The identification of the sample dated as Wk-26796: what that tells us about Cabeço da Amoreira, Muge, Portugal

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Abstract

The transition from the Mesolithic to the Neolithic in Portugal is complex, involving a cultural mosaic and probable overlap of the two ways of life for at least half a millennium. Much can hinge on a single radiocarbon date and the dating of specific sites. A major question relates to Late Mesolithic sites along the Muge and Sado rivers in central Portugal, and the suggestion that both act as Mesolithic enclaves between *ca.* 7500 and 6900 cal BP, parallel to the earliest Neolithic sites on the Atlantic coast of Portugal. We look at the youngest dates on human remains from Cabeço da Amoreira in discussing the nature and affiliation of the uppermost levels of the site, with some emphasis on one sample that has been dated but not identified. We identify the material dated and differentiate it from adjacent human remains, providing basic information on one of the two youngest dated human skeletal elements recovered in the Mesolithic context at Muge, making it central to any full understanding of the transition.

1 Introduction: the context

The transition from the Mesolithic to the Neolithic in Portugal is complex, no doubt involving a cultural mosaic. As such, the dating of specific sites becomes important, especially that of the important Late Mesolithic sites along the Muge, a tributary of the Tagus, the major river of central Portugal. The provision of full information on the Muge Mesolithic dates is central to a clear understanding of the transition.

Publication without identification of the radiocarbon date Wk-26796 (Bicho *et al.* 2011, 2013) has led to questions about the human remains referred to by Bicho as "CAM-01-01". The date was obtained

from a human bone sample from Cabeço da Amoreira, Muge, Portugal (henceforth Amoreira), excavated in 2001. The work was directed by Jose Rolão, with the excavations of the human remains carried out by Mirjana Roksandic. The excavation opened a 4 x 6 m trench yielding both human and faunal materials. Which bone from the 2001 excavation was dated by Wk-26796? The identity of the sample remained unknown despite requests for information and an appeal in print (Jackes & Lubell 2016: 670). Understanding "CAM-01-01" is relevant to any discussion of the suggestion that the upper level of the Amoreira shell midden was used for Neolithic burial following abandonment of the site by the preceding Mesolithic population (Bicho *et al.* 2011, 2013, 2017; Taylor *et al.* 2021).

The 2001 trench contained elements from at least three individuals, a fourth having also been mentioned by Roksandic (2006). Three different numberings of the principal individuals have been used in the literature, the original by the excavators in 2001 (Roksandic 2006; Rolão & Roksandic 2007), a revised number sequence by Ferreira *et al.* (2015), and amalgamation of all material under a single number, "multiple burial CAM-01-01", by Bicho *et al.* (2011, 2013, 2017)[1]. The text below uses the original numbering (Roksandic 2006).

The best represented individual was a young woman in partial articulation, identified as CAM-01-01. As shown in Figure 1 many bones and fragments were preserved, although with horizontal and vertical separation, lying 20 to 60 cm below the modern land surface. The skeleton was found in Square A1-1 (the original three 2 m^2 squares were each subdivided into 1 m^2 quadrants labelled 1, 2, 3 and 4). Additional units were opened to the south and east, exposing further bones scattered over an area of *ca.* 2 x 2 m (Rolão & Roksandic 2007). The oval perimeter of the main part of the skeleton is shown in Figure 1. Original identification of sex was based on pubic morphology with age based on the unfused iliac crest, providing an estimate of <20 years. Ferreira *et al.* (2015: 206) specified an age of 15 to 20 years, based on the dentition, the unfused ilium and the sternal end of the clavicles.

The second individual, CAM-01-02, was a foetus with bones scattered and well separated from CAM-01-01 in quadrants A1-3 and A1-4. A gestational age estimation of *ca.* 36 weeks was given by Ferreira *et al.* (2015: 204). Ferreira (2003) used Hungarian data (Fazekas & Kósa 1978) for her age estimate. She provides diaphyseal lengths for the right femur (bone fragments 68 + 69, 63 mm) and right tibia (bone 110, 55 mm), which suggest a lower age, perhaps *ca.* 33 weeks, based on more recent relevant evidence (Carneiro *et al.* 2016: Tables 5 and 6). The left humerus (bone 70) is far to the lower right in Figure 1, illustrating the separation of some of the bones of this one individual, within the dotted line.

A third individual was also present, numbered CAM-01-03 in the sequence used by the excavators. It was represented by fragmentary adult bones, all robust, including three femoral fragments identified in the field (bones 11, 164 and 177 are identified in Figure 1; 164 and 177 could be reconstructed). They were widely scattered beyond, but around, the location of the young female, with some marked as E in published plots (Roksandic 2006: Figure 5; Rolão & Roksandic 2007: Figure 8.4) and in Figure 1 below.

Roksandic (2006) also indicated the presence of a fourth individual, a subadult, represented by fragments of a scapula and a radius, not mentioned in later descriptions and not given a number. The scapula fragment (bone 172) is identified by E* in Figure 1: the radius was excavated from square A3-4, at several metres distance.

[1]Burials were also recovered in 2000 from the lowest level of the site. These were identified as CAM-00-01 and CAM-00-02 (Roksandic 2006). The inclusion of one of the burials in the 2001 upper level material by Bicho *et al.* (2011, 2013, 2017) is discussed below.

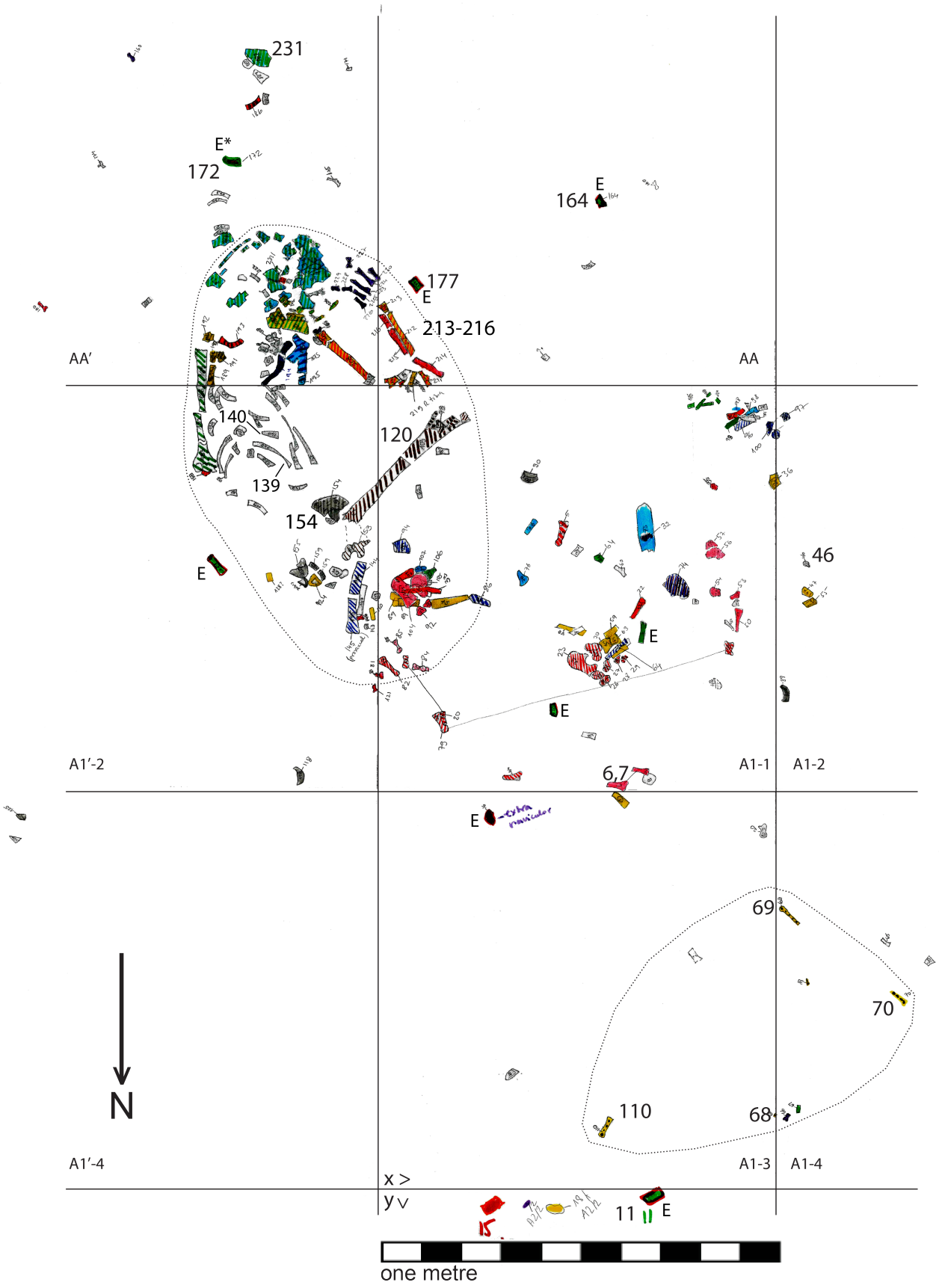

Figure 1: Field plot drawn by Roksandic in 2001 showing the location of the young female burial outlined to the upper left with the skull and dentition in AA' to the southeast. The lower right dotted line indicates some of the dispersed foetal bone positions. The positions of femur fragments 11, 164 and 177 and other bones mentioned in the text are indicated.

Finally, Roksandic (2006: 45; Rolão & Roksandic 2007: 80) noted an "additional femoral fragment with signs of excessive weathering not observed on any other bone from the assemblage". This bone, number 46 in quadrant A1-2 (Figure 1), was included in the "multiple burial CAM-01-01" by Bicho *et al.* (2017). The stable isotope data suggest that the bone is likely to be from a terrestrial mammal, with a δ^{15}N value outside the human range (Jackes & Lubell 2015: 61, Table 2; 2016: 670). The weathered condition and an unacceptable C:N atomic ratio of 4.4 (Schwarcz & Nahal 2021), indicating poor preservation, suggest an exogenous source.

As mentioned above, Ferreira *et al.* (2015) renumbered the individuals: the foetus was identified as CAM-01-01; the robust adult as CAM-01-02; and the late adolescent female as CAM-01-03. Beginning with Bicho *et al.* (2011, 2013), work by Bicho and colleagues has consistently used "CAM-01-01" for all three individuals, interpreting the 2001 finds as a "multiple burial", a term implying that the individuals recovered were part of an identifiable event, whether synchronous or stretched over a defined period of time. While "multiple burial" indicates a single unit, we note that the fragments of the robust adult and foetus, as well as the extra subadult, lay beyond the original limits of the CAM-01-01 *sensu stricto* identified in Figure 1 (Roksandic 2006; Rolão & Roksandic 2007). All are in a disturbed context, with the presence of Roman and post-Roman ceramic sherds. Rolão and Roksandic (2007: 82, Figure 8.7) provide details of the vertical distribution of intrusive materials.

The adult male, CAM-01-03 according to the original numbering, is much more fragmentary than suggested by Ferreira *et al.* (2015) who ascribed the lower limbs of CAM-01-01 to CAM-01-03 despite the clear association of those elements with the former, the young female (see Figure 1). The still incomplete right tibial shaft reconstructed from 22 fragments (Ferreira *et al.* 2015: Figure 16.4), exemplifies this. Sixteen of these fragments, reconstructed by Roksandic in the field laboratory, are identified in Figure 1 by the yellow colour, spread out as far as quadrant A1-2. Most were in close association with the partially scattered feet, shown in Figure 1 in striped red (right) and solid red (left) respectively.

As Figure 1 shows, the left foot was well positioned to accord with the location of the left ilium (bone 154) and tibia (bone 120), suggesting a typical Amoreira *dorsal decubitus* Mesolithic burial with flexed knees and feet drawn in close to the pelvis (Roksandic & Jackes 2014). While an apparent contradiction exists between the fragmentation of the right tibia and the almost complete preservation of the paired tarsals, the left foot still within the postulated burial limits of the young female, the original upright flexing of the knees would have made a tibia or femur maintaining the upright position vulnerable to damage.

The original field allocation of the foot bones to CAM-01-01, the young female, accords with the interpretation of the burial posture. However, the tarsals were said (Ferreira *et al.* 2015: 205) to be male because they are among "the most robust of the entire Muge series", but this is questionable. Talar measurements are available (Ferreira 2003) and can be compared with those from the 1880s excavations at Moita do Sebastião, *ca.* 800 m from Amoreira on the same bank of the Muge River. The length (Martin 1) of the talus (53 mm) is smaller than in 11 of 28 Moita individuals with a measurable talus, with a range of up to 58 mm. The 1880s Cabeço da Arruda tali ranged up to 60 mm in two individuals. The robusticity of the tarsals is said to contrast with the smaller upper limb bones. The CAM-01-01 humerus is described as gracile (Ferreira 2003) but, with the epicondylar breadth at 54 mm, it is the same as, or larger than, six of 21 individuals with epicondylar preservation from the 1880s Moita excavations[2]. There appears to be little reason to ascribe the lower limb bones to the robust male rather than to the young female.

[2]Excluding Moita xiv who had an abnormality of the distal humerus (Jackes 2004: Figure 4b).

Based on the information in Figure 1, as well as the fact that the tarsals are less than extreme in their robusticity, we confirm conclusions laid out in detail in Rolão & Roksandic (2007: 161) on the burial posture, as well as identification of the skeletal elements distal to the female innominate as those of the young female. Individual CAM-01-01 was widely dispersed, a spread of over two metres, as shown in Figure 1 which identifies a cranial fragment, bone 231, to the southeast and, at the northern edge of square A1-1, bones 6 and 7 which are fragments of her left MTIV. Thus, the few fragments belonging to the fully adult individual, apparently a robust male, lie beyond the postulated outline of the young female burial, and are widely scattered.

2 The dates and the questions

Two dates are associated with the burials excavated in 2001; TO-10225, first published in 2006, and Wk-26796 (Bicho *et al.* 2011). A third date, TO-10218, has been incorrectly published as from work in 2001.

TO-10218 was published by Roksandic (2006; see also Rolão *et al.* 2006), identified as from burial CAM-00-01, excavated from the base of the site in 2000. Taylor *et al.* (2021) identify TO-10218 as "(t)he second burial" in the CAM-01-01 group, with TO-10225 as the earliest and Wk-26796 as the youngest. The implication is that all three individuals from 2001 have been dated. However, TO-10218 is not from the CAM-01-01 group and has been withdrawn on several occasions (Meiklejohn *et al.* 2009; Jackes & Lubell 2015, 2016), replaced by TO-11819-R. Moreover, both Isotrace (i.e. TO) dates are used by Bicho *et al.* (2013) in a Bayesian analysis, with TO-11819-R correctly identified as the oldest date obtained on human remains from the basal level of the site and TO-10218, though withdrawn, identified as the second youngest date obtained on human remains.

There are only two dates on human material from the 2001 trench, TO-10225 and Wk-26796. TO-10225 is from the young woman, identified by Roksandic (2006; see also Jackes & Lubell 2015)[3].The stable isotope data for this individual (Table 1) suggests a terrestrial diet. Bicho *et al.* (2011) interpreted the $\delta^{13}C$ value as indicative of a Neolithic origin for TO-10225. This led to strontium ($^{87}Sr/^{86}Sr$) ratio analysis by Price (2015), showing the woman to have had a possible origin in the Ossa-Morena Zone which is part of the central Iberian Hesperian Massif (San José *et al.* 2004). From this, Bicho *et al.* (2017) correctly indicated that the individual was of "exogenous" origin, and from the $\delta^{13}C$ value calculated a diet with 0% marine input[4].

The CAM-01-01 $^{87}Sr/^{86}Sr$ ratio (0.7166, Price 2015: Figure 17.1) proves that she could not be originally from the Muge area, nor is the ratio consistent with an origin in an area of limestone in Estremadura (Waterman 2012; Price 2014; Carvalho *et al.* 2019), the area north of the Tagus River from which a Neolithic individual might be expected to have come in the earliest Neolithic. At present, the closest match appears to be to the Alentejo area of Perdigões, at least 120 km southeast of Muge. This is an area that is not known archaeologically for an Early Neolithic occupation, the earliest is Late Middle Neolithic. The Perdigões local bioavailable strontium isotope range, reaching close to 0.717, with a geological background of granites and schists, is now well established (Valera *et al.* 2020).

[3]Collagen extraction and stable isotope analysis were undertaken at McMaster University.

[4]Amoreira data listed in Bicho *et al.* (2017) were variously calibrated using -20 to -12‰ and -21 to -12‰ marine/terrestrial endpoint ranges, though neither range is explicitly mentioned. The Waikato samples listed accord with the -21 to -12‰ range used by that laboratory. The marine/terrestrial endpoints used for TO-10255 are not specified, but the 0% marine input is consistent with a -20 to -12‰ endpoint range.

*Table 1: Calibrations (Calib8.2) using ΔR_{Tagus} = -70 ± 126 ^{14}C years (Marine20; Heaton et al. 2020) with δ^{13}C endpoint values set at —10.1 and —21.7‰, those used by Jackes et al. (2016). The results are not rounded. Amoreira 3, 1931 (Peyroteo-Stjerna 2021: 22) is discussed below. Key: *, unpublished.*

Date (BP)	Lab ID	Source	δ^{13}C	δ^{15}N	C/N	Marine diet (%)	Cal BP 68% prob. (1σ)	Cal BP 95% prob. (2σ)	Cal BC 68% prob. (1σ)	Cal BC 95% prob. (2σ)	Median probability (age BP)
6329 ± 40	Wk-26796	CAM-01-01 male femur 177	-16.9	12.3	<3.6*	41.4	6899-7151	6789-7227	4950-5202	4840-5278	7001
6550 ± 70	TO-10225	CAM-01-01 female rib 139	-20.1	8.2	3.4	13.8	7310-7466	7255-7562	5361-5517	5306-5613	7379
-	-	CAM-01-01 female rib 140 [5]	-19.3		3.2	20.7	-	-	-	-	-
6770± 40	Beta-447686	skeleton 3 1931 left humerus	-15.7	13.0	3.4	51.7	7316-7482	7250-7569	5367-5533	5301-5620	7399

Secondly, though the stable isotope values associated with TO-10225 are at one end of the range for individuals from the Muge/Magos region, they accord perfectly with many of the dated Mesolithic individuals from the Sado Valley to the south (Peyroteo-Stjerna 2016, 2021). Those with δ^{13}C values of -19.8‰ and lower are as follows, two from Cabeço do Amoreira, three from Cabeço do Pez, two from Vale de Romeiras and one from Várzea da Mó. Except for the three from Cabeço do Pez, all δ^{15}N values are below 8.7‰. If the burials from the upper level of Amoreira are identified as Neolithic based on their stable isotope values, so should many of the Sado midden burials. The young woman, CAM-01-01, as an "incomer", would have had a relatively recent change in diet, since she could not have come from the Sado Basin based on her ^{87}Sr/^{86}Sr value.

We cannot view the calculation of dietary proportions as definitive – for example, another rib from the same individual (bone 139, Jackes & Lubell 2015) suggests a marine dietary component of 21% (see Table 1). Such variations are not unexpected (Jackes *et al.* 2019: 17-18), and although making little difference to the radiocarbon date, perhaps a decade or two, variations have implications if attributions rely solely on the marine dietary component.

A Neolithic association for TO-10225 has also been questioned based on the calibrated radiocarbon date (Jackes & Lubell 2012: 68; Jackes *et al.* 2016: footnote 1; Jackes & Lubell 2016: 670-671; Peyroteo-Stjerna 2021: 4, 28-29; Meiklejohn in prep.). Recalibration using CALIB 8.2 (Stuiver *et al.* 2021) indicates a median probability date of nearly 7400 cal BP, based on a marine dietary component of 13.8% (Table 1). This dates the TO-10225 individual as younger than some of the earliest Neolithic communities in Estremadura. Zilhão (2021) has recently demonstrated that people were buried in Cardial levels in inland limestone cave sites. In the Galeria da Cisterna, above the source of the Almonda River (Torres Novas), the oldest human material has a median probability age of 7299 cal BP (S-EVA-2741, 6380 ± 21 bp), while the oldest human material from the Gruta do Caldeirao (Tomar), *ca.* 40 km to the NE, had a median probability age of 7368 cal BP (Wk-38578, 6452 ±29 bp). There are at present no confirmed Early Neolithic sites in inland Alentejo[6].

The identification of the second individual, dated by Wk-26796, though consistently used in discussion of the upper levels of Amoreira, has never been made clear. The initial linkage of Wk-26796 to a specifically identified individual is in Jackes *et al.* (2016: Figure 2). The identification is related to the

[5]Collagen from bone 139 was sent to Isotrace from Henry Schwarcz's laboratory at McMaster University for dating. The collagen yield from bone 140 was very much lower and the δ^{15}N value could not be determined (in litt. to D. Lubell, 24/v/2002).

[6]A single early date on charcoal, Beta-310057, with a median probability of 7539 cal BP, from a site just south of the Tagus is, however, recorded (Gonçalves & Sousa 2018).

stable isotope values shown in the figure, and the caption states that "(t)he individual labelled 2001-02 is assumed to be CAM-01-02 (as listed in Ferreira *et al.* 2015)[7], since CAM-01-01 is perinatal."

The expectation was that the individual could not be perinatal because the δ^{15}N stable isotope values were not high. That assumption may have been unfounded since some studies indicate that perinatal values differ from later high δ^{15}N values in nursing infants (Mays *et al.* 2002: 655). On the other hand, there is increasing evidence that perinatal values may in fact differ from those of the mother not only in bone, but in hair, where δ^{15}N values were found to be "consistently higher in newborns than in their own mothers" (de Luca *et al.* 2012). Kinaston *et al.* (2009) and Bourbou *et al.* (2019) also state that foetal/perinatal bone exhibited δ^{15}N values higher than those of the females in their samples. The effect of these studies can be gauged from the comment by Siebke *et al.* (2019: 664–665) that "(o)verall, our data support the growing awareness that bone collagen δ^{15}N values of neonates/infants should not be used as a proxy for breastfeeding or birth survival on its own". From the above sources it became entirely unclear whether Wk-26796 dated a foetus, a full term neonate or an adult.

Before turning to the solution to this conundrum, we note that two further sources looked at the identification of Wk-26796 recently, coming to different conclusions. Cubas *et al.* (2019: Supplementary Material, ESM 1) identified Wk-26796 as dating a "Subadult, 36 months". Peyroteo-Stjerna (2021) correctly indicated that identifying information on Wk-26796 was not available.

3 The answers

In light of the above, the University of Waikato Radiocarbon Dating Laboratory was contacted to enquire whether evidence confirming the identity of the dated individual might be available. From this it was learnt that the Wk-26796 sample was submitted to Waikato in a bag labelled "femur frag" from "Sk. 3", aligning with Roksandic's field designation. During processing of the sample, it was noted to be "thick solid bone". The bone was broken to exclude glue or ink from the analysis: the remnants are up to a square cm or more in size with a cross section of 9 mm. The bone was clearly from a robust individual, as seen in Figures 2 and 3, and not from a foetus. The conclusion is that the dated bone was from the presumed male adult, CAM-01-03 according to the 2006 numbering system.

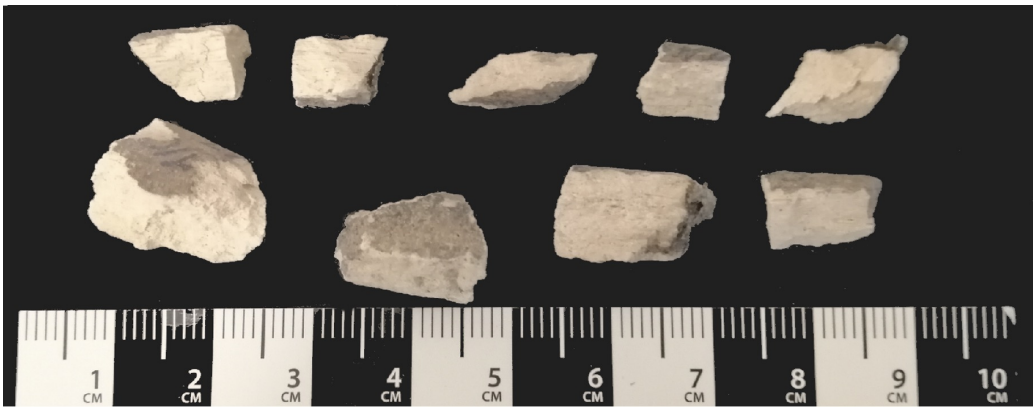

Figure 2: Surviving fragments of the sample sent to Waikato (photograph Fiona Petchey).

[7] As noted earlier, the numbering of individuals by Ferreira and colleagues is different from those assigned by Roksandic (2006). CAM-01-02 here referred to the adult male.

Figure 3: Identification of a bone fragment at 16x magnification, with glue on the end to the right, confirming that this is 164 which was glued to fragment 177 (photograph Fiona Petchey).

The bone dated was number 177, and it was initially glued to bone 164 (Figures 1 and 3). It was originally part of the small group of highly fragmented and scattered bones (Figure 1, Table 2) of what was apparently a robust adult. The dated bone (number 177) is shown in Figure 1 to be near the long bones of the left forearm of the female: the radius and ulna (bones 213-216) were however around 17 cm deeper, that is, the fragments labelled E in Figure 1 were higher in the 2001 trench than the bones of the young female. The proximity of a bone like 177 to the modern surface can be gauged by reference to Figure 15.5 in Rolão and Roksandic (2007: 161) which shows bone 120, the left tibia of CAM-01-01, in the east profile of square A1. The bone lies on a discontinuous layer of shell breccia *ca*. 20 cm below the surface: bone 177 must have been very near the surface.

From the above, it is clear that Wk-26796 dates the remains of the robust adult, with a *ca*. 41% marine diet, and a median probability age of 7000 cal BP (Table 1). This is the youngest date obtained on human bone at Amoreira by several hundred years, and, although the remains of the male were found in the same area as those of the young female, the male was considerably younger than the *ca*. 7400 cal BP median probability age of the young female.

Table 2: Field inventory of reconstructed femoral fragments relevant to the identification of Wk-26796

Number	Date	Square	x	y	z	Bone	Portion
164	1/x/2001	AA	56	56	150	Femur	Midshaft
177	1/x/2001	AA	10	26	143	Femur	Midshaft

The context of the two dates on human material can be examined further by reference to four other ^{14}C dates (see Figure 4) on material recovered from the 2001 Amoreira trench. Bicho *et al.* (2017: Table 1) states that all are from "Level 3, cairn", which was specified as also containing the "CAM-01-01 multiple burial". These six dates should be of roughly the same age if the level was undisturbed. The youngest, TO-11861 (Jackes & Lubell 2015: Table 4) from A1-3, Level 3, has a median probability date of 6808

cal BP (CALIB 8.2)[8].

However, mammal collagen from Square A3, Level 3 in the same 2001 trench has a median probability age of around 7400 cal BP, *ca.* 600 years older (Sac-2102, Martins *et al.* 2008). Figure 4 illustrates that the probability distributions of shell dates Sac-2079 and Sac-2080 from Square A3, Level 3 (Martins *et al.* 2008) accord with the faunal date, Sac-2102, and the young female, CAM-01-01 of Roksandic, dated by TO-10225. Though the four lower dates in Figure 4 are generally contemporaneous, TO-11861 and Wk-26796, the robust male, are both younger but also just significantly different in age from each other (t = 13.977, 1 df, p = 0.045, CALIB 8.1, Reimer *et al.* 2020). These six dates, all from the upper portion of the 2001 Amoreira trench, clearly show that the upper level is disturbed; in this they accord with other evidence from the Muge sites. Jackes and Lubell (2016: 671) draw attention to Roche's 1960s Amoreira north-south profile which showed that pieces of breccia "floated" in a very large area of disturbance (eight metres north-south, over one metre deep) no more than three metres from the 2001 trench. Similarly, the photograph mentioned above, of the east profile of A1.1 and A1.2 (Rolão & Roksandic 2007: 161), showing also the eastern end of the south profile, together with the southern and western A.1 section profiles (Rolão *et al.* 2006: 38, Figure 3), suggest that Level 3, as defined by Rolão in the profiles, was discontinuous, perhaps resulting from disturbance similar to that captured in detail in Roche's work.

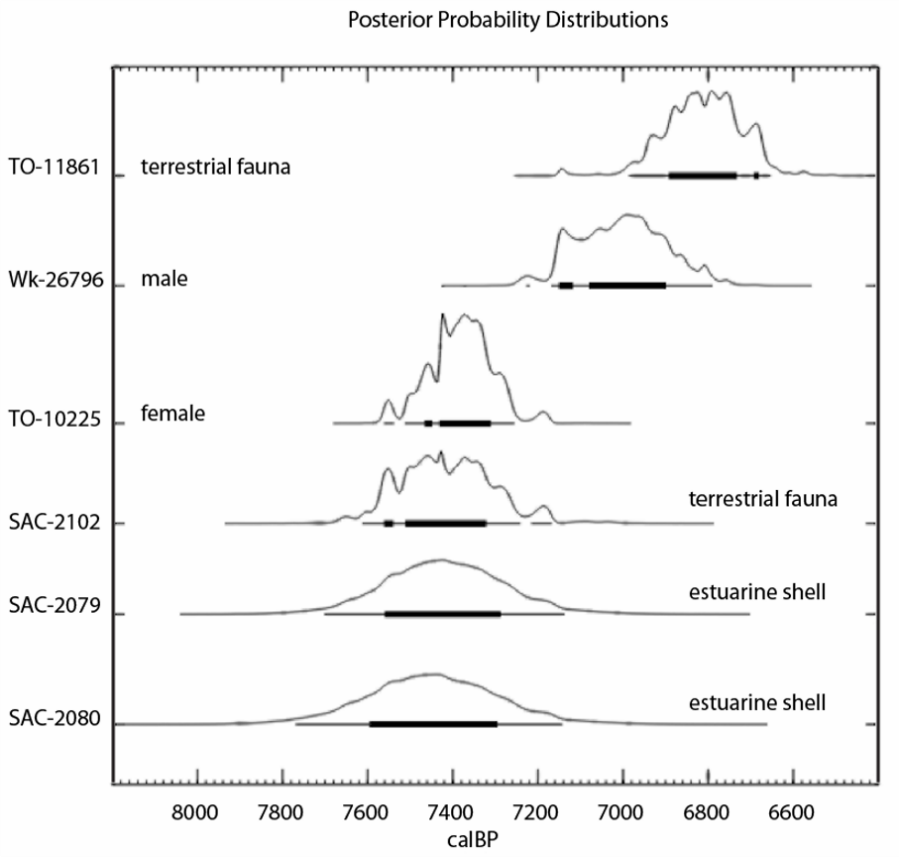

*Figure 4: Probability distributions (Calib8.2) of dates for human and faunal bone and shell (*Cerastoderma edule *and* Scrobicularia plana*) excavated from the 2001 trench at Cabeço da Amoreira: the three Saclay dates are from A3, the other three from square A1.*

[8]Collagen extracted at the Isotrace Laboratory, University of Toronto, stable isotope analysis undertaken by the Environmental Isotope Laboratory, University of Waterloo. Note the C:N atomic ratio of 3.7 indicating poor preservation.

Further information relevant to the context of the 2001 trench derives from the roughly contemporaneous date of Amoreira 3 from the 1930s Mendes Correia excavations (Figures 5 and 6) with the young female, CAM-01-01. The two lay *ca.* 12 m apart (Jackes *et al.* n.d.). Amoreira 3 (1931) at 6770 ± 40 BP (Beta-447686, Peyroteo-Stjerna 2021), gives a median probability of 7400 cal BP with a marine dietary component of 52%, using marine/terrestrial endpoints of -10.1 and -21.7‰. Peyroteo-Stjerna's (2021) Bayesian analysis of the Amoreira dates includes all three dates, TO-10225, Wk-26796 and Beta-447686, into a Model 2 third phase of burial activity at Amoreira. Both the young female from 2001 and Amoreira 3 from 1931 (Figure 5) were recovered only 20 cm below the surface, and have essentially identical date ranges (Figure 6). Calibrated age ranges at 95.4% (2σ) are 7270-7560 and 7250-7570 cal BP respectively, suggesting a *terminus post quem* of around 7400 cal BP for the third phase at the site, this phase lasting until perhaps 7000-6900 cal BP on the basis of Wk-26796. Identification of three phases at Amoreira was basic to the work of Mendes Correia and Roche during the 20th century excavations (summarised in Jackes & Lubell 2016: 659).

Figure 5: One of four[9] photographs taken by Rui de Serpa Pinto, August 1931, of Skeleton 3 (o velho, the old one), showing the main part of the skeleton. The right radius, ulna and a tibia, fibula and fragmented femur were found over a metre away, but a patella can be seen beside the right humerus. The skeleton was found 20 cm below the modern surface.

Wk-26796 dates towards the end of the Mesolithic at Muge, a conclusion in accord with the three youngest direct dates on human bone from nearby Cabeço da Arruda: TO-356 from Arruda N, excavated in the 1880s (6360 ± 80 BP, $\delta^{13}C$ = -15.3‰), TO-10217 CA-00-01, excavated in 2000 (6620 ± 60 BP, $\delta^{13}C$ = -18.1‰) and Ua-56457 from Arruda B from the 1880s (6647 ± 32 BP, $\delta^{13}C$ = -18.3‰). Median age estimates for these three individuals using Marine 20 are 6950, 7360 and 7390 cal BP respectively, congruent with the Amoreira later Mesolithic date range of 7400 to 6900 cal BP.

[9]Two photographs are held in Museu de História Natural, Reitoria da Universidade do Porto, Porto, digitised in 2010 (Jackes *et al.* n.d.; Jackes & Lubell 2016: 664) and two were retained by A. H. Bacelar Gonçalves, former curator at the museum and recorded in Abrunhosa (2012: 194, 201). The scale can be determined from the 2010 photographs of the

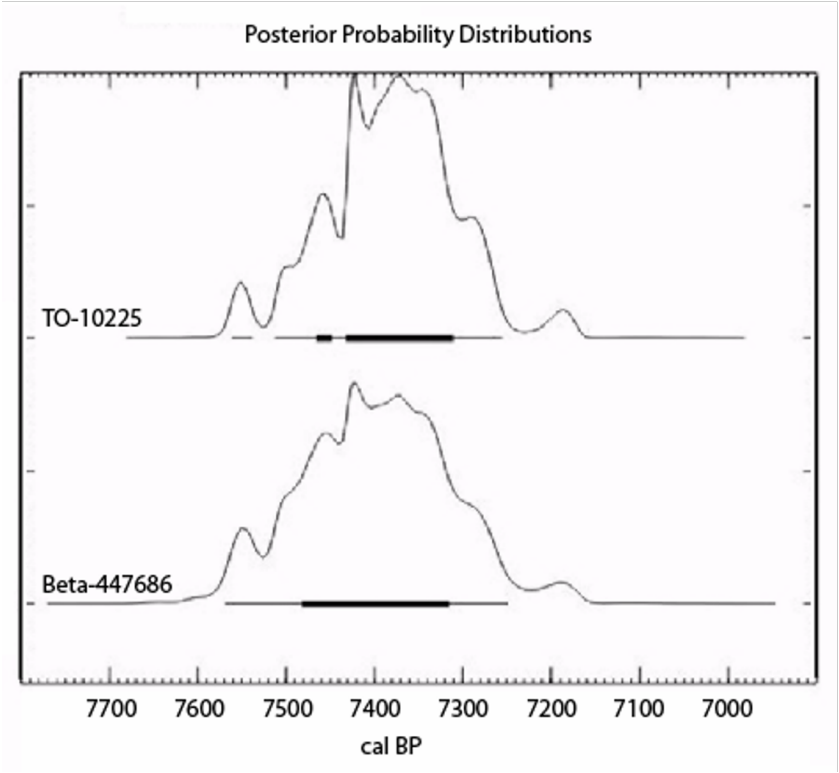

Figure 6: Probability distributions for two individuals from Cabeço da Amoreira, TO-10225, a late adolescent female excavated by Roksandic in 2001 and Beta-447686, an elderly adult excavated by Mendes Correia in 1931.

4 Conclusion

We have shown that the date Wk-26796 was on material from the extremely fragmentary adult male within the mixed remains recovered from the upper level at Amoreira, the third individual of Roksandic (2006). Elements from this burial lay in proximity to, though apparently above, the disturbed female skeleton dated by TO-10225. She was some 400 years older, although in the same shallow upper levels in Square A1 of the 2001 excavations at Amoreira.

We have also thrown new light on two questions that have been raised about the burials recovered in 2001, and their relationship to burials recovered from the upper levels at Amoreira in earlier work. The first question related to a suggestion that Wk-26796 sample was from a 36 month old child (Cubas *et al.* 2019), apparently an error for the *ca.* 36 week old foetus identified by Ferreira (2003). The answer is that the date is not from a foetus and can thus give us more certain information on the general diet. Given the evidence for disturbance in the upper level we can have no clear idea where the undated foetus stands chronologically, relative to the two dated individuals.

The second question is, what would the stable isotope analysis of the fragmentary male femur tell us about the diet of those buried in the Muge middens towards the end of the Mesolithic? Now that we know the Wk-26796 sample's identity as an adult we can come to a conclusion with more certainty. The individual dated as TO-10225 must have grown up in an area of granite and schist, and not within the estuarine Muge or Sado areas, though the CAM-01-01 $\delta^{13}C$ and $\delta^{15}N$ values are, in fact, very similar to those from contemporary Late Mesolithic individuals in the Sado Basin. The later Amoreira

proximal portion of the left humerus shaft: the bone fragment is 10 cm long. Identification of the individual was based on the bones, using the photographs and a field sketch (Cardoso & Rolão 1999/2000: 157, Figure 15).

individuals, dated by Wk-26796 and Beta-447686, show that the Amoreira diet remained strongly dependent on local estuarine resources through to the end of the Mesolithic occupation at *ca*. 6900 cal BP, just as at Cabeço da Arruda, where individual N, with a 55% marine component diet, was buried in the Mesolithic mode. The concordance in the date of the female with low dietary marine intake and the date of an elderly individual with a high marine component diet, both lying at *ca*. 20 cm below the modern surface, certainly suggests that there was no general terrestrial dietary shift at Amoreira *ca*. 7400 years ago.

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