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AMS ^{14}C CHRONOLOGY AND CERAMIC SEQUENCES OF EARLY FARMERS IN THE EASTERN ADRIATIC

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ABSTRACT. The eastern Adriatic is a key area for understanding the mechanisms and effects of the spread of agriculture. This article presents an accelerator mass spectrometry (AMS) radiocarbon chronology for the introduction and subsequent development of farming villages on the eastern shore of the Adriatic (~6000–4700 cal BC) and evaluates this in comparison with the established pottery chronology based on stylistic data from Pokrovnik (Drniš) on the Dalmatian coast of Croatia. Models for the spread of agriculture rely heavily on changing pottery styles to define cultural groups and trace geographic relationships. Based on AMS ^{14}C dates presented here, Impressed Wares first appear in central Dalmatia by 6000 cal BC and persist until 5300 cal BC, well into what is generally termed the Middle Neolithic. Similarly, a typical Middle Neolithic ware, *figulina*, appeared earlier than anticipated. These findings stand in contrast to cave and rockshelter assemblages in the eastern Adriatic, but mirror assemblages from farming villages on the Italian Adriatic coast. This study argues that the similarities in ceramic assemblage composition and change through time may have less to do with direct contacts between areas, but more with the nature of ceramic production and consumption at village sites in general. These data shed light on the limitations of regional ceramic chronologies in the eastern Adriatic and highlight the necessity for systematic expansion of ^{14}C chronologies to address the social, economic, and ecological relevance of early farming in the Adriatic for the spread of agriculture in Europe and the Mediterranean.

INTRODUCTION

The spread of agriculture into Europe is an important case study for understanding the dispersion of food production in general and the timing, tempo, and nature of its underlying processes. Early farming in the Mediterranean region of Europe is characterized by the manufacture of pottery in addition to an economic reliance on domesticated species of plants and animals. Chronologically and regionally distinctive pottery styles provide the temporal framework for economic change, agricultural intensification, population movements, interaction, and exchange. This article presents the accelerator mass spectrometry (AMS) radiocarbon chronology for the introduction and subsequent development of farming communities on the eastern shore of the Adriatic and the pottery chronology of the period through ceramic stylistic data from Pokrovnik (Drniš) on the Dalmatian coast of Croatia (Figure 1). Recent research on the northern Adriatic coast highlights ^{14}C dates and broad-scale trends in pottery production for early farming populations documented largely in cave and rockshelter sites in that region (Forenbaher et al. 2013). In contrast, our work focuses on open-air farming villages spanning most of the Neolithic in central Dalmatia and more fine-grained analyses of chronological shifts in pottery styles.

Neolithic pottery in southern Europe is of particular interest because it is one of the few clearly distinguishing material features of early farming groups. Models for the spread of agriculture throughout the Mediterranean and Europe rely heavily on pottery style to define different cultural groups and trace geographic relationships (see Özdoğan 2011; Rowley-Conwy 2011). This is particularly true in the Balkans, where differences in ceramic style have been used to model distinct pathways for the spread of food production, linking some areas more closely to Mediterranean groups and others to central Europe. Discussions of agricultural intensification and associated demographic shifts are often related to a widespread phenomenon of ceramic diversification and regionalization (e.g. Price 2000; Rowley-Conwy 2011).

Early Neolithic pottery from the central Dalmatian coast of Croatia suggests a coastal focus with close ties to other peoples in the Adriatic region, as opposed to interior groups on the Balkan Penin-

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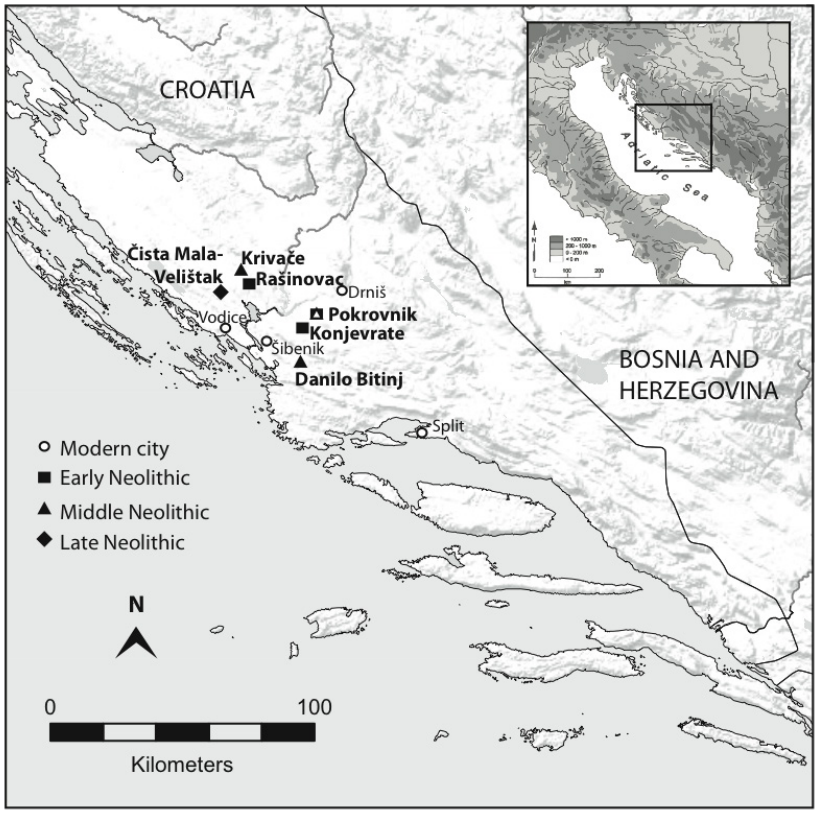

Figure 1 Neolithic sites in central Dalmatia mentioned in the text

sula. *Impresso* or Impressed Wares, typical of the Early Neolithic in the central and western Mediterranean, dominate Dalmatian assemblages. In contrast, the Middle Neolithic saw a diversification of pottery styles that became regionally distinct, following trends throughout the Adriatic, while evidencing contact with cultural groups in the Balkans. The Late Neolithic remains more enigmatic, with stylistic shifts in pottery decoration but little information on daily economic activities.

This article presents an AMS ^{14}C chronology for central Dalmatia for the Early Neolithic (Impressed Ware) to the beginning of the Late Neolithic (Early Hvar), including new dates from a series of open-air farming villages and previously published dates, and results of an extensive pottery analysis at Pokrovnik, a key site in the region. In order to discuss these results within a larger cultural context, we first briefly outline Neolithic settlement and economy in central Dalmatia and then focus on Neolithic pottery in the region, particularly issues of style, sourcing, exchange, and chronology. We then present the AMS ^{14}C dates and results of pottery analysis from Pokrovnik, and discuss these within the broader cultural context of Neolithic developments in Dalmatia.

BACKGROUND

Dalmatia is a geographically defined region of the Republic of Croatia, bounded to the west and south by the Adriatic Sea, and to the north and east by the Dinaric Alps that separate it from the rest of the Balkan Peninsula. It consists of a typical karst landscape with rows of relatively low hills (up to 500 m elevation) that divide small, narrow, elongated fertile valleys. Given the nature of the karst limestone landscape, water resources are more difficult to identify and consist of some rivers,

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underground or seasonal streams, springs, and ponds that provided farmers in the past enough water for agropastoral food production (Moore et al. 2007a,b).

There are over 50 documented Neolithic sites in Dalmatia, both open-air settlements and cave sites (temporary pastoralist shelters or possibly cult/ritual places), but only a few have been excavated with modern archaeological methods (for recently excavated open-air settlements see e.g. Moore et al. 2007a,b; Marijanović 2009; Podrug 2010; for cave sites see e.g. Čečuk and Radić 2005; Marijanović 2005; Forenbaher and Kaiser 2008). Neolithic peoples lived in aboveground (wattle-and-daub constructed) houses, planted a range of domesticated crops, and managed several domestic animal species (Moore et al. 2007a,b; Marijanović 2009; Legge and Moore 2011). Hunting decreased to a minimum and is not well represented in many sites, although the faunal material at Crno Vrilo showed a greater diversity of wild fauna than at other open-air Neolithic sites in the region (Radović 2009; Legge and Moore 2011).

Based on the available data, the basic economy and the assemblages of non-pottery material culture (primarily stone and bone tools) did not change much during the Neolithic (Batović 1979). As a result, pottery remains one of the most important sources of information for a more detailed picture of cultural change. Furthermore, until recently the ^{14}C record for this period has been limited and pottery style has served as the primary chronological marker for the Neolithic in the region (see also Forenbaher et al. 2013 for other parts of the eastern Adriatic). The chronology of Neolithic Dalmatia is traditionally divided into three phases: (1) Early Neolithic, *Impresso* or Impressed Ware (~6000–5500 cal BC); (2) Middle Neolithic, *Danilo* (~5500–4900 cal BC); and (3) Late Neolithic, *Hvar* (~4900–4000 cal BC), based largely on the stylistic sequences of pottery from excavated contexts (Figure 2; Batović 1979; see also Forenbaher et al. 2004; Čečuk and Radić 2005; Marijanović 2005).

Figure 2 Typical Neolithic pottery from central Dalmatia: A. Impressed Ware. B–D. Danilo Ware: B. Danilo smudged wares; C. Figulina; D. Rhyton; E. Hvar Ware. Photos courtesy of Šibenik City Museum.

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The Impressed Ware phase is defined by the appearance of farming communities with a pottery assemblage consisting of pots and bowls decorated with impressed motifs using various tools such as shell edges (e.g. Cardial), animal teeth, fingernails, bone tools, flint tools, roulette, and combs, among others. The transition to the Neolithic in the Adriatic is documented by diverse cultural shifts that have been explained as colonization by farmers, adoption of farming by hunter-gatherers, or combinations of the two models (Mlekuž 2003, 2005; Forenbaher and Miracle 2005; Miracle and Forenbaher 2006; Marijanović 2007, 2009; Moore et al. 2007b; Legge and Moore 2011; Forenbaher et al. 2013). The similarity of Dalmatian Impressed Ware to the early pottery in other parts of the Adriatic and the western Mediterranean highlights the centrality of ceramic analyses for addressing questions of the timing and spread of agriculture regionally (Gheorghiu 2008). However, Impressed Ware pottery varies in shape and decoration by region and its chronology spans 1000 yr (Spataro 2002; McClure 2011). Several researchers have argued that Dalmatian Impressed Ware pottery also shows local characteristics including impression motifs and techniques that are restricted in distribution, and several competing stylistic sequences of Impressed Ware pottery have been proposed (Batović 1966, 1979; Benac 1957; Müller 1994; see also Spataro 2002). The relationship between Dalmatian Impressed Ware and the broader Mediterranean Impressed Ware phenomenon remains unclear.

There is greater regionalization during the Middle Neolithic in the Mediterranean region, where distinctive farming and technological characteristics indicate more defined economic and cultural groups (e.g. Chapman 1988; McClure 2011). In the Dalmatian Middle Neolithic, Danilo pottery shifts stylistically in form, with the introduction of new shapes such as cups and plates, and in decoration. Danilo pottery consists largely of undecorated fine and coarse wares, but among the fine ware is a distinctive subgroup of smudged and burnished wares with incised or carved ornamentation. The typical motif is the spiral, usually encircling the entire vessel (Figure 2B). Other motifs include meanders, triangles, and nets, and often these incisions are filled with red or white incrustations, contrasting with the dark burnished vessels. Danilo assemblages furthermore include peculiar wares known as *figulina* (also sometimes referred to as various types of polychrome, such as *Danilo polychrome* or *Southern Dalmatian Polychrome*; see Korošec 1958:40–53; Forenbaher et al. 2013:600). Figulina is a pink, white, or light orange buff ware made from fine, inclusion-free clays and painted before firing (Figure 2C). It presents a very different manufacturing technology to the more common smudged wares and has clear links to similar pottery styles in Italy. Current chemical evidence supports the historic interpretation that this ware was manufactured locally within Dalmatia (Korošec 1964:56–9, 66; Batović 1979:563–70; Spataro 2002; Teoh et al. 2014). Another distinctive type of Middle Neolithic pottery found in Dalmatian sites is the rhyton. These footed "vessels" are unusual in shape and often display zoomorphic features (Figure 2D), and have been interpreted as cult or ritual paraphernalia (e.g. Perić 1996; Biagi 2003; Mlekuž 2007; Marijanović 2009; Rak 2011). No consensus about their function yet exists and rhyta remain an easily identifiable yet enigmatic feature of the Danilo period ceramic assemblages. Despite this ceramic diversity, there has been little discussion of the nature, roles, and chronology of figulina and rhyta within the context of pottery production and use at Middle Neolithic sites.

Finally, Hvar wares are similar to Danilo wares in that the fine vessels are also fired in dark hues and are highly polished or burnished (Figure 2E). Incisions continue as the most frequent decorative technique, but motifs are more simplified and geometric than in Danilo, and tend to be "messier" or less constrained. The main difference to Danilo wares, however, is the application of red paint to fine wares after firing.

The corpus of ^{14}C-dated archaeological deposits in the region has grown during the past 10 yr and this study summarizes the available AMS ^{14}C dates for Neolithic sites in central Dalmatia (Table 1;

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Figure 3; see also Miracle and Forenbaher 2006; Moore et al. 2007a,b; Forenbaher and Kaiser 2008; Marijanović 2009; Podrug 2010; Forenbaher et al. 2013). Our research has focused on sites around the Krka River valley and in particular on the sites of Danilo Bitinj and Pokrovnik (excavated during the "Early Farming in Dalmatia Project"; NSF #0422195, 2004–2006; Moore et al. 2007a,b), Čista Mala-Veliš tak (2007–present; Podrug 2010), and most recently the sites of Rašinovac and Krivače (project "Neolithic Landscapes of Central Dalmatia"; NGS#9146-12; directed by McClure and Podrug). In addition, bone samples for AMS ^{14}C dating were obtained from earlier excavations at Krivače and Konjevrate, two key sites in the region. In the following, we outline sample selection, methods, and results of AMS ^{14}C dating, and then turn to the methods and results of stylistic analysis of pottery from Pokrovnik and more detailed Bayesian chronology for these stratified deposits.

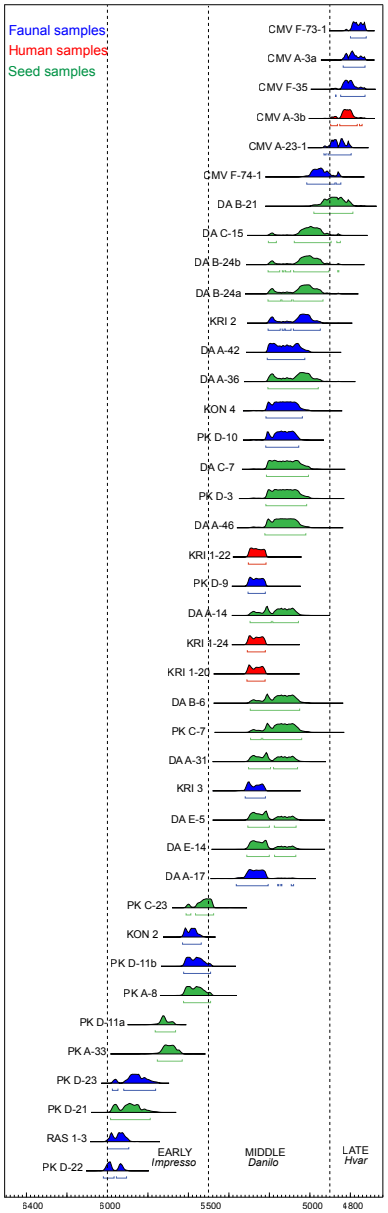

Figure 3 Radiocarbon dates for sites in central Dalmatia, calibrated with OxCal v 4.2.3 Bronk Ramsey (2009); r:5 and IntCal13 atmospheric curve (Reimer et al. 2013).

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METHODS: SAMPLE SELECTION AND AMS ^{14}C DATING

Two suites of AMS ^{14}C dates are presented here. The first group consists of dates generated at the Oxford Radiocarbon Accelerator Unit (ORAU) as part of the "Early Farming in Dalmatia Project" (Table 1). Samples consisted of 12 charred seeds and 1 bone (*Ovis musimon*) from Danilo Bitinj and 7 charred seeds from Pokrovnik (Moore et al. 2007a; Legge and Moore 2011). Samples were selected from lower and upper levels of each unit to characterize the duration of occupation and sample preparation followed conventions and procedures at ORAU (Brock et al. 2010).

A second suite of samples was selected from faunal remains from key sites in the region (Table 1) for AMS ^{14}C dating and stable isotope analysis (Zavodny et al. 2014). Bone samples from Konjevrate and the older excavations at Krivače were chosen from available holdings at the Šibenik City Museum, while new excavations at Čista Mala-Vel̆ištak, Krivače, and Rašinovac provided material with excellent stratigraphic control. Additional bone samples were chosen from Pokrovnik based on changes in the ceramic assemblage identified during pottery analysis (see below). Bone collagen for ^{14}C and stable isotope analyses was extracted and purified at Penn State (Human Paleoecology and Isotope Geochemistry Laboratory) using the modified Longin method (Brown et al. 1988) and following protocols of the UC Irvine Keck Carbon Cycle AMS Facility (Beaumont et al. 2010).

Bone samples were initially cleaned of adhering sediment and the exposed surfaces were removed by drilling or scraping with an X-ACTO® blade. Samples (200–400 mg) were demineralized for 24–36 hr in 0.5N HCl at 5°C followed by a brief (<1 hr) alkali bath in 0.1N NaOH at room temperature to remove humates. Collagen was rinsed to neutrality in multiple changes of Nanopure H_2O, and then gelatinized for 12 hr at 60°C in 0.01N HCl. Gelatin solution was pipetted into precleaned Centriprep® 30 ultrafilters (retaining >30kD molecular weight collagen) and centrifuged three times for 30 min, diluted with Nanopure H_2O, and centrifuged three more times for 30 min to desalt the solution. Ultrafiltered collagen was lyophilized and weighed to determine percent yield.

The recognition that foreign carbon could be introduced to samples during ultrafiltration by humectants (e.g. glycerol, glycerin) or filter material (e.g. reconstituted cellulose, polyethersulfone) has spurred much recent methodological work to determine effective precleaning protocols (Bronk Ramsey et al. 2004; Higham et al. 2006; Brock et al. 2007; Hüls et al. 2007). To remove the glycerin coating from the Centriprep filters, the inner and outer portions of the filters were filled with 0.01N HCl and sonicated at ~60°C for 1 hr and rinsed with Nanopure H_2O. Nanopure H_2O was centrifuged through the filters 3 times for 30 min each, and the inner and outer portions were refilled with Nanopure H_2O and sonicated for 1 hr at ~60°C. After three further centrifuge runs with Nanopure H_2O, the filters were kept wet until use, no more than 48 hr after precleaning. Results on Pleistocene and historic age bone standards processed along with the unknowns are used to detect contamination from either modern or ancient carbon.

^{14}C samples (~2.5 mg) were combusted for 3 hr at 900°C in vacuum-sealed quartz tubes with CuO wire and Ag wire. At KCCAMS, sample CO_2 was reduced to graphite at 550°C using H_2 and a Fe catalyst, with reaction water drawn off with $Mg(ClO_4)_2$ (Santos et al. 2004). Graphite samples were pressed into targets in Al boats and loaded on the target wheel for AMS analysis. ^{14}C ages were corrected for mass dependent fractionation with measured δ^{13}C values (Stuiver and Polach 1977), and compared with samples of Pleistocene whale bone (background, >48k ^{14}C BP), middle Holocene pinniped bone, late AD 1800s cow bone, and OX-1 oxalic acid standards for calibration. Carbon and nitrogen concentrations and stable isotope ratios were measured at the Penn State University Light Isotope Laboratory with a Costech EA (ECS 4010), Thermo Finnigan Conflo IV gas handling device, and a Thermo Finnigan Delta V analyzer.

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Table 1 AMS ^{14}C dates from open-air village sites in central Dalmatia; calibrated with OxCal v 4.2.3 Bronk Ramsey (2009); r:5 and IntCal13 atmospheric curve (Reimer et al. 2013).

Site; Sample #	Trench/ Level	Material	Lab #	^{14}C BP	2σ cal BC	Reference
Rašinovac RAS-1	1/SJ3	*Bos taurus* (cow) >30kDa gelatin	PSU-5612/UCI-AMS-127394	7060 ± 25	6005–5895	
Pokrovnik	A/8	*Triticum monococcum* (einkorn) charred grain	OxA-17195	6626 ± 39	5625–5490	
Pokrovnik	A/33	*Triticum dicoccum* (emmer) charred grain	OxA-17328	6810 ± 40	5755–5630	
Pokrovnik	C/7	*Triticum dicoccum* (emmer) charred grain	OxA-17124	6197 ± 39	5295–5240 (7.9%) 5235–5040 (87.5%)	
Pokrovnik	C/23	*Triticum dicoccum* (emmer) charred grain	OxA-17125	6568 ± 36	5615–5585 (9.1%) 5570–5475 (86.3%)	
Pokrovnik	D/3	*Triticum dicoccum* (emmer) charred grain	OxA-17223	6170 ± 35	5220–5015	Legge and Moore 2011
Pokrovnik PK-44	D/9	*Ovis aries* (sheep) >30kDa gelatin	PSU-4960/UCI-AMS-106477	6280 ± 20	5310–5215	
Pokrovnik PK-39	D/10	*Bos taurus* (cow) >30kDa gelatin	PSU-5294/UCI-AMS-116206	6190 ± 25	5220–5055	
Pokrovnik	D/11	*Triticum dicoccum* (emmer) charred grain	OxA-17193	6625 ± 36	5625–5490	
Pokrovnik PK-45	D/11	*Ovis aries* (sheep) >30kDa gelatin	PSU-4961/UCI-AMS-106478	6840 ± 25	5765–5660	
Pokrovnik	D/21	*Triticum monococcum* (einkorn) charred grain	OxA-17194	6999 ± 37	5985–5785	Legge and Moore 2011
Pokrovnik PK-7	D/22	*Bos taurus* (cow) >30kDa gelatin	PSU-5293/UCI-AMS-116205	7090 ± 25	6025–5965 (56.3%) 5960–5905 (39.1%)	
Pokrovnik PK-15	D/23	*Ovis aries* (sheep)	PSU-5556/UCI-AMS-119837	6975 ± 30	5980–5945 (8.3%) 5920–5760 (87.1%)	
Konjevrate KON-2		*Ovis aries* (sheep) >30kDa gelatin	PSU-5291/UCI-AMS-116203	6655 ± 25	5630–5535	
Konjevrate KON-4		*Ovis aries* (sheep) >30kDa gelatin	PSU-5557/UCI-AMS-119838	6175 ± 30	5220–5035	
Danilo-Bitinj	A/14	*Triticum monococcum* (einkorn) charred grain	OxA-17196	6212 ± 35	5300–5190 (34.4%) 5185–5055 (61%)	

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Table 1 AMS ^{14}C dates from open-air village sites in central Dalmatia; calibrated with OxCal v 4.2.3 Bronk Ramsey (2009); r:5 and IntCal13 atmospheric curve (Reimer et al. 2013).

Site; Sample #	Trench/ Level	Material	Lab #	^{14}C BP	2σ cal BC	Reference
Danilo-Bitinj	A/17	*Ovis musimon* (sheep)	OxA-14449	6284 ± 40	5365–5205 (94.2%) 5160–5150 (0.3%) 5145–5135 (0.3%) 5095–5080 (0.7%)	Moore et al. 2007a
Danilo-Bitinj	A/31	*Triticum dicoccum* (emmer) charred grain	OxA-15764	6226 ± 37	5305–5195 (50%) 5180–5060 (45.4%)	Moore et al. 2007a
Danilo-Bitinj	A/36	*Triticum monococcum* (einkorn) charred grain	OxA-17197	6121 ± 37	5210–4955	
Danilo-Bitinj DA-6	A/42	*Ovis aries* (sheep) >30kDa gelatin	PSU-5290/UCI-AMS-116202	6155 ± 25	5215–5025	
Danilo Bitinj	A/46	*Triticum dicoccum* (emmer) charred grain	OxA-15681	6180 ± 34	5225–5020	Moore et al. 2007a
Danilo-Bitinj	B/6	*Rosa* sp. (wild rose) charred seed	OxA-17329	6204 ± 38	5295–5050	
Danilo-Bitinj	B/21	*Triticum monococcum* (einkorn) charred grain	OxA-15680	5987 ± 35	4985–4785	Legge and Moore 2011
Danilo-Bitinj	B/24	*Rosa* sp. (wild rose) charred seed	OxA-17198	6093 ± 36	5210–5145 (10.2%) 5140–5095 (2.7%) 5085–4905 (82%) 4865–4855 (0.5%)	Moore et al. 2007a
Danilo-Bitinj	B/24	*Rosa* sp. (wild rose) charred seed	OxA-17199	6103 ± 37	5210–5090 (21.9%) 5085–4935 (73.5%)	
Danilo-Bitinj	C/7	*Rosa* sp. (wild rose) charred seed	OxA-17200	6161 ± 36	5215–5005	
Danilo-Bitinj	C/15	*Rosa* sp. (wild rose) charred seed	OxA-17224	6083 ± 35	5210–5165 (5.6%) 5080–4895 (88.1%) 4870–4850 (1.8%)	
Danilo-Bitinj	E/5	*Triticum monococcum* (einkorn) charred grain	OxA-17126	6237 ± 37	5310–5200 (63.2%) 5180–5065 (32.2%)	

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Table 1 AMS ^{14}C dates from open-air village sites in central Dalmatia; calibrated with OxCal v 4.2.3 Bronk Ramsey (2009); r:5 and IntCal13 atmospheric curve (Reimer et al. 2013).

Site; Sample #	Trench/ Level	Material	Lab #	^{14}C BP	2σ cal BC	Reference
Danilo-Bitinj	E/14	*Triticum monococcum* (einkorn) charred grain	OxA-15765	6245 ± 39	5315–5200 (70.1%) 5175–5070 (25.3%)	Moore et al. 2007a
Krivače KRI-2	III/A2	*Sus scrofa* (pig) >30kDa gelatin	PSU-5558/UCI-AMS-119839	6115 ± 30	5210–5145 (19.5%) 5140–5090 (6.2%) 5085–4945 (69.7%)	
Krivače KRI-3	III/A1	*Bos taurus* (cow) >30kDa gelatin	PSU-5292/UCI-AMS-116204	6300 ± 25	5320–5220	
Krivače KRI-6	1/SJ22	*Homo sapiens* (human) >30kDa gelatin	PSU-5613/UCI-AMS-127395	6270 ± 20	5305–5215	
Krivače KRI-7	1/SJ24	*Homo sapiens* (human) >30kDa gelatin	PSU-5614/UCI-AMS-127396	6285 ± 20	5310–5220	
Krivače KRI-8	1/SJ20	*Homo sapiens* (human) >30kDa gelatin	PSU-5615/UCI-AMS-127397	6290 ± 20	5315–5220	
Čista Mala-Veliš̆tak CMV-5	F/3	*Ovis aries* (sheep) >30kDa gelatin	PSU-5289/UCI-AMS-116201	5935 ± 20	4875–4870 (0.2%) 4850–4725 (95.2%)	
Čista Mala-Veliš̆tak CMV-2	F/74-1	*Bos taurus* (cow) >30kDa gelatin	PSU-5288/UCI-AMS-116200	6045 ± 25	5020–4845	
Čista Mala-Veliš̆tak CMV-38	A/23-1	Ovicaprid >30kDa gelatin	PSU-3701/UCI-AMS-78155	5975 ± 15	4935–4920 (2.7%) 4915–4795 (92.7%)	Podrug 2010
Čista Mala-Veliš̆tak CMV-28	A/3	Ovicaprid >30kDa gelatin	PSU-3702/UCI-AMS-78156	5920 ± 15	4840–4725	Podrug 2010
Čista Mala-Veliš̆tak CMV-12	A/SJ3	*Homo sapiens* (human) >30kDa gelatin	PSU-5616/UCI-AMS-127398	5945 ± 20	4900–4860 (8.7%) 4855–4765 (84.7%) 4760–4740 (2%)	
Čista Mala-Veliš̆tak CMV-3	F/73-1	*Bos taurus* (cow)	PSU-5563/5564/ UCIAMS-125829/ 125830	5903 ± 11	4800–4720	

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RESULTS: AMS ^{14}C DATES

Early Neolithic Sites

Three sites—Pokrovnik, Konjevrate, and Rašinovac—attest to the development of the Impressed Ware Neolithic and ^{14}C dates from Pokrovnik and Rašinovac document the beginning of food production in central Dalmatia at ~6000 cal BC. Pokrovnik is an open-air village that was occupied continuously during the Early (Impressed Ware) and Middle (Danilo) Neolithic and that is well documented (Table 1, Figure 3). Surface and occasional finds also indicate it was likely inhabited during the early Hvar period. The site has been excavated twice, first by Brusić in 1979 and more recently by Moore and Menđušić in 2006 (Brusić 2008; Legge and Moore 2011; Moore et al. 2007b). The 2006 excavation consisted of four large trenches (A–D) ranging in size from 5 × 5 to 8 × 5 m. These trenches were excavated to the subsoil in a strip field that transected the site, uncovering a cross-section of the inhabited area of the village. Trenches A and D had multiple layers of habitation debris, hearths, pits, and house remains. Large stone walls were documented in Trenches A, C, and D and likely served as terraces and boundaries. Faunal remains, polished and chipped stone tools, and large quantities of pottery were unearthed (Moore et al. 2007b; Legge and Moore 2011). The data suggest that farming arrived in coastal Dalmatia as a full package at 6000 cal BC—with domesticated plants and animals, as well as pottery—and early farmers did not change their basic economic activities for 800 yr (Moore et al. 2007a,b; Legge and Moore 2011).

Analysis of Pokrovnik continues, but a suite of 12 AMS ^{14}C dates has been generated for different parts of the site (Table 1). In particular, we concentrated on Trench D for the pottery analysis (see below) and obtained a number of ^{14}C dates specifically for this unit. Our goal was to constrain the stylistic shifts we documented in the pottery analysis in concert with ongoing research on animal management practices and stable isotope analyses (Zavodny et al. 2014). The resulting chronological framework consists of 8 AMS ^{14}C dates (Table 1). More detail on the pottery analysis is presented below.

Konjevrate is located under a modern churchyard and was test excavated in the late 1980s and 1990s. Although excavation was not extensive, material remains in the form of pottery, stone tools, and animal bones were recovered. Stylistically, the pottery is Impressed Ware, dating to the Early Neolithic. Two bone samples were ^{14}C dated from this site and one, KON-2, fell into the expected Early Neolithic chronology (Table 1, Figure 3). Surprisingly, however, a second sample (KON-4) is Middle Neolithic in date. Although only general provenience data are available for these samples and not specific information on the stratigraphy, no Middle Neolithic pottery or other material culture was unearthed. The significance of the AMS ^{14}C date is that there was some type of Middle Neolithic occupation at or around the Impressed Ware site that led to a Middle Neolithic bone being deposited there. Alternatively, it may reflect a continuity of an Impressed Ware pottery tradition into the Middle Neolithic. This issue will be discussed in more detail below. This location is currently a cemetery, so it is unlikely that additional excavations can take place to clarify the settlement history of this site.

Rašinovac is a newly discovered Early Neolithic site in the Piramatovci Valley (Figure 1) that was test excavated (2 × 2 m unit) by Podrug and McClure in May 2013. A substantial Impressed Ware cultural horizon (40 cm thick) was documented during these excavations. Analysis is ongoing, but the assemblage is largely comprised of Impressed Ware pottery and Early Neolithic stone tools. Future work will clarify the extent and intensity of occupation at this Neolithic settlement, but the AMS ^{14}C date presented here is the first date available for this site (Table 1).

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The earliest Impressed Ware dates center at 6000 cal BC at both Pokrovnik and Rašinovac. This is contemporary with published dates from other sites in the eastern Adriatic including Nakovana Cave (OxA-18120: 7050 ± 37, 6008–5846 cal BC; Forenbaher et al. 2013: Table 1) and the open-air site SU-002 (ETH-22912: 6925 ± 65 BP, 5877–5736 cal BC) on Sušac Island (Radić 2009:17; Forenbaher et al. 2013:598).

Middle Neolithic Sites

Danilo Bitinj is located in the fertile Danilo Valley, ~18 km east of Šibenik, and was occupied in the Middle Neolithic (Korošec 1964; Moore et al. 2007a; Legge and Moore 2011). It is the type-site for the Middle Neolithic and gives the chronological phase its name. Early excavations in the 1950s, rescue excavations in 1992, and a series of five 5 × 5 m trenches (A–E) excavated in 2004/2005 uncovered a total 2700 m^2 of the site. Based on surface distributions, the site is estimated to span 8–9 ha. Excavations unearthed several areas of habitation with remains of pits, house floors, walls, and large quantities of faunal and floral remains, pottery, and stone tools. A suite of 14 AMS ^{14}C dates has been generated for four trenches, spanning 5300–4900 cal BC (Table 1, Figure 3).

Krivače is located in the Bribir-Ostrovica Valley and was surface collected in 1963 (Korošec and Korošec 1974) and excavated in the early 2000s and in 2013. Pottery from Impressed Ware, Danilo, and Hvar periods were recovered in surface collections, suggesting this site was an open-air village occupied throughout the Neolithic. However, limited test excavations in the 2000s only unearthed a Middle Neolithic occupation. Recent excavation in May 2013 by Podrug and McClure focused on a 2 × 2 m test trench. Over 60 cm of cultural deposits contained large quantities of pottery, including figulina and rhyton fragments, stone tools made of chert and obsidian, and faunal remains. Furthermore, ditches, hearths, pits, and house floors were uncovered. Material is still under analysis, but five AMS ^{14}C dates are available (Table 1, Figure 3). Two of these dates, KRI-2 and KRI-3, are on animal bones from the 2000s excavations. Three additional AMS ^{14}C dates are on human remains found embedded in the clay floors at the base of the unit, just above the sterile subsoil. KRI-3 is statistically identical to the human remain ^{14}C dates and suggests that occupation of this part of the village began around 5300 cal BC. Further dating of other parts of the cultural horizon will help us identify the duration of settlement at Krivače.

Based on these data, typical Middle Neolithic villages are documented in central Dalmatia by 5300 cal BC and remained occupied for up to 400 yr. People living at multicomponent sites like Pokrovnik began to create the typical suite of Middle Neolithic pottery around the same time.

Late Neolithic Sites

Čista Mala-Veliš̆tak is a Hvar period open-air village currently under excavation by Podrug. It was discovered in 2007 and in seven excavation seasons an area of 200 m^2 has been examined (Podrug 2010). The site has a vertical stratigraphy with several distinct contexts, including a series of pits excavated into the subsoil and remains of aboveground house floors and hearths. A large quantity of Hvar pottery and other materials has been collected. Čista Mala-Veliš̆tak is particularly significant because the Hvar Neolithic is largely known from cave sites, and this is currently the only Hvar open-air village to be excavated in Dalmatia. In the case of the valley surrounding Čista Mala-Veliš̆tak, museum collections contain Danilo and Impressed Ware pottery, indicating the presence of sites from these periods in the valley, though precise locations are unknown. Six AMS ^{14}C dates are currently available spanning ~5000–4700 cal BC (Table 1, Figure 3).

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METHODS: POTTERY ANALYSIS

The large ceramic assemblage from Pokrovnik is ideal to address questions of the timing, tempo, and nature of stylistic shifts during the Early and Middle Neolithic. This study is based on material from the excavation unit, Trench D, with the deepest (up to 2 m) intact deposit and includes data from over 26,000 sherds. Here, we present data on pottery style; future work will include technological studies, petrography, sourcing analyses, and residue analyses.

Pottery was cleaned in the field and is curated by the Drniš City Museum. Analysis was conducted at the Šibenik City Museum and consisted of several phases. First, undiagnostic sherds (i.e. wall fragments) were sorted by level and decorative type and counted. Diagnostic sherds were sorted by level into rims, bases, and handles, and recorded individually with decorative information. All rim sherds were drawn. Fragments with data on vessel shape were further studied and recorded.

RESULTS: POTTERY ANALYSIS

In total, we analyzed 23,327 undiagnostic and 2919 diagnostic sherds from Pokrovnik Trench D (Tables 2, 3). The stratigraphy of this excavation unit spanned 2 m in its deepest area. Figure 4A illustrates the western profile wall (C–D) with the succession of strata, while Figure 4B shows the Harris matrix for the unit as a whole. As can be seen in Figure 5, pottery becomes less decorated through time. Early Neolithic Impressed Ware vessels are often completely decorated, with recurring impressions on the entire external surface of the pot. A steady decline in decoration is visible through time. This shift is due to an increase in more zonal decoration on the pottery, resulting in a greater percentage of the vessel surfaces being simply smoothed or burnished. Although zonal decoration is well known from the Danilo wares with their bands of meandering spirals and other motifs (Figure 2), these data indicate that this trend begins in the Early Neolithic, particularly represented in Levels 14 and 11. A shift towards zonal decoration in Impressed Wares has been documented elsewhere, and in some cases, distinct phases have been suggested to capture the shift to zonal decorations (Impressed A vs. Impressed B; Batović 1979; Müller 1994; Čečuk and Radić 2005). However, the significance of this shift as a clear chronological marker has been questioned (Forenbaher et al. 2013:598) and our data suggest it was more of a gradual change. This trend in the Pokrovnik pottery specifically and the Adriatic more generally echoes Impressed Ware pottery styles found in the western Mediterranean, where zonal motifs are common (Bernabeu et al. 2012; McClure and Bernabeu 2012).

Table 2 Summary of pottery analysis for Pokrovnik Trench D. In columns with multiple numbers, the first refers to number of diagnostic sherds and the second to undiagnostic sherds (diag/undiag).

Level	Total	Diag. total	Undec.	Decorated	Impressed	Danilo	Figulina	Rhyton
1, 2, 3	6115	726	644/5259	82/130	0/6	64/142	9/64	9/0
5, 6, 7, 8	2087	293	246/1767	47/27	0/6	31/37	11/69	5/0
9	3397	404	381/2951	23/42	2/22	14/27	6/38	1/0
10	4430	419	406/3985	13/26	6/21	2/10	5/24	0/0
11	2670	242	231/2321	11/107	11/107	0/0	0/0	0/0
14	2236	241	231/1794	10/201	9/202	0/0	1/0	0/0
15, 16, 18, 20, 21	3308	368	309/2016	59/924	59/924	0/0	0/14	0/0
19	719	61	47/393	14/265	13/266	0/0	1/0	0/0
22, 23	1284	165	114/516	51/603	51/603	0/0	0/0	0/0
Total	**26,246**	**2919**	**2609/21,002**	**310/2325**	**151/2157**	**111/216**	**33/209**	**15/0**

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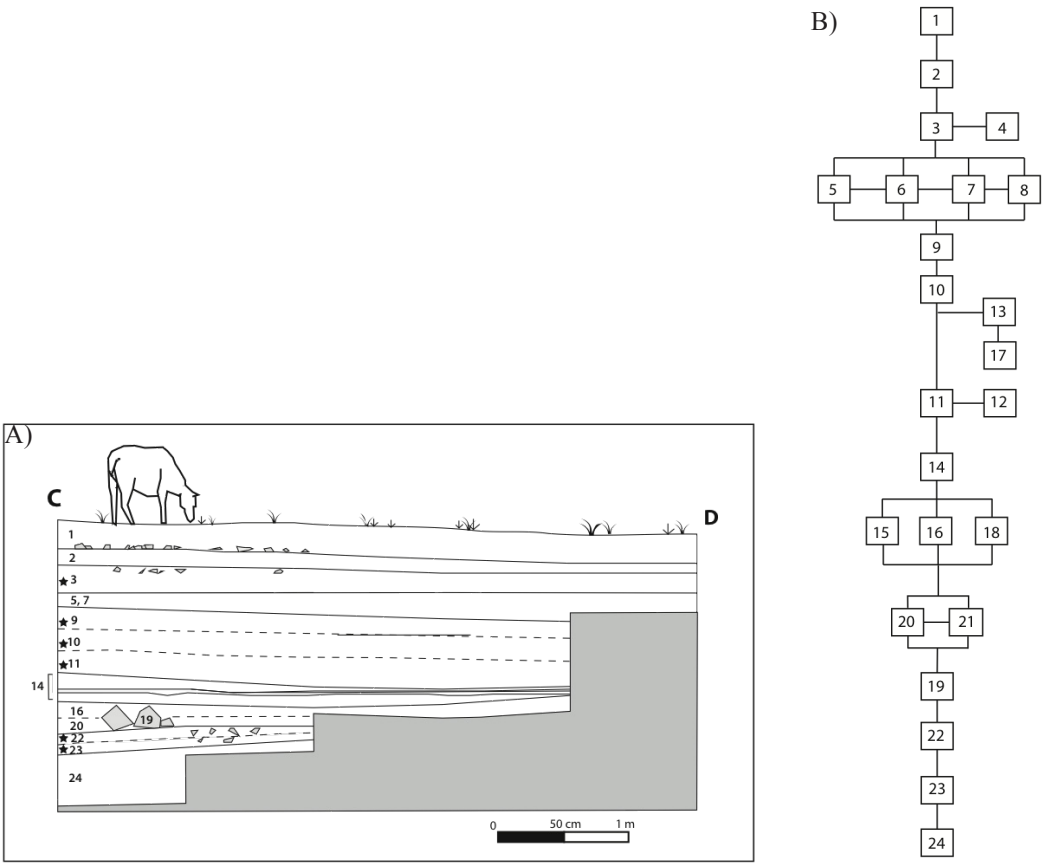

Figure 4 Pokrovnik Trench D: A) Western profile (C–D). Stars indicate levels with ^{14}C dates (see Table 1). B) Harris matrix.

Table 3 Summary of Impressed Ware decorative techniques in number of diagnostic pottery sherds.

Level	Cardial	Roulette	Tremolo	Other Impressed
9	1	0	0	1
10	3	3	1	0
11	3	2	3	6
14	0	2	5	9
15, 16, 18, 20, 21	18	1	9	56
19	2	2	0	11
22, 23	15	2	0	44
Total	**42**	**12**	**18**	**127**

A summary of the distribution of decorative types (Figure 6A, Table 2) indicates clear shifts in wares and decoration types during the Early and Middle Neolithic. For the Early Neolithic, Figure 6B shows changes in techniques and demonstrates that a variety of styles were in use during the earliest phases of pottery production at Pokrovnik (see also Table 3). Stylistic diversity increased in later phases of the Early Neolithic assemblage with the addition of tremolo decorations. This partic-

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ular decorative technique uses a sharp object to make very small, regular impressions in a zig-zag motif. The data presented here support prior claims (e.g. Müller 1994; Spataro 2002; Brusić 2008) that tremolo was a later addition to an Early Neolithic decorative repertoire.

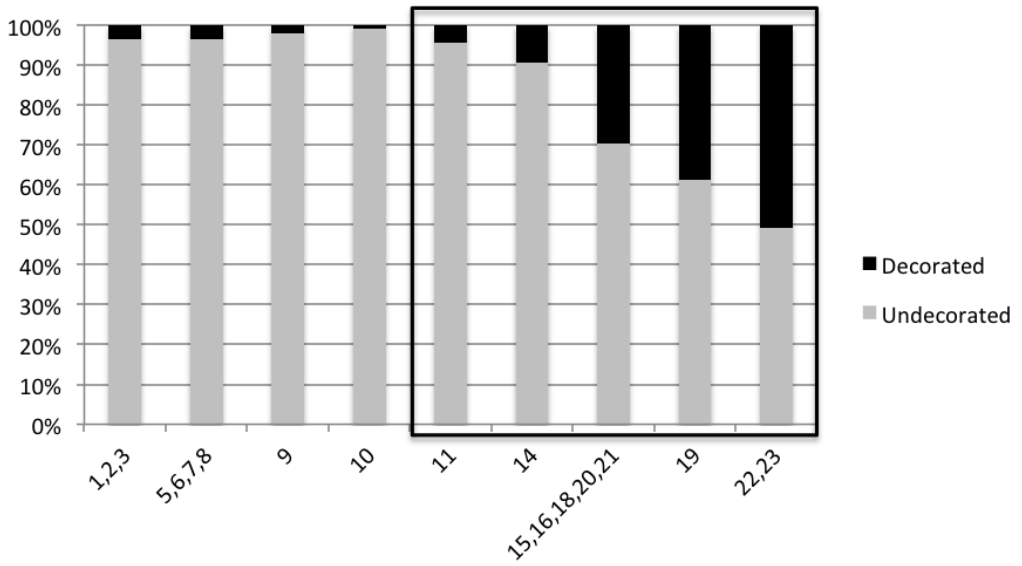

Figure 5 Relative proportion of decorated and undecorated pottery through time (n = 26,246). Box indicates Early Neolithic levels.

Levels 9 and 10 show a more interesting pattern with a mix of impressed, typical Danilo incised, and figulina wares (Figure 6A). We were unable to identify transitional pottery in techniques or motifs between Impressed Ware and Danilo, and these levels in particular had the highest concentrations of figulina pottery of all levels analyzed. We interpret these levels as a transitional phase between Impressed Ware and Danilo since there are no data to suggest that they were mixed with underlying Impressed Ware levels (see also Brusić 2008 for similar observations; Figures 3 and 4).

Finally, Figure 6A highlights questions regarding the timing and significance of figulina and rhyta. Although the relative proportion of figulina is very small throughout the Neolithic, it first appears at Pokrovnik in the Early Neolithic. The numbers presented in Figure 6A are very small, but an additional 14 undiagnostic sherds were recovered from Early Neolithic levels that are not captured in the bar chart (see Table 2). It is striking that only figulina appears in the earlier levels and none of the more ubiquitous Danilo pottery is present. We discuss issues of taphonomy in greater detail below. Based on published research, figulina wares have typically been analyzed in Dalmatia without any emphasis on chronology. Our results suggest that the timing and contexts of figulina in Dalmatian Neolithic sites may be more complex and should be examined more closely.

Bayesian Analysis of the Pokrovnik Sequence

The basic distributions of stylistic groups through time at Pokrovnik in conjunction with the AMS ^{14}C chronology reported above provide an opportunity to delve more deeply into the chronological patterning of stylistic change in the region. We established a stratigraphic model for Trench D using OxCal (Bronk Ramsey 2009) that combines 8 AMS ^{14}C dates with stratigraphic information to understand better the pace and timing of changes seen archaeologically. Figure 7A presents the available AMS ^{14}C dates for Pokrovnik in a phased stratigraphic sequence from the earliest (bottom)

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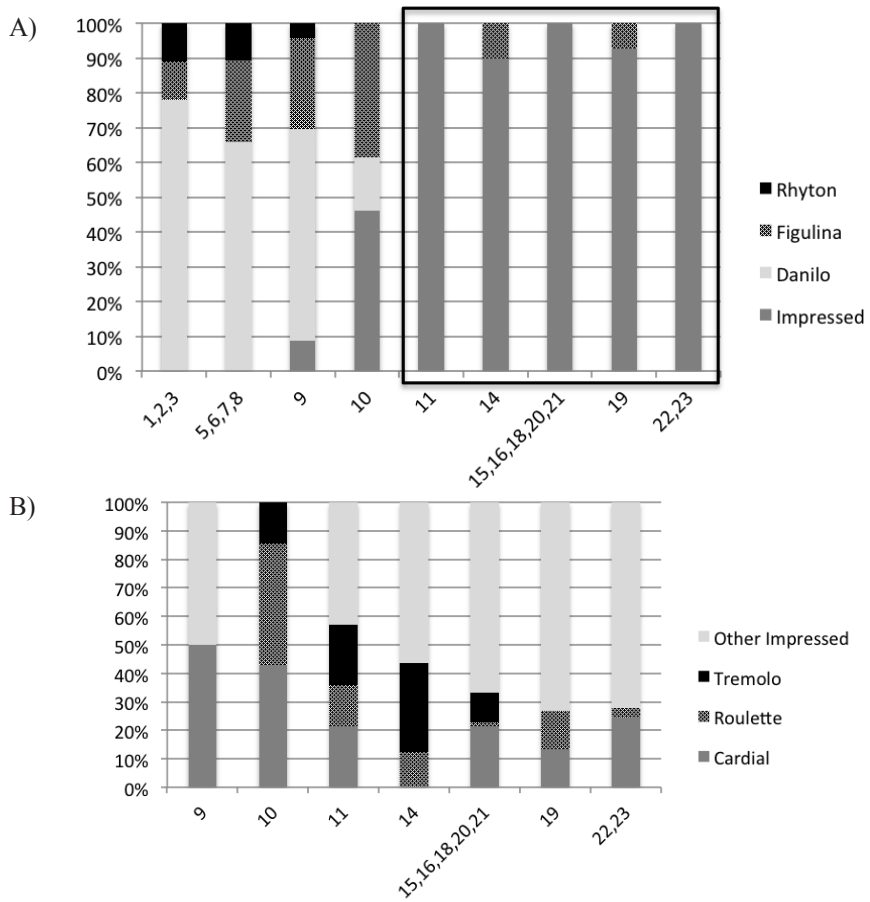

Figure 6 A) Comparison of relative (%) distributions of diagnostic decorated pottery: Impressed Ware, typical Danilo ware, rhyta and figulina (does not include undecorated diagnostics; n = 314; Table 2). Box indicates Early Neolithic levels. B) Comparison of relative (%) distributions of Early Neolithic pottery decorative types (n = 204; Table 3). The category "Other Impressed" includes a variety of impressed decorative types (e.g. non-denticulated, fingernail).

to latest (top) Neolithic horizons. Phases were constructed based on the Harris matrix (Figure 4B) for the site, and events and strata that were not directly dated were modeled as *boundaries* (e.g. Str. 14, the Early to Middle Neolithic transition, end of occupation). In Figure 7B, the light gray probability distributions represent calibrated date ranges (2σ) without model constraints. The dark gray distribution shows these probability estimates constrained by the stratigraphic model. Agreement indices (A) provide a measure of fit between the data and model with values higher than the critical threshold (A′ = 60%) indicating good concordance. This measure is provided for each date distribution (e.g. *R_Date D11 (b) Ovis, [A:95]*) and for the model as a whole (Sequence [A_{model}]). Overall, there is good agreement between the available data and the stratigraphic model (A_{model} *75*).

Boundaries defining the ages of ceramic-bearing strata are reproduced in Figure 7B and shown relative to the abundance of diagnostic pottery styles through time. Pottery abundances are shown vertically for each level and add up to 100%. The age of each level on the timescale uses the mean of each distribution for a point estimate. These data indicate that the use of specific ceramic styles as chronological markers needs to be re-evaluated. Specifically, the co-occurrence of figulina wares

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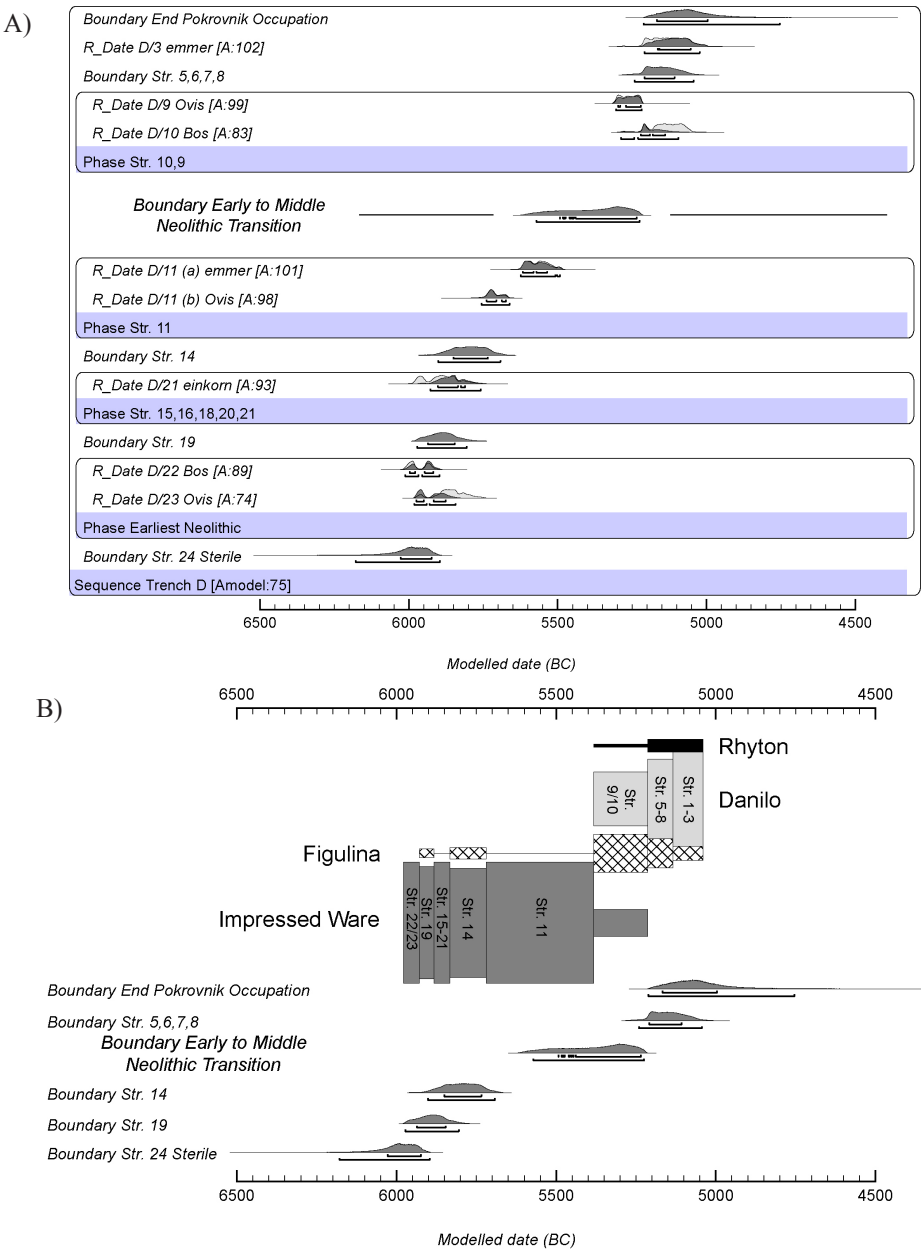

Figure 7 A) Bayesian chronology of ceramic sequences at Pokrovnik, Trench D. B) Radiocarbon phases paired with the relative distribution of pottery styles highlighting the overlap of ceramic typologies.

with Impressed Ware pottery as well as the persistence of Impressed Wares into otherwise typical Middle Neolithic contexts indicates longer chronologies for both wares and the need for a more nuanced approach to pottery styles in early farming communities. This is echoed by recent research on sequences largely from caves and rockshelters elsewhere in the eastern Adriatic (Forenbaher et al. 2013), where the utility of traditional divisions of the Neolithic into Early, Middle, and Late phases has been questioned.

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In central Dalmatia, Impressed Wares appear by 6000 cal BC (e.g. Pokrovnik, Rašinovac) and continue to be produced at Pokrovnik until ~5300 cal BC, when they were replaced by more typical Danilo wares. The persistence of Impressed Ware is 3 centuries longer than documented in other parts of the eastern Adriatic. In the northern part of the coast, Danilo-Vlaška wares, a variant of the Dalmatian Danilo wares, appear by 5600 cal BC and overlap with the end of the Impressed Ware production for only around 100 yr, although they do not occur in the same sites and there is no mixing within any of the stratified cave sites (Forenbaher et al. 2013). In Dalmatia, the co-occurrence of these styles does not appear to be taphonomically structured.

Instead, we argue that the assemblage is distinct from cave sites due to differences in site use, pottery production areas, and vessel function. This observation is consistent with pottery from the Italian side of the Adriatic, where Impressed Wares co-occur with stylistically "later" pottery at a number of open-air villages until around 5250 cal BC (Malone 2003:243; Robb 2007:163–72). The production of Impressed Ware into what has traditionally been termed the Middle Neolithic in Dalmatia may help explain the later date from Konjevrate (KON-4; Table 1) mentioned earlier. This date (KON-4: 6175 ± 30 BP; 5220–5035 cal BC) is statistically identical to the date for Pokrovnik Trench D, level 10 (PK-39: 6190 ± 25 BP; 5220–5055 cal BC) that had 45% Impressed Wares among the diagnostic pottery and 69% of all decorated sherds along with figulina and typical Danilo wares.

The similarities to the Early Neolithic in the Italian Adriatic do not end there. At Pokrovnik, figulina appears archaeologically in levels dated to 5700–5500 cal BC (Table 1, Figure 7), but becomes more common after ~5200 cal BC. Only a small number of figulina sherds were recovered from the earlier levels 14 through 19, begging the question if their presence is due to taphonomic issues.

The levels in Trench D were well stratified and seemingly suffered very little from disturbance or mixing. For example, the terrace wall (level 19) was well grounded and largely *in situ*. Higher up the sequence, level 7 consisted of an intact clay floor with impacted limestone fragments that covered the entire trench. This clay floor was also found in adjacent Trench A. The relatively undisturbed nature of the stratification in Trench D is confirmed by the locations and frequencies of the artifacts. The main categories other than pottery, including chipped stone, ground and other stone tools, and bone artifacts, were all much more abundant in the Danilo levels than lower down. Very few of them seem to have been displaced. Notably, there was no obsidian in the lower, Impressed Ware levels. It should further be noted that the AMS dates from the trench are in stratigraphic order (Table 1, Figure 3).

Most striking, however, is that figulina is the only "typical" Middle Neolithic ware to be recovered from these lower levels, despite its minor role in the Middle Neolithic ceramic repertoire. If its presence in the earlier levels were due to mixing or postdepositional effects, one would expect to find at least some Danilo wares in the same contexts. This was not the case and supports our interpretations that these few fragments do indeed suggest an earlier presence of figulina at the site.

Figulina is present in all levels analyzed at Danilo Bitinj, indicating a clear presence of this type in central Dalmatia by 5300 cal BC. This stands in contrast to elsewhere on the eastern Adriatic coast, where figulina has a relatively late appearance, ~5200–4800 cal BC (Forenbaher et al. 2013:600–1). Although the identification of figulina in the earlier levels at Pokrovnik was surprising given the trends observed elsewhere in the region, figulina commonly overlaps with Impressed Wares in eastern Italy, beginning in the early 6th millennium BC (Robb 2007:170).

The Danilo-Vlaška wares on the northern coast mentioned earlier predate Danilo wares in central Dalmatia by several centuries. At Pokrovnik, Danilo wares appear by 5300 BC, and are present at Krivače and Danilo Bitinj, both with associated earliest dates of ~5300 cal BC (Table 1). The tem-

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poral framework of Danilo pottery supports Forenbaher et al.'s (2013:604) inference that Dalmatian Danilo wares may have originated in Istria and the Trieste karst, but developed independently into regionally specific Hvar wares in the Late Neolithic. Although none of the sites analyzed in this study span the entire Neolithic, the pottery assemblage from Čista Mala-Vel̆ištak is clearly a classic "outline style" pottery type with dates spanning 5000–4700 cal BC. Later phases of the Late Neolithic known from cave sites on the Dalmatian islands (Forenbaher and Kaiser 2008; Forenbaher et al. 2013) have yet to be identified on the central Dalmatian mainland.

It appears, then, that Early Neolithic ceramic sequences in central Dalmatia are more comparable to other Neolithic open-air villages in Italy than to caves and rockshelters on the northern end of the eastern Adriatic. There is some evidence of contact among peoples in the Adriatic during this period, including seafaring and the establishment of settlements on islands (Forenbaher 2009). However, we suggest that the similarities in ceramic assemblage composition and change through time on either side of the Adriatic may have little to do with direct contacts between areas, but rather more generally with the nature of ceramic production and consumption at village sites. Regardless of the myriad taphonomic issues of the archaeological record, we can safely assume that the majority of pottery found in caves and rockshelters was transported there for a reason, whereas we would expect a greater diversity of ceramics to have been produced, used, and discarded in villages. Given these issues, the disparities between data sets produced for the eastern Adriatic is not surprising. Why should we expect the pottery found in caves/rockshelters and contemporary villages to have been the same, when we know that the activities and duration of occupation at these locations were different? The key, instead, is to focus more energy on building independent chronological frameworks for early farming sites on the one hand, and understanding the mechanisms of pottery production, consumption, and discard on the other. As demonstrated here, the link between pottery style and chronology is more regional, tenuous, and nuanced than previously appreciated.

CONCLUSION

The eastern Adriatic is a key area for understanding the mechanisms and effects of the spread of agriculture into Europe. New AMS ^{14}C dates from Neolithic village sites in central Dalmatia are creating a temporal framework to assess these developments. Focused AMS ^{14}C chronologies are a relatively new line of research in the region; previous investigations used long-standing ceramic typologies to date archaeological sites and features. Our data shed light on the limitations of traditional ceramic chronologies for addressing fine-grained questions in subregions and archaeological contexts in the eastern Adriatic. Specifically, we are redefining the "suites" of ceramic wares that co-occur and their relative placement in time and space. With these more fine-grained approaches to chronology and pottery, we can begin to address issues of inter-regional contacts and similarities, the roles of caves, rockshelters, and villages to farming populations, and the social and economic relevance of shifts in ceramic technologies through time.

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