Marcham: Stable isotopes, radiocarbon dating, and chronological modelling

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There were six samples of human bone from excavations in Marcham, Oxfordshire that were subjected to radiocarbon dating and a suite of isotopic analyses at SUERC, East Kilbride, UK. The samples all consisted of single entities (Ashmore 1999).

Methods

Radiocarbon dating

The bones were pretreated following Dunbar *et al.* (2016). Briefly, samples are sanded, weighed, and placed in a beaker with 100 mL of 1M HCl at room temperature for 24–48 hrs or until fully demineralised. If more than 48 hrs are required, the sample is rinsed and the acid replenished. After demineralisation the sample is rinsed to near neutral pH and 100 mL of ultrapure MillQ® water is added. The sample is then placed on a hotplate at ~80ºC until fully solubilised. The solution is then passed through GF/A filter paper and reduced to 5–10 mL prior to freeze-drying.

For graphitisation, 10–20 mg of the collagen is weighed into a clean quartz insert and placed into a precleaned quartz combustion tube containing copper oxide to provide the oxygen for the reaction and silver foil to remove gaseous impurities (Vandeputte *et al.* 1996). The resulting carbon dioxide is then cryogenically purified and a 3 mL subsample reduced to elemental carbon (graphite) using the two-step iron and zinc process proposed by Slota *et al.* (1987). The graphite is then pressed into aluminium target holders and measured on either the SUERC 5MV tandem or 250kV single-stage AMS.

The SUERC lab maintains rigorous internal quality assurance procedures, and participation in international inter-comparisons (Scott 2003; Scott et al. 2010) indicate no laboratory offsets; thus, validating the measurement precision quoted for the radiocarbon ages. The radiocarbon results (Table RC-1) are conventional radiocarbon ages (Stuiver and Polach 1977). They have been calibrated using the internationally agreed terrestrial (IntCal20) calibration curve of Reimer *et al.* (2020) and the OxCal v.4.4 computer program (Bronk Ramsey 2009).

Stable isotope methods ($\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$)

Sayle *et al.* (2019) fully describe how the simultaneous $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values were obtained by combusting approximately 1–1.5 mg of collagen, which was weighed into a tin capsule and subsequently introduced to a single combustion reactor containing tungstic oxide and reduced copper wires held at 1020ºC. Samples were introduced via the Thermo Scientific MAS Plus Autosampler alongside a pulse of oxygen to aid combustion. The resulting N_2, CO_2, and SO_2 gases produced in the reactor were separated using a temperature variable GC column (70–240ºC), and then transferred to a Thermo Scientific DELTA V Advantage IRMS via a Thermo Scientific ConFlo IV Universal Interface (Thermo Fisher Scientific, Bremen, Germany). Optimising the gas chromatography separation and helium carrier gas flow during sample analysis in the EA IsoLink IRMS System enabled simultaneous $\delta^{13}C$ and $\delta^{15}N$ values of archaeological bone collagen to be obtained in approximately 10 minutes, providing sharp peak shapes. There is 20% duplication of all samples in each run. Results are reported (Table RC-2) as per mil (‰) relative to the internationally accepted standards V-PDB, AIR, and V-CDT for $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$, respectively with 1σ precisions of ±0.1‰, ±0.2‰, and ±0.4‰ for $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$, respectively.

Chronological modelling

A Bayesian approach (Buck *et al.* 1996) has been applied to the interpretation of the chronology of the burials from Marcham. While simple calibrated dates are accurate estimates of the radiocarbon age of samples, usually archaeologists really wish to know the dates of the archaeological events represented by those samples. For example, the start and end of burial activity associated is of interest.

The methodology used here allows the combination of these different types of information explicitly, to produce realistic estimates of the dates of archaeological interest. The posterior density estimates produced by this modelling are not absolute, rather they are interpretative estimates, which can and will change as further data become available and as other researchers choose to model the existing data from different perspectives. The technique used is a form of Markov Chain Monte Carlo sampling and has been applied using the program OxCal v4.4 (http://c14.arch.ox.ac.uk/). Details of the algorithms employed by this program are available in Bronk Ramsey (1995; 1998; 2001; 2009) or from the online manual. The algorithm used in the models can be derived from the OxCal keywords and bracket structure shown in Figure RC-3.

Stable isotope results

The stable carbon and nitrogen isotopes indicate the individuals subsisted primarily on a terrestrial-based diet (Fig. RC-1). Therefore, no correction of the radiocarbon measurements was necessary to account for any marine reservoir effect.

Sulfur isotopes were also measured as part of the radiocarbon dating process. The human bone results were compared to measurements made on Iron Age cattle, sheep/goat, and horse remains from sites in central southern Britain and the Midlands (Fig. RC-2). Sites on the White Chalk included Gussage All Saints (Dorset), Suddern Farm (Hants), and Winnall Down (Hants). From the Kellaways/Oxford Clays, samples came from Gravelly Guy (Oxon), Yarnton (Oxon), and TEAs 7, 10, 12, 28, and 31 along the A14 Huntington Bypass (Cambs). The Lias Group is represented by remains from the Iron Age settlement at Burrough Hill (Leics), while TEA38 along the A14 Huntington Bypass (Cambs) supplied the samples from the West Walton Formation. There are no known sulfur isotope measurements from prehistoric domestic herbivores recovered from the same lithology (Corallian Group) that the Marcham site lies on. With the exception of the White Chalk, which formed in the Upper Cretaceous period, all the other referenced lithologies formed at different times in the preceding Jurassic and are generally characterised as being composed of mudstone, siltstone, and sandstones, with the Lias and Corallian also characterised as containing limestone. It should be noted that the Corallian Group lies as a band never much wider than 5 km across (N–S) between the West Walton and Kellaways/Oxford Clay Formations in the southern-central region of the Jurassic lithologies, though Marcham is sited within a hundred meters of the West Walton Formation. While it would seem more likely the expected isotope values for the Corallian Group might be closer to those of the West Walton Formation, without direct data from prehistoric domestic terrestrial herbivores from near Marcham, a more conservative interpretation will consider all the data from the different Jurassic lithologies.

The data ($\delta^{15}N$ vs $\delta^{34}S$) are given in Figure RC-2 and show that the $\delta^{34}S$ values from the Marcham skeletons do not differ greatly from the Jurassic lithology datasets, with the exception of SK25, which may represent an incomer to the area in the period of life represented by the bone collagen. In this case, rib bones were submitted for the radiocarbon dating and the collagen is considered to represent the final few years of the individual's life.

So, it is likely SK25 either spent a considerable amount of time in the final years of their life consuming plants and animals grown and raised on a lithology that is enriched in ^{34}S, or else they lived locally but procured their food from lithologies enriched in ^{34}S.

Until a more robust local baseline can be developed, it is difficult to move the interpretation much further. However, more material has been made available and will be processed in the near future, at which time the report can be updated.

The radiocarbon samples and chronological model results

The submitted samples come from a series of Iron Age burial contexts from Marcham. There are two primary questions asked: 1) are the measurements indicative of a short span or burial activity or even a single 'event'; and if not 2) when did the burial activity start and end.

To answer Query 1, a *t*-test was run on the six measurements. This was done using the R_Combine function in OxCal, which follows the methodology of Ward and Wilson (1978). The measurements are not statistically consistent (T'=28.1; df=5; T'(5%)=11.1), suggesting the deaths of the buried individuals occurred over a protracted period.

Therefore, to address Query 2, a chronological model was created following the simple bounded phase approach in Hamilton and Kenney (2015). The model has good agreement (Amodel=104) and estimates the first burial in the group took place in *410–235 cal BC* (*95% probability*; Fig. RC-3; *first burial: Marcham*) or *400–370 cal BC* (*68% probability*). The latest burial in the group took place in *350–165 cal BC* (*95% probability*; Fig. RC-3; *last burial: Marcham*) or either *345–260 cal BC* (*49% probability*) or *240–175 cal BC* (*19% probability*). The deaths of these six individuals occurred over a period of *20–225 years* (*95% probability*; Fig. RC-4; *span: Marcham burials*) or *35–140 years* (*68% probability*).

Table RC-1: Radiocarbon dates from the burials from Marcham, Oxfordshire

Lab ID	Sample ID	Material dated	$\delta^{13}C$ (‰)	C:N	Radiocarbon age (BP)	Calibrated date (95% probability)
SUERC-134480	Noah's Ark 1964	human bone: rib	−20.2	3.5	2158 ±26	350–70 cal BC
SUERC-134481	SK19	human bone: rib	−20.4	3.4	2307 ±25	410–230 cal BC
SUERC-134482	SK21	human bone: rib	−20.4	3.3	2185 ±26	360–150 cal BC
SUERC-134486	SK24	human bone: rib	−20.9	3.3	2186 ±25	360–160 cal BC
SUERC-134487	SK25	human bone: rib	−20.9	3.4	2228 ±26	380–200 cal BC
SUERC-134488	SK26	human bone: rib	−20.2	3.3	2288 ±26	400–220 cal BC

Table RC-2: Stable isotope results from the radiocarbon-dated samples from Marcham, Oxfordshire

Lab ID	Sample ID	Material dated	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\delta^{34}S$ (‰)	C:N	C:S	N:S
SUERC-134480	Noah's Ark 1964	human bone: rib	−20.2	10.3	−2.4	3.5	594	172
SUERC-134481	SK19	human bone: rib	−20.4	11.2	−4.6	3.4	505	151
SUERC-134482	SK21	human bone: rib	−20.4	10.1	−9.2	3.3	531	161
SUERC-134486	SK24	human bone: rib	−20.9	11.5	1.3	3.3	518	157
SUERC-134487	SK25	human bone: rib	−20.9	9.7	7.0	3.4	530	164
SUERC-134488	SK26	human bone: rib	−20.2	9.1	−1.6	3.3	546	166

Figures

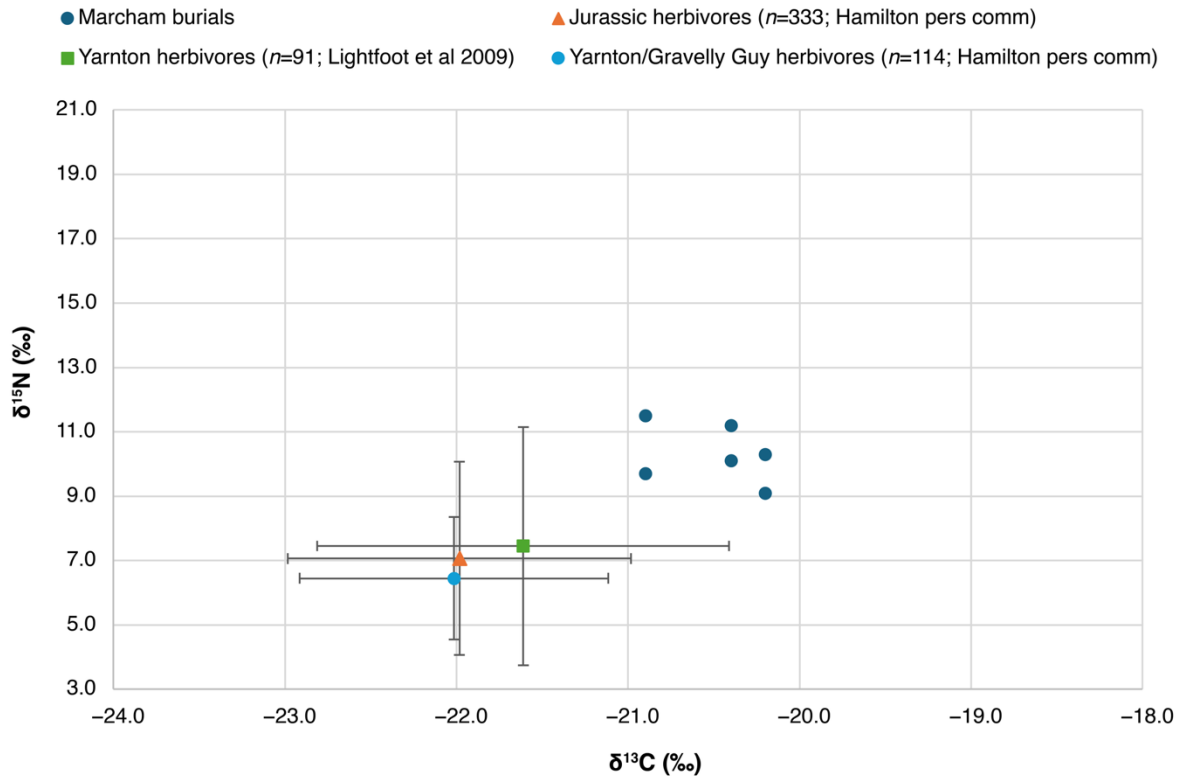


Figure 1: Biplot of $\delta^{15}N$ versus $\delta^{13}C$ for the human remains from Marcham. The baseline data from late prehistoric domestic herbivores (cattle, sheep/goat, and horse) recovered from the nearby sites of Yarnton and Gravelly Guy (nr Oxford) and more broadly from across the Jurassic lithologies of the Kellaways/Oxford Clays, Lias Formation, and West Walton Formation are provided for comparison. These isotopes suggest no marine protein consumption that might otherwise impact the interpretation of the radiocarbon measurements.

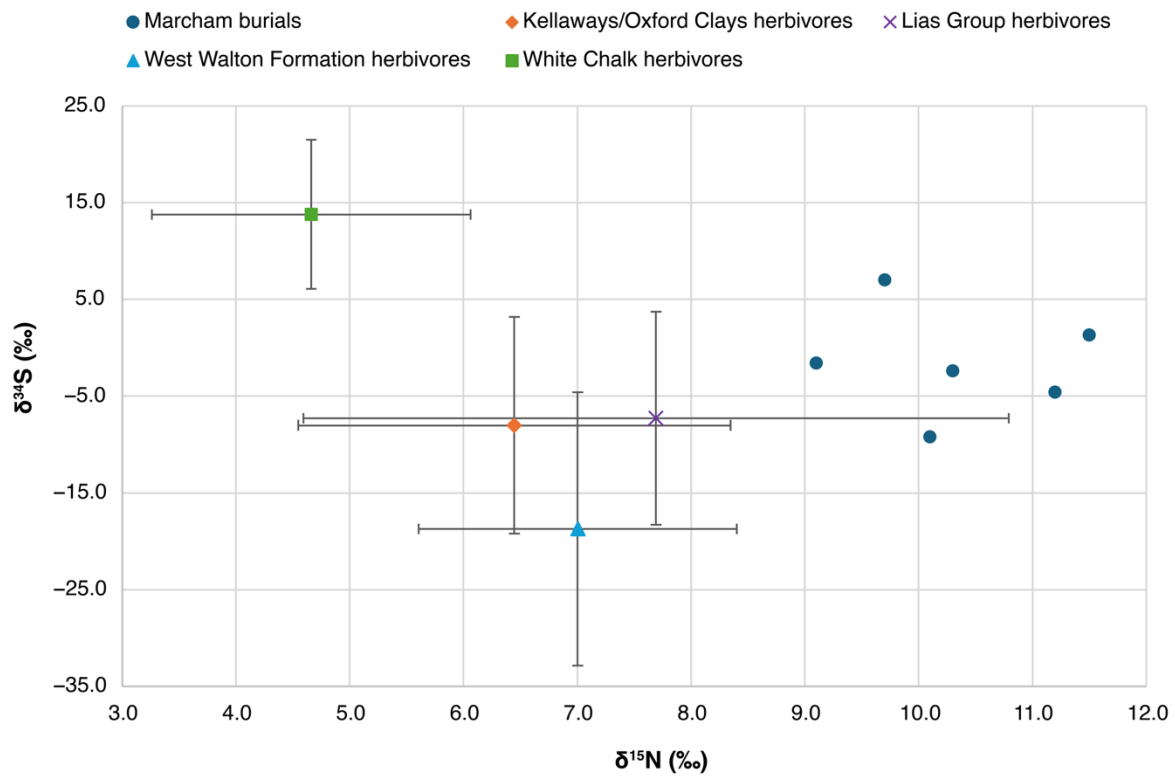


Figure RC-2: Plot of $\delta^{15}N$ vs $\delta^{34}S$ for the bone collagen samples from the human bone samples from Marcham. The data are compared here to expected range for three nearby Jurassic lithologies – Kellaways/Oxford Clays (*n*=114), Lias Group (*n*=122), and West Walton Formation (*n*=97) – as well as the White Chalk (*n*=125) to the south, as measured on Iron Age terrestrial herbivore samples (cattle, sheep/goat, and horse) from archaeological sites. All comparative data are Hamilton pers comm.

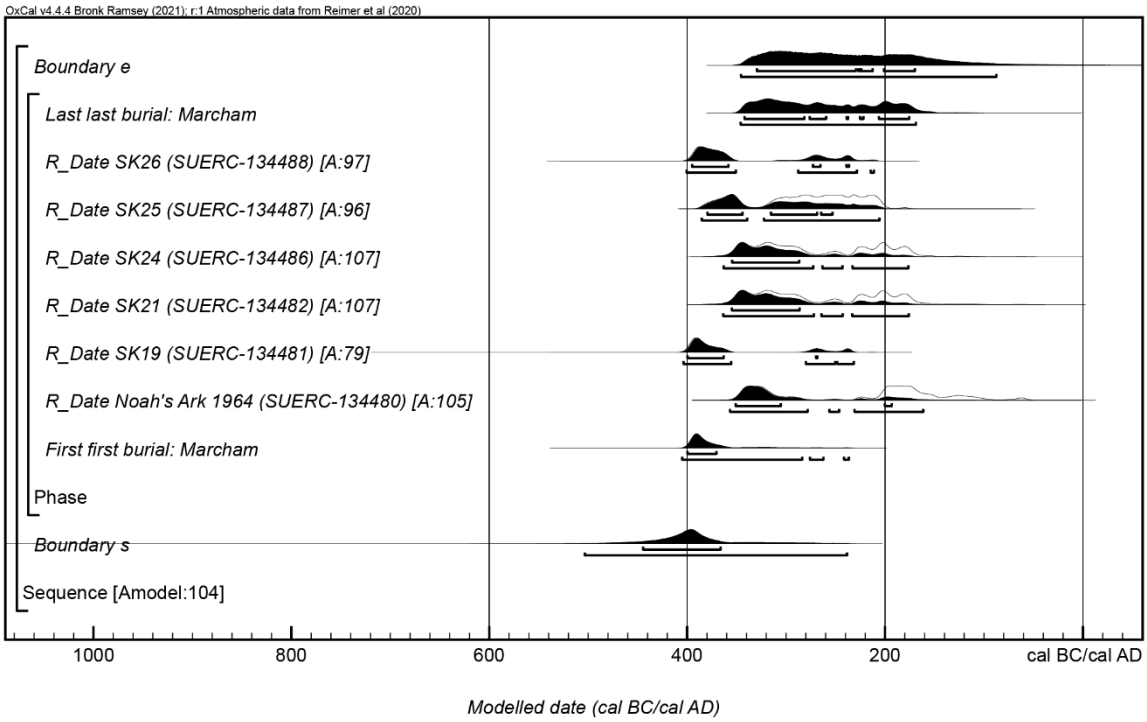


Figure RC-3: Chronological model for the six dated burials from Marcham. Each distribution represents the relative probability that an event occurred at some particular time. For each of the radiocarbon measurements two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model use. The other distributions correspond to aspects of the model. For example, '*first burial: Marcham*' is the estimated date the first person in the group died, based on the radiocarbon dating results. The large square 'brackets' along with the OxCal keywords define the overall model exactly.

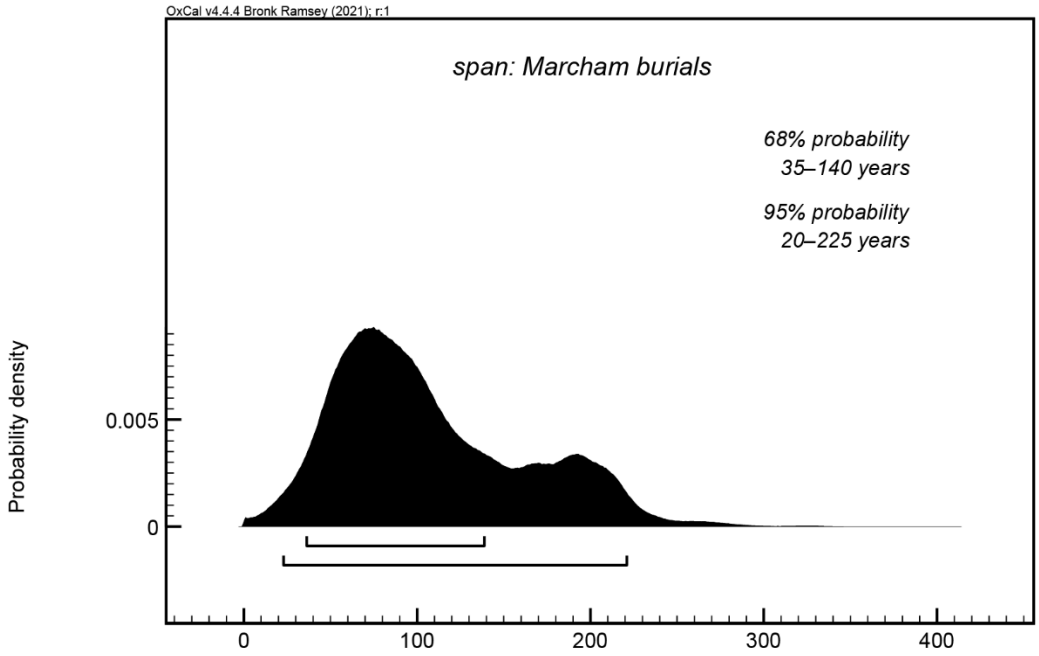


Figure RC-4: Span of the six burials modelled from Marcham. The spans are derived from the modelling shown in Figure RC-3.

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