Danubian *Limes* and those in the large urban settlements, including *Mursa* and *Cibalae*, suggest similarities in diet. More research is clearly needed to explore production and consumption in southern Pannonia, the relationship of the rural, urban and military populations and how these changes shaped local identities.

Acknowledgements: The article results from the project LIFE ON ROMAN ROAD: communications, trade and identities on Roman roads in Croatia from 1st–8th CE, supported by the Croatian Science Foundation.

This article would not have been possible if not for the exceptional help from many colleagues including Kristina Jelincic Vuckovic, Renata Sostaric, Sinisa Radovcic, Aleksandar Bugar, Dora Kušan Špalj, Anita Rapan Papeša and Ivan Radman Livaja who allowed us access to some of the data detailed here.

References

Aguilera, M., Zech-Matterne, V., Lepetz, S., & Balasse, M. (2017). Crop fertility conditions in North-Eastern Gaul during the La Tène and Roman periods: A combined stable isotope analysis of archaeobotanical and archaeozoological remains. *Environmental Archaeology, 23*(4), 323–337. https://doi.org/10.1080/14614103.2017.1291563

Allen, M. & Lodwick, L. (2017). Agricultural strategies in Roman Britain. In M.G. Allen, L. Lodwick, T. Brindle, M. Fulford, & A. Smith, (Eds.), *The Rural Economy of Roman Britain* (pp. 142–177). Britannia Monograph 30. London: Society for the Promotion of Roman Studies.

Allen, M. G., Lodwick, L., Brindle, T., Fulford, M., & Smith, A. (Eds.). (2017). *The Rural Economy of Roman Britain*. Britannia Monograph 30. London: Society for the Promotion of Roman Studies.

Arthur, P. (2007). Form, function and technology in pottery production from Late Antiquity to the Early Middle Ages. In L. Lavan, E. Zanini, & A. Sarantis (Eds.), *Technology in Transition: A.D. 300–650*. Late Antique Archaeology 4 (pp. 159–86). Leiden: Brill.

Bakels, C. & Jacomet, S. (2003). Access to luxury foods in central Europe during the Roman period: The archaeobotanical evidence. *World Archaeology, 34*(3), 542–557. https://doi.org/10.1080/0043824021000026503

Balassa, I. (1969). The Agricultural Museum, Budapest. *Museum International, 22*(1), 44–55. https://doi.org/10.1111/j.1468-0033.1969.tb01726.x

Bezeczky, T. (1996). Notes – amphorae inscription – legionary supply. *Britannia, 27*, 329–336. https://doi.org/10.2307/527048

Bintliff, J. (2000). *Settlement and Territory: a Socio-Ecological Approach to the Evolution of Settlement Systems*. Oxford: Oxbow books.

Bintliff, J. (2002). Going to market in antiquity. In E, Olshausen & H, Sonnabend (Eds.), *Stuttgarter Kolloquium zur historischen Geographie des Altertums* (vol. VII, Zu Wasser und zu Land: Verkehrswege in der Antiken Welt, pp 209–250). Stuttgart: Franz Steiner.

Bjelajac, L. J. (1996). *Amfore Gornjo Mezijskog Podunavlja*. Beograd: Archaeological Institute.

Boatwright, M. T. (2002). *Hadrian and the Cities of the Roman Empire*. Princeton: Princeton University Press.

Bogaard, A., Heaton, T. H. E., Poulton, P., & Merbach, I. (2007). The impact of manuring on nitrogen isotope ratios in cereals: Archaeological implications for reconstruction of diet and crop management practices. *Journal of Archaeological Science, 34*(3), 335–343. https://doi.org/10.1016/j.jas.2006.04.009

Bödőcs, A., Kovács, G., & Anderkó, K. (2014). The impact of the roman agriculture on the territory of Savaria. *Dissertationes Archaelogicae, 3*(2), 321–332.

Botte, E., Piquès, G., & Djaoui, D. (2014). Nouvelles données sur les pots dits "à garum" du Latium, d'après les découvertes subaquatiques du Rhône. In D. Djaoui & V. Leitch (Eds.) *Fish and Ships. Production et commerce des salsamenta durant l'Antiquité* (coll. BIAMA 17, pp. 175–197). Aix-en-Provence: France.

Bowman, A. K. & Wilson, A. I. (2009). *Quantifying the Roman Economy: Methods and Problems*. Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199562596.001.0001

Bowman, A. K. & Wilson, A. I. (2011). *Settlement, Urbanization, and Population*. Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199602353.001.0001

Bowman, A. K. & Wilson, A. I. (2013). *The Roman Agricultural Economy: Organization, Investment, and Production*. Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199665723.001.0001

Breeze, D. J. (2000). Supplying the army. In G. Alföldy, B. Dobson, & W. Eck (Eds.), *Kaiser, Heer, und Gesellschaft in der Römischen Kaiserzeit* (pp. 59–64). Stuttgart: Verlag.

Brukner, O. (1981). *Rimska keramika u jugoslovenskom delu provincije Donje Panonije*. Beograd: L'Association des Archéologiques de Yougoslavie.

Brunšmid, J. (1907). Kameni spomenici hrvatskoga narodnoga muzeja u Zagrebu. *Vjesnik Arheološkog muzeja u Zagrebu*, 9 (pp. 82–184). Zagreb.

Bulat, M. (1969). Topografska istraživanja limesa u Slavoniji i Baranji. *Osječki zbornik, 12*, 39–52.

Bulat, M. (2002). Tragovi antičkog vinogradarstva i vinarstva u Slavoniji. *Osječki zbornik*, *26*, pp. 45–52.

Campbell, D. B. (2013). *The Rise of Imperial Rome AD 14–193*. Oxford: Osprey Publishing.

Cappers, R. T. J. (2006). *Roman foodprints at Berenike, Archaeobotanical evidence of subsistence and trade in the Eastern Desert of Egypt*. Los Angeles: University of California. https://doi.org/10.2307/j.ctvdjrqwh

Carreras, C. & De Soto, P. (2013). The Roman transport network: A precedent for the integration of the European mobility. *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, *46*(3), 117–133. https://doi.org/10.1080/01615440.2013.803403

Casarotto, A., Pelgrom, J., & Stek, T. D. (2016). Testing settlement models in the early Roman colonial landscapes of Venusia (291 B.C.), Cosa (273 B.C.) and Aesernia (263 B.C.). *Journal of Field Archaeology, 41*(5), 568–586. https://doi.org/10.1080/00934690.2016.1211474

Christaller, W. (1933). *Die Zentralen Orte in Süddeutschland*. Jena: Gustav Fischer Verlag. English translation: The Central Places of Southern Germany. Englewood Cliffs (N.J.): Prentice-Hall (1966).

Cool, H. E. M. (2006). *Eating and Drinking in Roman Britian*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511489570

Cramp, L. J. E., & Evershed, R. P. (2015). Reading the residues: the use of chromatographic and mass spectrometric techniques for reconstructing the role of kitchen and other domestic vessels in Roman antiquity. In M. Spataro & A. Villing (Eds.), *Ceramics, Cuisine and Culture: The Archaeology and Science of Kitchen Pottery in the Ancient Mediterranean World* (pp. 125–140). Oxford: Oxbow.

Crane, E. (1983). *The archaeology of beekeeping*. London: Duckworth.

Cvjetičanin, T. (2003). Basic attributes of the late Roman glazed pottery from central and southern Serbia. In *Rümanisch Jugoslawische Kommission für die Erforschung der Region des Eisernen Tores, zwischen 275-602 n.* Chr, Kolloquium in Drobeta Turnu Severin 2001, Archäologische Abteilung V, (pp. 93–108). Bucuresti: Rümanisches Institut für Thrakologie.

Cvjetičanin, T. (2006). *Late Roman Glazed Pottery: Glazed Pottery from Moesia Prima, Dacia Ripensis, Dacia Mediterranea And Dardania.* Belgrade: National Museum

Dalby, A. (2003). *Food in Ancient World from A-Z*. London: Routledge.

Dalnoki, O. (2009). Collected or cultivated? Exotic and indigenous fruit remains from Celtic to Roman times in Pest County. In J.-P. Morel & A. M. Mercuri (Eds.), *Plants and Culture: seeds of the cultural heritage of Europe* (pp. 145–152). Bari: Edipulgia.

Davies, R. (1971). The Roman military diet. *Britannia, 2*, 122–142. https://doi.org/10.2307/525803

De Neeve, P. W. (1984). *Peasants in Peril: Location and Economy in Italy in the Second Century B.C*. Amsterdam: J.C. Gieben.

Demicheli, D., Radman Livaja, I., & Wiewegh, Z. (2012). List of personal names on a ceramic bowl fragment from Siscia. In M. Fuchs, R, Sylvestre, & C, Schmidt Heidenreich (Eds.), *Actes du Colloque Ductus; "Inscriptions mineurs: nouveautes et reflexions"* (pp. 185–192). Bern: Peter Lang.

Djaoui, D. & Capelli, C. (2017). Objets d'importation ou objets personnels? La dotation de bord des marins au regard du grand commerce, l'exemple du dépotoir portuaire d'Arles-Rhône 3. SFECAG, *Actes du Congrès de Narbonne*, 115–132.

Dobreva, D. & Mantovani, V. (2017). Ceramiche fini di produzione dalmata, pannonica e retica e di Treviri ad Aquileia. Zbornik III. međunarodnog arheološkog kolokvija. In G. Lipovac Vrkljan, B. Šiljeg, I., & Ožanić Roguljić, A. Konestra (Eds.), Rimske keramičarske i staklarske radionice. Proizvodnja i trgovina na jadranskom prostoru. 4. - 5. studenoga 2014 (pp. 225–252). Zagreb Crikvenica: Institut za arheologiju.

Donahue, J. F. (2015). Roman dining. In J. Wilkins & R. Nadeau (Eds.), *A Companion to Food in the Ancient World* (pp. 253–264). Oxford: Wiley-Blackwell. https://doi.org/10.1002/9781118878255.ch24

Duncan-Jones, R. (2006). Roman Customs Dues: A Comparative View. *Latomus, 65*(1), 3–16. Retrieved from http://www.jstor.org/stable/41543974

Erdkamp, P. (1999). Agriculture, underemployment, and the cost of rural labour in the Roman world. *Classical Quarterly, 49*(2), 556–572. https://doi.org/10.1093/cq/49.2.556

Erdkamp, P. (2001). Beyond the Limits of the 'Consumer City'. A Model of the Urban and Rural Economy in the Roman World. *Historia-Zeitschrift Fur Alte Geschichte, 50*(3), 332–356.

Erdkamp, P. (2005). *The grain market in the Roman Empire. A social, political and economic study*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511482755

Erdkamp, P. (2016). Seasonal labour and rural-urban migration in Roman Italy. In L. De Ligt & L. Tacoma (Eds.), *Migration and Mobility in the Early Roman Empire* (pp. 57–74). Leiden: Brill. https://doi.org/10.1163/9789004307377_004

Erdkamp, P., Verboven, K., & Zuiderhoek, A. (Eds.). (2015). *Ownership and Exploitation of Land and Natural Resources in the Roman World*. Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198728924.001.0001

Figueiral, I., Pomarèdes, H., Court-Picon, M., Bouby, L., Tardy, C., & Terral, J.-F. (2015). New insights into Mediterranean Gallo-Roman farming: A closer look at archaeological wells in Southern France. *Archaeological and Anthropological Sciences, 7*(2), 201–233. https://doi.org/10.1007/s12520-014-0181-8

Font, J., Salvadó, N., Butí, S., & Enrich, J. (2007). Fourier transform infrared spectroscopy as a suitable technique in the study of the materials used in waterproofing of archaeological amphorae. *Analytica Chimica Acta, 598*(1), 119–127. https://doi.org/10.1016/j.aca.2007.07.021

Forshaw, R. (2014). Dental indicators of ancient dietary patterns: dental analysis in archaeology. *British Dental Journal, 216*(9), 529–535. https://doi.org/10.1038/sj.bdj.2014.353

Fujii, H., Mazzitelli, J.-B., Adilbekov, D., Olmer, F., Mathea, C., & Vieillescazes, C. (2019). FT-IR and GC–MS analyses of Dressel IA amphorae from the Grand Congloué 2 wreck. *Journal of Archaeological Science: Reports, 28*. https://doi.org/10.1016/j.jasrep.2019.102007

Fulford, M. (1992). Territorial expansion and the Roman Empire. *World Archaeology, 23*(3), 294–305. https://doi.org/10.1080/00438243.1992.9980181

Glicksman, K. (2007). Olive and wine cultivation in the Roman province of Dalmatia. *Histria Antiqua, 15*, 43–50.

Goodchild, H. (2007). *Modelling Roman Agricultural Production in the Middle Tiber Valley, Central Italy* (PhD thesis). Birmingham: University of Birmingham.

Grant, M. (2015). *Roman Cookery: Ancient Recipes for Modern Kitchens* (3rd ed.). London: Serif.

Gyulai, F. (2010). *Archaeobotany in Hungary: Seed, Fruit and Beverage Remains in the Carpathian Basin from the Neolithic to the Late Middle Ages*. Budapest: Archaeolingua 21.

Hincak, Z., Mihelić, D., & Bugar, A. (2007). Cremated human and animal remains of the roman period – microscopic method of analysis (Šepkovčica, Croatia). *Collegium Antropologicum, 31*(4), 1127–1134.

Hitchner, R. B. (2012). Roads, integration, connectivity, and economic performance in the Roman Empire. In S. E. Alcock, J. Bodel, & R. J. A. Talbert (Eds.), *Highways, Byways, and Road Systems in the Pre-Modern World* (pp. 222–234). Oxford: Wiley-Blackwell. https://doi.org/10.1002/9781118244326.ch11

Hollander, D. B. (2019). *Farmers and Agriculture in the Roman Economy*. London: Routledge.

Horden, P. & Purcell, N. (2000). *The Corrupting Sea: A Study of Mediterranean History*. Oxford: Blackwell.

Iskra Janošić, I. (2001). *Urbanizacija Cibala i Razvoj Keramičarskih Središta*. Vinkovci: Hrvatska akademija znanosti i umjetnosti, Centar za znanstveni rad u Vinkovcima.

Izzo, F. C., Zendri, E., Bernardi, A., Balliana, E., & Sgobbi, M. (2013). The study of pitch via gas chromatography-mass spectrometry and Fourier-transformed infrared spectroscopy: The case of the Roman amphoras from Monte Poro, Calabria (Italy). *Journal of Archaeological Science, 40*(1), 595–600. https://doi.org/10.1016/j.jas.2012.06.017

Jadrić, I. (2007). Primjeri za trgovinu vinom i maslinovim uljem u rimskoj provinciji Dalmaciji. *Histria antiqua: časopis Međunarodnog istraživačkog centra za arheologijuqua*, 15, 353–361.

Jashemski, W. F. (2017). Produce gardens. In W. E. Jashemski, K. L. Gleason, K. J. Hartswick, & A.-A. Malek (Eds.), *Gardens of the Roman Empire* (pp. 121–151). Cambridge: Cambridge University Press. https://doi.org/10.1017/9781139033022.005

Jelinčić Vučković, K. (2015). *Rimsko selo u provinciji Gornjoj Panoniji: Virovitica Kiškorija Jug*. Zagreb: Institute of archaeology

Jelinčić, K. (2003). Rimska keramika iz Iloka. *Prilozi Instituta za arheologiju u Zagrebu* 20, 79–88.

Jones, G. (1991). Numerical analysis in archaeobotany. In W. van Zeist, K. Wasylikowa, & K.-E. Behre (Eds.), *Progress in Old World Palaeoethnobotany* (pp. 63–80). Rotterdam: A.A. Balkema.

Kelemen, M. H. (1990). *Roman Amphorae in Pannonia III. Acta archaeologica Academiae Scientiarum Hungaricae*, 147–193.

Killgrove, K., & Tykot, R. H. (2013). Food for Rome: A stable isotope investigation of diet in the Imperial period (1st–3rd centuries AD). *Journal of Anthropological Archaeology, 32*(1), 28–38. https://doi.org/10.1016/j.jaa.2012.08.002

Kovács, P. (2014). *A History of Pannonia during the Principate*. Bonn: Rudolf Habelt.

Landry, C. & Moulin, B. (2016). When GIS goes to the countryside: detecting and interpreting Roman orchards from the 'Grand Palais' (Drôme, France). In S. Campana, R. Scopigno, G. Carpentiero, & M. Cirillo (Eds.), CAA 2015, Keep the Revolution Going. *Proceedings of the 43rd Annual Conference on Computer* (pp. 499–515). Oxford: Archaeopress.

Leleković, T. (2004). Crustulum iz Vinkovaca. *Arheološki radovi i rasprave, 14*, 103–119

Leleković, T. (2018). How were imitations of samian formed? *Internet Archaeology, 50*. https://doi.org/10.11141/ia.50.18

Leleković, T. & Rendić-Miočević, A. (2012). Rural settlements. In M. Branka (Ed.), *The Archaeology of Roman Southern Pannonia* (pp. 279–311). Oxford: Archaeopress.

Lepetz, S. & Zech-Matterne, V. (2018). *Agro-Pastoral Systems during the Late Iron Age and Roman Period in Northern Gaul*. France: CNRS.

Lightfoot, E., Slaus, M., & O'Connell, T. C. (2014). Water consumption in Iron Age, Roman and Early Medieval Croatia. *American Journal of Physical Anthropology, 154*(4), 535–543. https://doi.org/10.1002/ajpa.22544

Livarda, A. (2011). Spicing up life in northwestern Europe: Exotic food plant imports in the Roman and medieval world. *Vegetation History and Archaeobotany, 20*(2), 143–164. https://doi.org/10.1007/s00334-010-0273-z

Livarda, A. (2017). Tastes in the Roman provinces: an archaeobotanical approach to sociocultural change. In K. C. Rudolph (Ed.), *Taste and the Ancient Senses* (pp. 179–196). London: Routledge. https://doi.org/10.4324/9781315719245-11

Livarda, A. & Van der Veen, M. (2008). Social access and dispersal of condiments in North-West Europe from the Roman to the medieval period. *Vegetation History and Archaeobotany, 17*, 201–209. https://doi.org/10.1007/s00334-008-0168-4

Lodwick, L. (2017). Arable farming, plant foods and resources. In M.G. Allen, L. Lodwick, T. Brindle, M. Fulford & A. Smith (Eds.), *The Rural Economy of Roman Britain* (pp. 11–84). Britannia Monograph 30. London: Society for the Promotion of Roman Studies.

Lolić, T. & Wiewegh, Z. (2012). Urbanism and architecture. In M. Branka (Ed.), *The Archaeology of Roman Southern Pannonia* (pp. 191–224). Oxford: Archaeopress.

Lowe, D. (2010). The symbolic value of grafting in ancient Rome. *Transactions and Proceedings of the American Philological Association*, *140*(1), 461–488.

Lukić, K. & Filipec, K. (2019). Antique and Late Antique fibulae, decorative items and certain accompanying finds from Verušed. *Vjesnik Arheološkog muzeja u Zagrebu, 52*(1), 83–111.

MacKinnon, M. (2010). Cattle 'breed' variation and improvement in Roman Italy: connecting the zooarchaeological and ancient textual evidence. *World Archaeology, 42*(1), 55–73. https://doi.org/10.1080/00438240903429730

MacMullen, R. (1987). Late Roman slavery. *Historia-Zeitschrift Fur Alte Geschichte, 36*(3), 359–382.
Madgwick, R., Lewis, J., Grimes, V., & Guest, P. (2019). On the hoof: exploring the supply of animals to the Roman legionary fortress at Caerleon using strontium (87Sr/86Sr) isotope analysis. *Archaeological and Anthropological Sciences, 11*(1), 223–235. https://doi.org/10.1007/s12520-017-0539-9
Maltby, M. (2016). The exploitation of animals in Roman Britain. In M. Millett, L. Revell, & A. Moore (Eds.), *The Oxford Handbook of Roman Britain* (pp. 791–806). Oxford: Oxford University Press.
Mandich, M. J. (2015). Re-defining the Roman '*suburbium*' from Republic to Empire: A Theoretical Approach. *Theoretical Roman Archaeology Journal, 2014*, 81–99. https://doi.org/10.16995/TRAC2014_81_99
Marshall, L., Cook, S., Almond, M., & Fulford, M. (2008). Roman Diet and Trade: Evidence from Organic Residues on Pottery Sherds Recovered at the Roman Town of Calleva Atrebatum (Silchester, Hants.). *Britannia, 39*, 245–253. https://doi.org/10.3815/006811308785917187
Marzano, A. (2018). Fish and fishing in the Roman world. *Journal of Maritime Archaeology, 13*(3), 437–447. https://doi.org/10.1007/s11457-018-9195-1
Mattingly, D. (1996). First fruit? The olive in the Roman world. In G. Shipley & J. Salmon (Eds.), *Human landscapes in classical antiquity: Environment and culture* (pp. 213–253). London: Routledge.
Migotti, B. (2000). Prilog poznavanju putova trgovine između Dalmacije I Panonije. *Opuscula archaeologica*, 23-24, 195-202.
Migotti, B. (Ed.). (2012). *The Archaeology of Roman Southern Pannonia, The state of research and selected problems in the Croatian part of the Roman province of Pannonia*. Oxford: BAR.
Miletić Čakširan, I. (2019). *Tipološko-kronološka Klasifikacija Rimske Keramike iz Siscije* (PhD Thesis). Zagreb: University of Zagreb.
Mócsy, A. (1974). *Pannonia and Upper Moesia. A History of the Middle Danube Provinces of the Roman Empire*. London, Boston: Routledge.
Morley, N. (1996). *Metropolis and Hinterland: the City of Rome and the Italian Economy, 200 B.C.-A.D. 200*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511518584
Mouritsen, O. G., Duelund, L., Calleja, G., & Frøst, M. B. (2017). Flavour of fermented fish, insect, game, and pea sauces: Garum revisited. *International Journal of Gastronomy and Food Science, 9*, 16–28. https://doi.org/10.1016/j.ijgfs.2017.05.002
Murphy, C., Thompson, G., & Fuller, D. Q. (2013). Roman food refuse: urban archaeobotany in Pompeii, Regio VI, Insula 1. *Vegetation History and Archaeobotany, 22*(5), 409–419. https://doi.org/10.1007/s00334-012-0385-8
O'Connell, S. (2018). Visual evidence: picturing food and food culture in roman art. In C. Holleran & P. Erdkamp (Eds.), *The Routledge Handbook of Diet and Nutrition in the Roman World* (pp. 26–35). Abingdon: Routledge. https://doi.org/10.4324/9781351107334-3
Oliva, P. (1962). *Pannonia and the Onset of Crisis in the Roman Empire*. Prague: I Urwin.
Ontiveros, M. Á., Farreras, V., & Pecci, A. (2018). archaeometric analysis for provenance and content of roman amphorae from the site of sa mesquida (Mallorca, Spain). *Mediterranean Archaeology and Archaeometry, 18*(2), 87–105.
Orengo, H. A., & Livarda, A. (2016). The seeds of commerce: A network analysis-based approach to the Romano-British transport system. *Journal of Archaeological Science, 66*, 21–35. https://doi.org/10.1016/j.jas.2015.12.003
Ožanić Roguljić, I., Rapan Papeša, A., Raičković Savić, A., Mantovani, V., . . . Šiljeg, B. (2019). Aktivnosti i rezultati uspostavnog istraživačkog projekta Život na rimskoj cesti (LRR) (HRZZ, UIP-05-2017-9768) u 2018. godini. *Annales Instituti Archaeologici, 15*, 37–40.
Ožanić Roguljić, I. & Konestra, A. (2017). Pannonian slipped ware in Dalmatia. In G. Lipovac Vrkljan, B. Šiljeg, I. Ožanić Roguljić, & A. Konestra (Eds.), *Rimske keramičarske i staklarske radionice* (pp. 453–460). Zagreb: Institut za arheologiju.
Ožanić Roguljić, I. & Raičković Savić, A. (in press). Sub testu – preparation of Roman food under a clay dome. *VAMZ* 3. serija /53 (2020).
Ožanić Roguljić, I. (2010). De caseo faciendo. *Prilozi Instituta za arheologiju u Zagrebu, 27*, 171–176
Ožanić Roguljić, I. (2016). *Tipologija rimske keramike iz Vinkovaca.* Monographiae Instituti archaeologici 10. Zagreb: Institut za arheologiju
Ožanić Roguljić, I. (2017). Amophoras from Žuta Lokva. In G. Lipovac Vrkljan, I. Radić Rossi & A. Konestra (Eds.), *Amfore kao izvor za rekonstrukciju gospodarskoga razvoja jadranskeregije u antici: lokalna proizvodnja* (pp. 80–85). Zagreb: Institut za arheologiju.
Ožanić, I. (2004). Dvije rimske posude s rešetkom. *Opuscula Archaeologica, 28*, 177–186
Paro, A., Novaković, O., & Radman Livaja, I. (2018). Amphorae from the position of Sisak - Railway station with special reference to a Dressel 8 type amphora with an inscription. In I. Drnić (Ed.), *Segestica and Siscia - From the Periphery of the Empire to a Provincial Center* (pp. 223–293). Zagreb: Archaeological museum in Zagreb.
Patterson, J. R. (2004). City, territory and metropolis: the case of the Tiber valley. In H. Patterson (Ed.), *Bridging the Tiber: approaches to regional archaeology in the Middle Tiber Valley* (pp. 61–73). London: British School at Rome.
Peacock, D. P. S. & Williams, D. F. (1986). *Amphorae and the Roman economy*. London: Longman.
Pecci, A. & D'Andria, F. (2014). Oil production in Roman times: residue analysis of the floors of an installation in Lecce (southern Italy). *Journal of Archaeological Science, 46*, 363–371. https://doi.org/10.1016/j.jas.2014.03.019

Pecci, A., Cau, M. A., & Garnier, N. (2013). Identifying wine and oil production: Analysis of residues from Roman and Late Antique plastered vats. *Journal of Archaeological Science, 40*(12), 4491–4498. https://doi.org/10.1016/j.jas.2013.06.019

Pecci, A., Clarke, J., Thomas, M., Muslin, J., van der Graaff, I., Toniolo, L., Di Pasquale, G. (2017). Use and reuse of amphorae. Wine residues in Dressel 2–4 amphorae from Oplontis Villa B (Torre Annunziata, Italy). *Journal of Archaeological Science: Reports, 12*, 515–521. https://doi.org/10.1016/j.jasrep.2017.02.025

Pelling, R., Campbell, G., Carruthers, W., Hunter, K., & Marshall, P. (2015). Exploring contamination (intrusion and residuality) in the archaeobotanical record: case studies from central and southern England. *Vegetation History and Archaeobotany, 24*(1), 85–99. https://doi.org/10.1007/s00334-014-0493-8

Perko, V. (2000). Amfore v Sloveniji. *Annales, Series historia et sociologia,* 10 (2), 421-455.

Pinterović, D. (1978). *Mursa i njeno područje u antičko doba*. Osijek.

Preusz, M., Tříska, J., Vrchotová, N., Vilímek, J., Enei, F., & Preusz, K. (2019). Chemical profile of organic residues from ancient amphoras found in Pyrgi and Castrum Novum, Tyrrhenian Sea (Italy). *Journal of Archaeological Science: Reports, 24*, 565–573. https://doi.org/10.1016/j.jasrep.2019.02.002

Radman-Livaja, I. & Domiter, B. (2018). Roman fishing implements from Sisicia - http://limes2018.org/themes-and-sessions/abstracts/session-10-going-wild-the-roles-of-wild-animals-in-life-and-death-on-the-frontier/ accessed 24/09/2019

Radman-Livaja, I. (2012). Rimski trnokop iz Siska s urezanim natpisom. *Vjesnik Arheološkog muzeja u Zagrebu*, 3.s, 45, 483–497.

Reed, K. (2016). Archaeobotany in Croatia: An overview. *Journal of the Archaeological Museum in Zagreb, 49*(1), 7–28.

Reed, K., & Drnić, I. (2016). Iron age diet at Sisak, Croatia: Archaeobotanical evidence of Foxtail Millet (*Setaria Italica* [L.] P. Beauv.). *Oxford Journal of Archaeology, 35*(4), 359–368. https://doi.org/10.1111/ojoa.12101

Reed, K., & Leleković, T. (2019). First evidence of rice (*Oryza* cf. *sativa* L.) and black pepper (*Piper nigrum*) in Roman Mursa, Croatia. *Archaeological and Anthropological Sciences, 11*(1), 271–278. https://doi.org/10.1007/s12520-017-0545-y

Reed, K., & Ryan, P. (2019). Lessons from the past and the future of food. *World Archaeology, 51*(1), 1–16. https://doi.org/10.1080/00438243.2019.1610492

Reed, K., & Leleković, T. (in press). Food, farming and trade on the Danube frontier: Plant remains from Roman Mursa (Osijek, Croatia). *Vegetation History and Archaeobotany.*

Reed, K., Lodwick, L., Leleković, T., & Vulić, H. (2019a). Exploring Roman ritual behaviours through plant remains from Pannonia Inferior. *Environmental Archaeology, 24*(1), 28–37. https://doi.org/10.1080/14614103.2018.1443601

Reed, K., Ožanić Roguljić, I., Radović, S., & Kolak, T. (2019b). Daily consumption in a rural Roman villa: Excavations at Lički Ribnik, Croatia. *IANSA, X*(1), 53–63. https://doi.org/10.24916/iansa.2019.1.4

Rickman, G. E. (1971). *Roman Granaries & Store Buildings*. Cambridge: Cambridge University Press.

Roller, M. (2017). *Dining Posture in Ancient Rome: Bodies, Values, and Status*. Princeton: Princeton University Press.

Rosenstein, N. (2008). Aristocrats and agriculture in the middle and late republic. *Journal of Roman Studies, 98*, 1–26. https://doi.org/10.3815/007543508786239238

Rossiter, J. (1981). Wine and oil processing at Roman farms in Italy. *Pheonix, 35*(4), 345–361. https://doi.org/10.2307/1087929

Scheidel, W., & von Reden, S. (Eds.). (2002). *The Ancient Economy*. Edinburgh: Edinburgh University Press.

Šlaus, M., Pećina Šlaus, N., & Brkić, H. (2004). Life stress on the Roman limes in continental Croatia. *Homo, 54*(3), 240–263. https://doi.org/10.1078/0018-442X-00072

Smith, A., Allen, M., Brindle, T., & Fulford, M. (2016). The Rural Settlement of Roman Britain. New Visions of the Countryside of Roman Britain: *Vol. 1. Britannia Monograph 29*. London: Roman Society Publications.

Šoštarić, R., Dizdar, M., Kušan, D., Hršak, V., & Mareković, S. (2006). Comparative analysis of plant finds from early Roman graves in Ilok (Cuccium) and Ščitarjevo (Andautonia), Croatia – a contribution to understanding burial rites in southern Pannonia. *Collegium Antropologicum, 30*, 429–436.

Šoštarić, R., Radović, S., Jelinčić Vučković, K., & Ožanić Roguljić, I. (2015). Diet at the Roman village of Virovitica Kiškorija, south Croatia. *Collegium Antropologicum, 39*, 829–842.

Šuljug, M., & Filipović, S. (2018). Pannonian production of thin-walled pottery from Mursa: Campus 2001–2015. *Rei Cretarae Romanae Favtorvm Acta, 45*, 653–657.

Swan, V.G. (2009). Ethnicity, conquest, and recruitment: two case studies from the northern military provinces, Portsmouth, R.I. *Journal of Roman Archaeology*, Supplementary series no. 72.

Sykes, N. (2010). Worldviews in transition: The impact of exotic plants and animals on Iron Age/Romano-British landscapes. *Landscapes, 10*(2), 19–36. https://doi.org/10.1179/lan.2010.10.2.19

Temin, P. (2012). *The Roman Market Economy*. Princeton: Princeton University Press.

Thapar, R. (1992). Black gold: South Asia and the roman maritime trade. *South Asia: Journal of South Asian Studies, 15*(2), 1–27. https://doi.org/10.1080/00856409208723165

Thomas, E. B. (1980). Villa settlements. In A. Lengyel & G. T. B. Radan (Eds.), *The archaeology of Roman Pannonia* (pp. 275–321). Budapest: The University Press of Kentucky, Akademiai Kiado.

Thurmond, D. L. (2006). *A Handbook of Food Processing in Classical Rome: For Her Bounty No Winter*. Leiden: Brill.

Tončinić, D. (2015). Der Limes in Kroatien. *Der Limes*. *Nachrichtenblatt der Deutschen Limeskommission, 9*(2), 28–33.

Van der Veen, M., & Morales, J. (2015). The Roman and Islamic spice trade: New archaeological evidence. *Journal of Ethnopharmacology, 167*(5), 54–63. https://doi.org/10.1016/j.jep.2014.09.036

Van der Veen, M. (2003). When is food a luxury? *World Archaeology, 34*(3), 405–427. https://doi.org/10.1080/0043824021000026422

Van der Veen, M. (2008). Food as embodied material culture: diversity and change in plant food consumption in Roman Britain. *Journal of Roman Archaeology, 21*, 83–109. https://doi.org/10.1017/S1047759400004396

Van der Veen, M. (2011). *Consumption, Trade and Innovation: Exploring the Botanical Remains from the Roman and Islamic Ports at Quseir al-Qadim, Egypt*. Frankfurt: Verlag.

Vehling, J. M. (1977). *Apicius: Cookery and Dining in Imperial Rome*. New York: Dover Publications.

Vidošević, I. (2003). Rimska keramika s lokaliteta Starčevićeve ulice 27 u Sisku. *Godišnjak, GMS, III-IV*, 11–74.

Vidrih Perko, V. (1999). A Survey of Recent Research on Roman Amphorae, Trade & Diet in the North Adriatic and its Hinterland. In M. De Maine, R. M Taylor (Eds.), *Life of the average Roman*, (pp. 1-21), Minesotta.

Vikić-Belančić, B. (1974). Prilog istraživanju antičkog naseobinskog kompleksa u Varaždinskim Toplicama. *VAMZ, 6-7*, 75–127.

Visy, Z. (2003). *The Ripa Pannonica in Hungary*. Budapest: Akadémiai Kiadó.

Vita-Finzi, C., Higgs, E. S., Sturdy, D., Harriss, J., Legge, A. J., & Tippett, H. (1970). Prehistoric economy in the Mount Carmel area of Palestine: Site catchment analysis. *Proceedings of the Prehistoric Society, 36*, 1–37. https://doi.org/10.1017/S0079497X00013074

von Thünen, J. H. (1826). *Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie*. Hamburg: Perthes. English translation by C. M. Wartenberg: von Thünen's Isolated State. Oxford: Pergammon Press (1966).

Vossen, I. & Groot, M. (2009). Barley and horses: surplus and demand in the civitas Batavorum. *Theoretical Roman Archaeology Journal* (2008), 85–100.

Weaverdyck, E. J. S. (2019). The Role of Forts in the Local Market System in the Lower Rhine: Towards a Method of Multiple Hypothesis Testing Through Comparative Modelling. In P. Verhagen, J. Joyce, & M. Groenhuijzen (Eds.), *Finding the Limits of the Limes* (pp. 165–190). Computational Social Sciences. Cham: Springer. https://doi.org/10.1007/978-3-030-04576-0_9

Weber, A. (1909). *Ueber den Standort der Industrien*. Tübingen: J. C. B. Mohr. English translation: The Theory of the Location of Industries, Chicago, Chicago University Press, (1929).

Whitbread, I. K. (2015). Materials choices in utilitarian pottery: kitchen wares in the Berbati Valley, Greece. In M. Spataro, & A. Villing (Eds.), *Ceramics, Cuisine and Culture: The archaeology and science of kitchen pottery in the ancient Mediterranean world* (Chapter 2). Oxford: Oxbow Books.

Wilkins, J., & Hill, S. (2006). *Food in the Ancient World*. Oxford: Blackwell Publishing.

Wilson, A. G. (2009). Approaches to quantifying Roman trade. In A. Bowman & A. G. Wilson (Eds.), *Quantifying the Roman economy: methods and problems* (pp. 213–249). Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199562596.003.0009

Witcher, R. (2006). Agrarian Spaces in Roman Italy: Society, Economy and Mediterranean Agriculture. *Arqueología especial, 26*, 341–359.

Witcher, R. (2008). The middle Tiber valley in the imperial period. In F. Coarelli & H. Patterson (Eds.), *Mercator Placidissimus: the Tiber valley in antiquity* (pp. 467–487). Rome: Edizioni Quasar.

Zach, B. (2002). Vegetable offerings on the Roman sacrificial site in Mainz, Germany – short report on the First Results. *Vegetation History and Archaeobotany, 11*, 101–106. https://doi.org/10.1007/s003340200011

Ziche, H. (2006). The 'Consumer City' once again revisited. *Analele Universitatii "Dunarea De Jos". Din Galati, 5*, 21–40.

Žižek, I. (2012). Petoviona – produkcijsko središće oljenk. In V. Vidrih-Perko, A. Nestorović, & I. Žižek (Eds.). *Ex oriente lux, Rimskodobna svetila in oljenke iz Slovenije* (pp. 84–92). Ljubljana: Filozofske fakultete Univerze v Ljubljani.