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BROADENING THE SCOPE OF BONE ANVILS: DIRECT AMS ^{14}C DATING FROM THE ISLAND OF MENORCA (WESTERN MEDITERRANEAN)

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ABSTRACT. This article presents the results of direct accelerator mass spectrometry (AMS) radiocarbon dating of a new bone anvil retrieved in the Iron Age–Roman site of Montefí (Ciutadella), in the southwest of the island of Menorca (western Mediterranean). The radiometric date confirms the chronology obtained through the stratigraphy and typological analysis of ceramics (1st–3rd century AD), and indicates that this bone-made tool not only represents the first archaeological anvil from the island but also constitutes the earliest evidence in the western Mediterranean. This ancient date is more consistent with the known eastern regional chronology and reinforces the importance of obtaining direct AMS ^{14}C dates to refine artifact chronologies.

KEYWORDS: bone anvil, Menorca, Roman ironworking, serrated sickles, western Mediterranean.

INTRODUCTION

For a long time, the ultimate function of a number of artifacts made of bone with a set of asymmetric rows of triangular indentations was an enigma that generated various explanations in the archaeological literature (Semenov 1964; Briois et al. 1995; Benco et al. 2002; Rodet-Belarbi et al. 2002). In the early 21st century, some ethnographic studies demonstrated that blacksmiths used these worked bones as an anvil to anchor the metal blade of a sickle while it was being cut to make a serrated edge (Aguirre et al. 2004; Esteban and Carbonell 2004). The characteristic triangular marks on these objects were the result from the hammering of the chisel on the bone surface. This technique of making toothed-blade sickles has been attested to be in use until the second half of the 20th century in Spain and Portugal (Moreno-García et al. 2007), and until today in Tunisia (Rodet-Belarbi et al. 2007; Anderson et al. 2014).

In recent years, the research has begun to focus on the establishment of the origin, chronological framework, and dispersal patterns of these implements. According to the last data summarized (Moreno-García et al. 2006; Rodet-Belarbi et al. 2007; Grau 2012; Anderson et al. 2014), the spatial distribution of the bone anvils is very wide, but mainly focused around the Mediterranean and Black Sea. The origin of these objects is still debated, but the data show that the earliest bone anvils were documented in the Hellenistic–Roman period in southeastern Europe (about 5th century BC to 2nd century AD; Beldiman et al. 2011, 2014), and in the Roman period for the central Mediterranean (2nd century BC to 1st century AD; Gál and Bartosiewicz 2012). In the western Mediterranean, at least 500 bone anvils from the Iberian Peninsula, north Africa, Sardinia, and France have been documented, thereby becoming the most explored region (Figure 1). However, the earliest artifacts in this zone have been dated to the 5th–7th centuries AD by pottery association (Moreno-García et al. 2006; Grau 2012; Anderson et al. 2014). This chronological gap of nearly 400–500 yr between the western and eastern part of the Mediterranean distribution implies that the bone anvil originated in the eastern Mediterranean (Beldiman et al. 2011, 2014).

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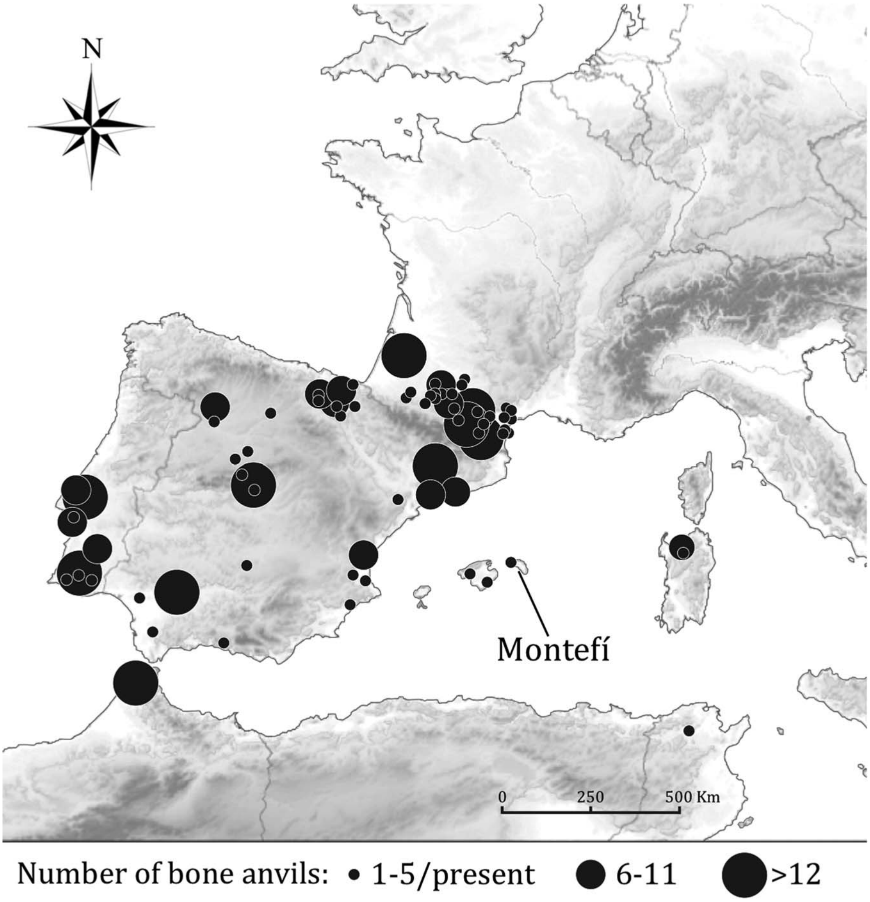

Figure 1 Distribution of sites with known bone anvils from the western Mediterranean (after Moreno-García et al. 2006; Rodet-Belarbi et al. 2007; Grau 2012; Anderson et al. 2014).

Other authors consider this geographic difference a bias of the archaeological record (Moreno-García et al. 2006; Gál and Bartosiewicz 2012; Grau 2012; Anderson et al. 2014).

In this paper, we report on a bone anvil recovered in the archaeological site of Montefí (Ciutadella), in the island of Menorca (Figure 1 and 2). This artifact was tentatively dated by pottery association between the 1st and 3rd century AD (Herránz and León 2007), challenging the temporal scope of the bone anvils in the western part of the Mediterranean. Through the direct accelerator mass spectrometry (AMS) ^{14}C dating, we present sound evidence for the chronological placement of the artifact, and offer new insights on the historical framework and implications that the spread of these craftsman tools entailed.

MATERIAL AND METHODS

During roadworks construction, a fragment of a bone anvil was identified in a new archaeological area at the southern edge of the prehistoric settlement of Montefí (Herránz and León 2007). This site, located in the southwest of the island of Menorca (western Mediterranean), features a number of well-preserved megalithic structures of the Iron Age although other chronological phases have also been documented (Herránz and León 2007). The artifact was recovered in the sediment

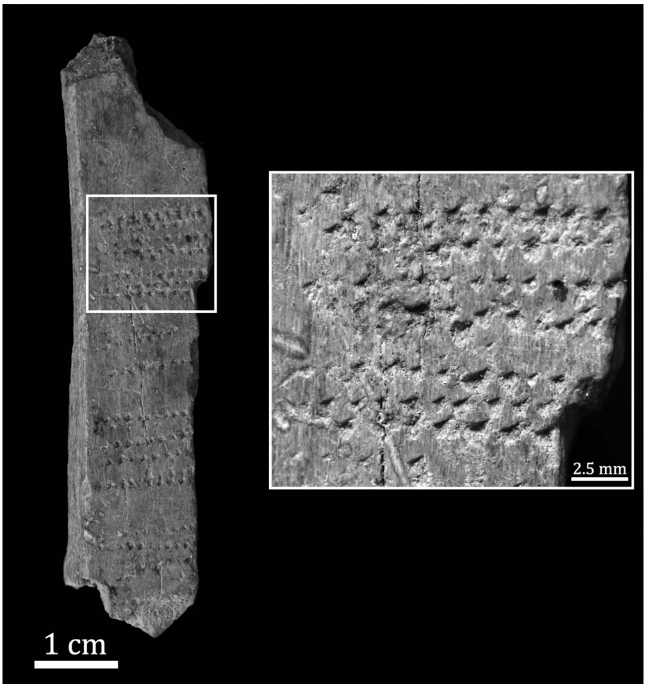

Figure 2 The bone anvil from Montefí, Menorca (MTF05-319-161)

(SU-319) filling a storage pit excavated on the natural limestone (Pit-17). This structure, globe-shaped with a cylindrical entrance and 2.3 m deep, contained several pottery shards, animal bones, and a human body. The pottery from within the infill has been provisionally dated between the 1st to 3rd centuries AD (Herranz and León 2007).

The bone anvil (MTF05-319-161) only retains a fragment of ~7.5 cm in length and was made on a cattle (*Bos taurus*) metapodial (Figure 2). This is in line with the archaeological record as most bone anvils correspond to fragments of diaphysis, proximal or distal halves of long bones of cattle, although other species and skeletal elements have also been observed (Rodet-Belarbi et al. 2002; Moreno-García et al. 2007; Beldiman et al. 2011). The small preserved section of the artifact limits our ability to identify in more detail the skeletal element or anatomical side. Both preserved sides of the metapodial show signs of having been smoothed down during the manufacture of the bone anvil, but just one presents the characteristic marks of its use (i.e. set of triangular marks disposed transversely to the axis).

A sample 38.6 mm long was selected from the broken end of the lateral side of the bone anvil and sent for AMS analysis to the KIK-IRPA Radiocarbon Laboratory facility in Brussels, Belgium. The pretreatment of the sample was conducted following the Longin (1971) method, but using a preparation line adapted for (small) AMS samples. A supplementary NaOH step (1%) to remove humic acids was added. The hydrolyzed sample was then freeze-dried. A 20.6-mg sample of the hydrolyzed protein was combusted and the CO_2 processed into graphite using a Fe/H_2 reaction (Van Strydonck and Van der Borg 1990–1991) and dated by AMS using a MICADAS (Boudin et al. 2015). A subsample of the hydrolyzed bone was used for C:N ratio and stable isotope measurements using a Thermo Scientific™ Flash EA/HT elemental analyzer, coupled with a Thermo Scientific™ Delta V™ Advantage isotope ratio mass spectrometer (IRMS) via a Conflo IV interface.

RESULTS

The AMS analysis of the bone anvil produced an age of 1905 ± 32 BP (RICH-22211). The carbon to nitrogen atomic weight ratio (C:N = 3.2) indicates that the bone protein was within recognized ranges for good preservation (C:N range of 2.9 and 3.6; DeNiro 1985). The other monitored parameters, including percentage collagen yield (2.9%), percentage of carbon (34.8%C), and percentage of nitrogen (12.5%N), also showed that the sample integrity and preservation were good. The calibration of this date was performed using OxCal v 4.2 (Bronk Ramsey 2009) with IntCal13 data (Reimer et al. 2013). The calibrated date, at two standard deviations (95.4% probability), has a range between cal AD 24 to 213. Taking into consideration a less restrictive but still very robust interval (91.5% probability), the dated bone anvil is situated between cal AD 24 to 178. Both age ranges are coherent with the previous pottery date of the archaeological context (i.e. 1st to 3rd century AD). It is therefore reasonable to postulate that the bone anvils were introduced in Menorca, at least, during the Roman period.

DISCUSSION

The bone anvil of Montefí is the first documented and published date of the Balearic Islands. This new evidence supports earlier claims that the temporal and spatial record of the bone anvils was not reflecting a real picture but a biased archaeological record (Moreno-García et al. 2006; Gál and Bartosiewicz 2012; Grau 2012; Anderson et al. 2014). Our survey has also documented two other unpublished bone anvils from Mallorca, but both come from Medieval and post-Medieval contexts (Can Oleo in Palma and Carrer de l'Estrella in Manacor). This evidence allows us to incorporate the Balearic Islands to the known geographic range where bone anvils were present.

However, it is in the temporal framework that the dated bone anvil from Montefí has its most significant implications. Recent age estimates based on associated pottery suggest that the earliest bone anvils may have first appeared in the western Mediterranean at roughly the 5th–7th century AD (Moreno-García et al. 2006; Grau 2012). This is around 300–400 yr later than the dated anvil of Montefí. Thus, the dated artifact we present not only represents the first archaeological anvil of the Balearic Islands but also constitutes the earliest evidence of the western Mediterranean.

Origin and Distribution of Bone Anvils

Traditionally, it has been pointed out that the earliest bone anvils come from Olbia in south-central Ukraine and are dated to the Hellenistic period (Moreno-García et al. 2007; Beldiman et al. 2011). Similar finds have been reported from the contemporaneous sites of Phanagoreia and Neapolis, also on the Black Sea coast (Semenov 1964). This has led to suggest the Black Sea Basin as place of origin of the bone anvil and from where it was dispersed to the Mediterranean (Beldiman et al. 2011, 2014). Unfortunately, the contextual information and by extension the chronology of all these bone tools remains poorly known (e.g. Grau 2012). However, within the same area, other bone anvils with a more archaeologically grounded context have been dated to the 1st–2nd centuries AD (Roman site of *Histria*; see Beldiman et al. 2011, 2014).

In the absence of more reliable data from the eastern regions, the earliest attested bone anvil comes from the central Mediterranean. It is a directly AMS ^{14}C-dated bone anvil found in a kiln deposit from Pantanello in southern Italy (Gál and Bartosiewicz 2012). The calibrated age at 2σ (i.e. 95.4% certainty) ranges from 190 BC to AD 10 (SUERC-30885; 2070 ± 35 BP).

Taking into account the new archaeological record for the western Mediterranean, the updated temporal framework for bone anvils suggests that they were probably produced for the first time during the early Roman period. Thus, bone anvils originated in the Italic Peninsula, and then spread across the Mediterranean as the Roman expansion was taking place. The spatial distribution of the earliest artifacts reflects a general coastal pattern, suggesting that the diffusion process may have been mediated through shipping routes. After this first phase, the scope of the bone anvils was extended into the continent where they became widespread, especially in Medieval times, when, as already pointed out, most archaeological specimens have been recorded (Moreno-García et al. 2006, 2007; Grau 2012; Anderson et al. 2014).

Tracking Metal Sickles with a Serrated Edge and Its Socioeconomic Implications

The interpretative value of these tools goes beyond determining the spatial and temporal scope of its distribution. The presence of a bone anvil is inherently linked to the use of toothed metal sickles and consequently to the agricultural practices that they imply (Anderson et al. 2014).

Agriculture was one of the key drivers of the Roman economy. Among the most important crops traded in this period (i.e. grains, olives, and grapevines), grain played a major role as staple food (e.g. Duncan-Jones 1982; Green 1986; Bowman and Wilson 2013). The sickle was a tool specifically associated in harvesting this cereal and although its manufacture was not a Roman innovation, it has been shown that some technical improvements took place at that time (White 1967, 1970; Mongez 1983). One of the conditioning factors of this change was the increased availability of the hitherto scarce iron metal (Margaritis and Jones 2009) and thus the potential to expand the repertoire of implements and the scale of production (White 1967).

Some ancient authors, such as Columella, Varro, and Palladius, mention different types of implements with curved blades (*falx*) that probably were designed to make full use of the exceptional fragmentation and variation of the Mediterranean landscapes and crops (e.g. Horden and Purcell 2000). Nevertheless, the ordinary sickle (*falx messoria*), either with a plain or serrated edge, was considered one of the most extended tools to harvest grain (White 1967).

Metal sickles with toothed cutting edges, as opposed to sickles with smooth blade, are regularly considered to be more efficient in crop harvesting (Sutjana 2000). This is particularity true for the Mediterranean climatic zone where cereal stalks tend to be tougher due to its high silica content (White 1967; Anderson et al. 2014). Compared with the smooth-edged sickle, the serrated sickle required little if any sharpening in the field, whereas smooth blades had to be resharpened as harvesting proceeded (McClelland 1997). This results in a reduction of working time loss maintaining the tool and hence to a higher harvesting capacity. Thus, tracking the development and use of these serrated sickles could provide new insights of past agricultural intensification processes.

One major constraint is the small number of such tools in the archaeological record. This is probably due to the fact that iron tools are usually recovered fragmented and their state of preservation does not always allow the identification of specific features (Olsen 1988). For this reason, although Roman iron sickles have been reported (e.g. Sanahuja 1971; Mezquíriz 2007–2008), it is not always easy to identify the specific presence of toothed blades (Anderson et al. 2014). In this regard, it becomes evident that tracking the better-preserved bone anvils would have an important role to play, at least in those areas where they were used in the manufacture of metal sickles with a toothed edge (Poplin 2009).

CONCLUSIONS

Understanding regional processes requires a solid grasp of the temporal relationship between objects and events. Following previous works (e.g. Rick 2001; Gál and Bartosiewicz 2012), this paper highlighted the use of directly AMS-dated artifacts to develop chronologies and trace the dissemination of technological change.

The ^{14}C dating presented here significantly refines the chronology of the presence of bone anvils in the western Mediterranean, suggesting that these artifacts appeared around the Roman period. At the same time, these new data also open the possibility that the dispersion of this craftsman's tool could have occurred in a relatively short period of time following the Roman expansion.

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REFERENCES

Aguirre A, Etxeberria F, Herrasti L. 2004. El yunque de hueso para afilar la hoz metálica dentada. *Munibe* 56:113–21.

Anderson PC, Rodet-Belarbi I, Moreno-García M. 2014. Sickles with teeth and bone anvils. In: van Gijn A, Whittaker J, Anderson PJ, editors. *Exploring and Explaining Diversity in Agricultural Technology*. Oxford: Oxbow Books. p 118–25.

Beldiman C, Sztancs DM, Rusu-Bolineţ V, Achim IA. 2011. Skeletal technologies, metal-working and wheat harvesting: ancient bone and antler anvils for manufacturing saw-toothed iron sickles discovered in Romania. In: Baron J, Kufel-Diakowska B, editors. *Written in Bones. Studies on Technological and Social Contexts of Past Faunal Skeletal Remains*. Wrocław: Uniwersytet Wrocławski. p 173–86.

Beldiman C, Rusu-Bolindeţ V, Sztancs DM, Bădescu A. 2014. Bone artefacts from Histria. *Materiale şi cercetări Arheologice* 10:221–41.

Benco NL, Ettahiri A, Loyet M. 2002. Worked bone tools: linking metal artisans and animal processors in medieval Islamic Morocco. *Antiquity* 76(292): 447–57.

Boudin M, Van den Brande T, Synal H-A, Wacker L, Van Strydonck M. 2015. RICH – a new AMS facility at the Royal Institute for Cultural Heritage. Brussels, Belgium. *Nuclear Instruments and Methods in Physics Research B* 361:120–3.

Bowman A, Wilson A. 2013. *The Roman Agriculture Economy: Organization, Investment, and Production*. Oxford: Oxford University Press.

Briois F, Poplin F, Rodet-Belarbi I. 1995. Aiguisoirs, polissoirs médiévaux en os (XIe-XIVe S.) dans le sud-ouest de la France. *Archéologie du Midi Medieval* 15:197–213.

Bronk Ramsey C. 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51(1):337–60.

DeNiro MJ. 1985. Postmortem preservation and alteration of *in vivo* bone collagen isotope ratios in relation to palaeodietary reconstruction. *Nature* 317(6040):806–9.

Duncan-Jones R. 1982. *The Economy of the Roman Empire*. Cambridge: Cambridge University Press.

Esteban M, Carbonell E. 2004. Saw-toothed sickles and bone anvils: a medieval technique from Spain. *Antiquity* 78(301):637–46.

Gál E, Bartosiewicz L. 2012. A radiocarbon-dated bone anvil from the chora of Metaponto, southern Italy. *Antiquity* 85(331): http://antiquity.ac.uk/projgall/gal331/.

Grau I. 2012. Agriculture and ironwork in the Middle Ages: new evidence of bone anvils in Spain. *Munibe* 63:305–19.

Green K. 1986. *The Archaeology of the Roman Economy*. Berkeley: University of California Press.

Herranz M, León MJ. 2007. Excavació arqueològica de la Ronda Sud. In: *L'arqueologia a Menorca: eina per al coneixement del Passat*. Maó: Consell Insular de Menorca. p 185–94.

Horden P, Purcell N. 2000. *The Corrupting Sea: A Study of the Mediterranean Sea*. Oxford: Blackwell.

Longin R. 1971. New method of collagen extraction for radiocarbon dating. *Nature* 230(5291):241–2.

Margaritis E, Jones MK. 2009. Greek and Roman agriculture. In: Oleson JP, editor. *The Oxford Handbook of Engineering and Technology in the Classical World*. New York: Oxford University Press. p 158–74.

McClelland P. 1997. *Sowing Modernity: America's First Agricultural Revolution*. Ithaca: Cornell University Press.

Mezquíriz MA. 2007–2008. Instrumentos de hierro para la explotación agropecuaria en época romana. *Trabajos de Arqueología Navarra* 20:197–228.

Mongez A. 1983. *Mémoires sur les instruments d'agriculture employés par les anciens*. Naples: Jovene Editore.

Moreno-García M, Esteban M, Pimenta CM, López MD, Morales A. 2006. Los yunques de hueso en la Península Ibérica: estado de la cuestión. In: Bicho NF, editor. *Animais na Pré-história e Arqueologia da Península Ibérica, actas do IV Congresso de Arqueologia Peninsular, 14–19 Setembro de 2004*. Faro: Universidade do Algarve. p 247–62.

Moreno-García M, Pimenta CM, López PM, Pajuelo A. 2007. The signature of a blacksmith on a dromedary bone from Islamic Seville (Spain). *Archaeofauna* 16:193–202.

Olsen SL. 1988. The identification of stone and metal tool marks on bone artefacts. In: Olsen SL, editor. *Scanning Electron Microscopy and Microwear of Bone Artifacts*. British Archaeological Reports, International Series 452. Oxford: Archaeopress. p 337–59.

Poplin F. 2009. Des os supports à denter les faucilles: une longue histoire technologique dans le basin de la Méditerranée et de la mer Noire. *Bulletin de la Société Nationale des Antiquaires de France* 2007:215–21.

Reimer PJ, Bard E, Bayliss A, Beck JW, Blackwell PG, Bronk Ramsey C, Buck CE, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Haflidason H, Hajdas I, Hatté C, Heaton TJ, Hoffman DL, Hogg AG, Hughen KA, Kaiser KF, Kromer B, Manning SW, Niu M, Reimer RW, Richards DA, Scott M, Southon JR, Staff RA, Turney CSM, van der Plicht J. 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. *Radiocarbon* 55(4):1869–87.

Rick TC. 2001. AMS radiocarbon dating of a shell fishhook from Santa Rosa Island, California. *Radiocarbon* 43(1):83–6.

Rodet-Belarbi I, Forest V, Gardel ME, Guinouvez O. 2002. Aiguisoirs-polissoirs médiévaux en os (VIIe-XIVe s.). Nouvelles données. *Archéologie du Midi Medieval* 20:149–53.

Rodet-Belarbi I, Esteban M, Forest V, Moreno-García M, Pimenta CM. 2007. Des aiguisoirs/polissoirs aux enclumes en os: l'historiographie des os piquetés. *Archéologie Médiévale* 37:157–67.

Sanahuja ME. 1971. Instrumental de hierro agrícola e industrial de la época ibero-romano en Cataluña. *Pyrenae* 7:60–110.

Semenov SA. 1964. *Prehistoric Technology*. London: Cory, Adams and Mackay.

Sutjana D. 2000. Use of serrated sickle to increase farmer's productivity. *Journal of Human Ergology* 29(1–2):1–6.

Van Strydonck M, Van der Borg K. 1990–1991. The construction of a preparation line for AMS-targets at the Royal Institute for cultural heritage Brussels. *Bulletin of the Royal Institute for Cultural Heritage* 23:228–34.

White KD. 1967. *Agricultural Implements of the Roman World*. Cambridge: Cambridge University Press.

White KD. 1970. *Roman Farming*. London: Cornell University Press.